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# Adherence to guidelines for creatinine and potassium monitoring and discontinuation following renin-angiotensin system blockade



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# Adherence to guidelines for creatinine and potassium monitoring and discontinuation following renin-angiotensin system blockade

**Running title:** Creatinine and potassium monitoring after ACEI/ARB initiation

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## ABSTRACT

**Objectives** To examine adherence to serum creatinine and potassium monitoring and discontinuation guidelines following initiation of treatment with angiotensin converting-enzyme inhibitors (ACEI) or angiotensin-receptor blockers (ARB); and whether high-risk patients are monitored.

**Design** Population-based cohort study using electronic health records from the UK Clinical Practice Research Datalink and Hospital Episode Statistics.

**Setting** UK primary care, 2004–2014.

**Subjects** 223,814 new ACEI/ARB users.

**Main outcome measures** Proportion of patients with renal function monitoring before and after ACEI/ARB initiation; adverse renal outcomes (creatinine increase ≥30% or potassium levels >6 mmol/L) at first follow-up monitoring; and treatment discontinuation after such changes. Using logistic regression models, we also examined patient characteristics associated with such adverse outcomes, and with follow-up monitoring within the guideline-recommend two weeks of treatment initiation.

**Results** Ten percent of patients had neither baseline nor follow-up monitoring of creatinine within 12 months before and 2 months after initiation of an ACEI/ARB, 28% had monitoring only at baseline, 15% only at follow-up, and 47% both at baseline and follow-up. The median period between the most recent baseline monitoring and drug initiation was 40 days (interquartile range: 12-125 days). 34% of patients had baseline creatinine monitoring within one month before initiating therapy, but less than 10% also had the guideline-recommended follow-up test recorded within two weeks. Among patients experiencing a creatinine increase ≥30% (n=567, 1.2%) or potassium level >6 mmol/L (n=191, 0.4%), 80% continued treatment. Although patients with prior myocardial infarction, hypertension, or baseline potassium >5 mmol/L were at high risk of adverse renal outcomes after ACEI/ARB initiation, there was no evidence that they were more frequently monitored.

**Conclusions** Only one tenth of patients initiating ACEI/ARB therapy receive the guideline-recommended creatinine monitoring. Moreover, the vast majority of the patients fulfilling post-initiation discontinuation criteria for creatinine and potassium increases continue on treatment.

**Strengths and limitations of this study:**

- This is the largest monitoring study to date, examining both adherence to creatinine and potassium monitoring and discontinuation guidelines following initiation of angiotensin converting-enzyme inhibitors or angiotensin-receptor blockers in UK primary care, and whether patients are monitored in accordance with their individual risk profile
- Use of the UK Clinical Practice Research Datalink and Hospital Episode Statistics ensured that the study was population-based and not restricted to specific demographic, hospital, or insurance groups.
- Blood tests performed in hospital systems were not recorded in the Clinical Practice Research Datalink, but the results were consistent for patients with no recent hospital admissions
- If the recording of creatinine levels was not missing completely at random, the associations between patient characteristics and creatinine increase may have been underestimated

## INTRODUCTION

Renin angiotensin system blockade using angiotensin-converting enzyme inhibitors (ACEI) and angiotensin-receptor blockers (ARB) is a mainstay in treatment of hypertension,[1] heart failure,[2] diabetic microalbuminuria or proteinuric renal diseases,[3] and after myocardial infarction.[4] However, some patients experience a sudden decline in kidney function when initiating these drugs, presumably due to antagonism of the angiotensin II-mediated efferent arteriolar constriction or impaired kidney excretion of potassium.[5 6]

The potential impact on kidney function should be evaluated by comparing pre- and post-initiation levels of serum creatinine and potassium.[7] Discontinuation is recommended if the rise in creatinine exceeds 30% above baseline or if hyperkalaemia develops.[8] It is unclear whether these recommendations are routinely followed in clinical practice.[9]

A few studies have compared baseline and follow-up monitoring results,[9] but large studies using contemporary data with reference to current guidelines are lacking, and it is unknown whether patients' individual risk of renal impairment influence their likelihood of being monitored.[9] We therefore examined adherence to creatinine and potassium monitoring and treatment discontinuation guidelines following ACEI/ARB initiation in UK primary care, and whether patients are monitored in accordance with their individual risk profile.

## METHODS

### Data sources

We used the UK's Clinical Practice Research Datalink (CPRD) linked to hospital record data from the Hospital Episode Statistics (HES) database. The CPRD database contains primary care electronic health record data from 7% of the UK population (~15 million patient lives, with ~8 million currently under follow-up).[10] Patients included in the CPRD are largely representative of the UK population in terms of age, sex and ethnicity.[10 11] Information recorded in the database includes demographics such as sex and year of birth, the location of the general practice, medical diagnoses (based on 'Read' codes), drug prescriptions, and a

range of routine laboratory test results. HES records cover all hospital admissions for patients covered by the NHS who receive treatment either from English NHS trusts or independent providers.[10 11] Fifty-eight percent of general practices included in the CPRD have agreed to HES linkage.[10] We obtained linked data on socioeconomic status (index of multiple deprivation) based on area of residence.

**Monitoring guidelines**

Consistent with other international guidelines, the National Institute for Health and Care Excellence (NICE) recommend baseline testing of creatinine when initiating ACEI/ARB therapy in patients with hypertension,[1] heart failure,[2] myocardial infarction,[4] or chronic kidney disease (CKD).[3] The time interval for baseline testing is not further specified.[1-4] Among patients with heart failure, myocardial infarction, and chronic kidney disease, NICE recommends follow-up monitoring within 2 weeks of treatment initiation,[2-4] and for myocardial infarction patients at least annually thereafter.[4] A baseline assessment and follow-up test within 2 weeks are also recommended by the UK Renal Association,[12] as well as the frequently used online web resource General Practice (GP) Notebook.[13] GP Notebook additionally recommends monitoring 1, 3, 6, and 12 months after the first follow-up test.[13] NICE recommends not to initiate ACEI/ARBs in patients with a baseline potassium level >5 mmol/L and to discontinue therapy if potassium rises above 6 mmol/L.

**ACEI/ARB initiators**

We identified a cohort of all HES linked CPRD patients aged ≥18 years, who initiated ACEI/ARB treatment between January 1, 2004 and March 31, 2014. We did not include earlier calendar periods, as laboratory data before 2004 were incomplete due to interface problems between laboratory reporting software and GP practice software.[14] Also, creatinine testing was incentivised in 2004 with the introduction of the diabetes Quality and Outcomes

Framework (QOF) and further in 2006 with the CKD QOF.[14] To rule out any potential influence of incomplete data around 2004, we also examined the most recent 5-year calendar period separately in a sensitivity analysis. New users were defined as persons with at least one year of continuous registration in the CPRD before their first recorded ACEI/ARB prescription.

**Laboratory data**

All creatinine test results were extracted from the general practice records of the study population, using creatinine-specific codes in CPRD. Cross-reference was then made to creatinine test results identified from a broad Read code search. Any irrelevant codes were excluded. The same procedure was used to identify potassium test results.

**Patient characteristics**

We obtained information for all patients on age, sex, calendar period of ACEI/ARB initiation (2004–2008 and 2010–2014), socioeconomic status (quintiles of the 2004 index of multiple deprivation scores), lifestyle factors (smoking, alcohol intake, and body mass index), baseline potassium level (≤5 or >5 mmol/L), CKD, cardiovascular comorbidities (heart failure, myocardial infarction, hypertension, peripheral arterial disease, and arrhythmia), and diabetes.[15] We used algorithms for smoking status, alcohol intake, and body mass index based on the most recent records in the CPRD before ACEI/ARB initiation.[16 17] As measures of baseline creatinine and potassium levels, we used the single most recent measurement within 12 months before the first ACEI/ARB prescription. We calculated estimated glomerular filtration rate (eGFR) level from the most recent creatinine measurement and CKD stage from the CKD-EPI equation.[18] Cardiovascular comorbidities and diabetes were identified from both the CPRD and HES based on diagnoses recorded prior to ACEI/ARB initiation. The code lists for all variables are provided in the online repository at

https://clinicalcodes.rss.mhs.man.ac.uk/.[19]

**Patient involvement**

The study included no patient involvement

**Statistical analysis**

We described ACEI/ARB users according to patient characteristics, both overall and according to creatinine monitoring status (no baseline or follow-up monitoring, baseline only, follow-up only, and both baseline and follow-up monitoring). Baseline monitoring was defined as a test performed on the date of drug initiation or within either 12 months before (generous interval) or one month before initiation (more ideal interval assumed to be driven by planned ACEI/ARB initiation). To accord with the post-initiation monitoring interval recommended from previous trial data, we considered only follow-up monitoring within the first 2 months after drug initiation.[8]

We calculated the proportion of persons in the total cohort of new users who had baseline and follow-up monitoring (within 1, 3, and 12 months before drug initiation and within 2 weeks, 1 month, and 2 months after initiation). We then computed the proportion of persons with both baseline and initial follow-up monitoring within the guideline-recommended interval of 2 weeks following drug commencement.

We repeated the analyses for continuing users, in order to examine adherence to the stricter guideline recommendations for ongoing monitoring (*i.e.*, monitoring within 1, 3, 6, and 12 months after the first retest).[13] Continuation was defined as ACEI/ARB use beyond 30 days following the monitoring date, *i.e.*, when the end date of the first continuous course of therapy was after the date of the first monitoring date plus 30 days (to allow for stockpiling). The end date of each prescription was calculated by adding the prescription duration (total number of tablets prescribed divided by the specified number of tablets per day) to the

prescription date. In identifying continuous courses of therapy, we allowed for a 30-day gap between the end date of one prescription and the start of the next consecutive prescription.

In sensitivity analyses, we repeated the analyses (1) extending the follow-up window for the first follow-up monitoring from two to three weeks to account for minor delays; (2) including only the most recent calendar period (2009-2014) to account for temporal changes in data completeness and quality of care; (3) excluding patients with a hospital admission or discharge date within 1 month before or after their first ACEI/ARB prescription, in order to account for drug initiation and any subsequent renal function tests occurring in the hospital and therefore not captured in the CPRD; (4) focusing on specific patient subgroups (heart failure, myocardial infarction, hypertension, CKD (eGFR<60mls/min/1.73m$^2$), peripheral arterial disease, and diabetes); and (5) defining drug use continuation as ACEI/ARB use beyond 90 days (instead of 30 days) after the first retest date.

We used the subcohort of patients with both baseline and follow-up monitoring to calculate the proportion of patients with creatinine increases ≥30% or potassium levels >6 mmol/L at the first follow-up monitoring within 2 months after initiation, as well as the proportion of patients continuing treatment despite these contraindications for use.

Finally, we fitted a logistic regression model to identify patient characteristics associated with a severe decline in renal function (creatinine increase ≥30% or potassium level >6 mmol/L) and compared these characteristics with those associated with receiving post-initiation follow-up monitoring within 2 weeks. The model included age, sex, CKD stage, cardiovascular comorbidities, diabetes, and baseline potassium level (>5 vs. ≤5 mmol/L). In three additional model-based sensitivity analyses, we repeated the analyses (1) excluding patients with a recent hospitalization (as defined above); (2) omitting baseline potassium from the model to examine the extent of potential overfitting when both baseline potassium and CKD stage were kept in the model; and (3) also adjusting additional for ethnicity.

The study protocol was made available to the journal reviewers and approved by the London School of Hygiene and Tropical Medicine Ethics Committee (No. 6536) and the Independent Scientific Advisory Committee (ISAC) for Medicines and Healthcare Products Regulatory Agency (No. 16_025). All analyses were performed using STATA 14 statistical software package.

## RESULTS

### Serum creatinine monitoring before and after ACEI/ARB initiation

We identified 223,814 new users of ACEI/ARBs (Table 1). Among these patients, 21,411 (10%) had no baseline or follow-up creatinine tests within 12 months before and 2 months after treatment initiation, 63,359 (28%) had only a baseline test, 33,185 (15%) had only follow-up tests, and 105,859 (47%) had both baseline and follow-up tests. Median age varied only slightly between the groups (60, 62, 59, and 63 years, respectively) and there were no substantial differences in socioeconomic status, lifestyle factors, or peripheral arterial disease. Compared with patients with neither pre- nor post-initiation monitoring, patients with both were more likely to have diagnosed hypertension (76% vs. 61%) and diabetes (20% vs. 7%), but less likely to have diagnosed heart failure (4% vs. 7%), myocardial infarction (4% vs. 18%), and arrhythmia (7% vs. 10%). Among patients with baseline monitoring, 83% did not have CKD, 13% stage 3a, 3% stage 3b, 0.5% stage 4 CKD. In the same population, 7% commenced ACEI/ARB therapy despite baseline potassium above 5 mmol/L. The median number of days between baseline monitoring and first prescription date was 40 days (interquartile range: 12-125 days).

The proportion of patients receiving creatinine testing before initiating ACEI/ARB therapy was 76% within 12 months before treatment initiation, declining to 34% within one month before initiation (Table 2). The proportion with follow-up testing after treatment initiation was 29% within 2 weeks, increasing to 62% within 2 months. 21% of ACEI/ARB initiators had both a baseline test within 12 months before and a follow-up test within 2

weeks after starting treatment (Table 3). However, among patients undergoing testing within one month prior to treatment initiation, only 9% had also the recommended follow-up test within 2 weeks of treatment start. When we extended the follow-up window to three weeks, this proportion increased only to 14% (Table 3). Among patients continuing treatment, only 1% had follow-up measurements at 1, 3, 6, and 12 months after the first retest, in compliance with the strictest recommendation (eTable 1). These results were unchanged when the analysis was restricted to the most recent calendar period (eTable 1-2) and to patients with heart failure, myocardial infarction, hypertension, peripheral arterial disease, diabetes or no recent hospitalization (eTable 3). Only patients with CKD received a slightly higher degree of monitoring (13%) within two weeks following treatment initiation (eTable 3).

**Serum creatinine and potassium changes after ACEI/ARB initiation**

Among patients receiving the recommended renal function monitoring, 567 (1.2%) experienced a creatinine increase ≥30% and 191 (0.4%) a potassium level >6 mmol/L at their first follow-up test within two months of treatment initiation (1.4% received in total either) (Table 4). Among these patients, 80% continued treatment beyond 30 days following the monitoring date (Table 4). The sensitivity analysis showed that 65% of patients with a creatinine increase ≥30% and 60% of those with a potassium level >6 mmol/L continued also treatment beyond 90 days after the monitoring date (eTable 4). The results remained consistent for longer baseline monitoring intervals (eTable 4).

**Patients at high risk for creatinine increases ≥30%**

When we examined patient characteristics associated with a creatinine increase ≥30% and adjusted for the other characteristics in a multivariable analysis (Table 5), we found an increased odds ratio (OR) for women (1.6-fold increased), for age above 70 years (at least 1.3-fold increased), for CKD stage 4 (1.6-fold increased), heart failure (2.9-fold increased),

peripheral arterial disease (1.9-fold increased), myocardial infarction (1.6-fold increased), and hypertension (1.6-fold increased).

**Patients at high risk for potassium >6 mmol/L**

Baseline potassium level and CKD stage, but not age and sex, were associated with potassium levels >6 mmol/L after ACEI/ARB initiation. Thus, the OR was 7-fold increased for baseline potassium >5 mmol/L, two-fold increased for CKD stage 3a, 5-fold increased for stage 3b, and 11-fold increased for stage 4 (Table 5). Among cardiovascular comorbidities, heart failure was associated with the strongest OR of a potassium level >6 mmol/L (2.22, 95% CI: 1.38-3.58).

**Monitoring high-risk patients**

The odds of having a follow-up test within 2 weeks following drug initiation were higher for persons aged 70 years or above compared with ≤50 years (1.18, 95% CI: 1.13-1.23 for 70-79 years and 1.17, 95% CI: 1.11-1.23 for 80+ years). It was also increased for patients with CKD stage (1.41, 95% CI: 1.20-1.66), heart failure (1.16, 95% CI: 1.08-1.23), and peripheral arterial disease (1.11, 95% CI: 1.02-1.20). However, there was no substantially increased OR (>10%) associated with female sex (1.07, 95% CI: 1.04-1.09), prior history of myocardial infarction (0.77, 95% CI: 0.72-0.82), hypertension (1.05, 95% CI: 1.00-1.11), or baseline potassium >5 mmol/L (1.04, 95% CI: 0.99-1.09). When we excluded patients with a recent hospital admission, the reduced OR for myocardial infarction was no longer observed (0.93, 95% CI: 0.80-1.08) (eTable 5). Finally, the results remained consistent when we omitted adjustment for baseline potassium (data not shown) and when we adjusted additionally for ethnicity (eTable 5).

**DISCUSSION**

Only one tenth of patients initiating ACEI/ARBs in UK primary care appear to receive the guideline-recommended creatinine monitoring. One in 15 patients commenced ACEI/ARBs despite baseline potassium above the recommended level, which was also shown to be a strong predictor for severe post-initiation hyperkalaemia. Among monitored patients, a creatinine increase ≥30% or a potassium level >6 mmol/L occurred in almost 1.5% of patients, and most did not discontinue therapy despite guideline recommendations to stop. Although patients with prior myocardial infarction, hypertension, or a high baseline potassium level were at higher risk of sudden decline in kidney function after ACEI/ARB initiation, there was no evidence that these patient groups were monitored more frequently while initiating the drugs.

**Strengths and limitations**

Several issues should be considered when interpreting our study results. Its large sample size increased precision. Use of the CPRD ensured that the study was population-based and not restricted to specific demographic, hospital, or insurance groups.

We did not have access to blood tests performed in hospital systems, which may have been reported to GPs, but not recorded in CPRD. However, restricting the analysis to patients with no recent hospital admissions had little effect on our findings. Although some patients may also have been seen in outpatient specialty clinics, it is common practice for specialists to ask GPs to initiate new drugs such as ACEI/ARBs, with local biochemical monitoring, limiting misclassification.

Consistent with findings from other studies,[20] we found that approximately 50% of all ACEI/ARB initiators were monitored both before and after treatment start. If GPs are retesting renal function in patients at higher risk of adverse outcomes, we may have overestimated the proportion of patients with high potassium levels or creatinine increases compared with the untested lower-risk general population.

GP system software is used for issuing prescriptions, ensuring the accuracy of prescription data. However, it cannot be inferred that all patients actually redeemed their prescription at the pharmacy and start medication on the same day that it was prescribed.[18 21] Similarly, the estimated coverage of prescriptions may not be completely accurate due to such factors as stockpiling and irregular use. We also do not know whether GPs contacted patients with elevated laboratory results to advise them to stop taking the medication prior to the end of their prescriptions. However, 80% of patients who developed creatinine increase ≥30% after ACEI/ARB initiation were still issued a subsequent ACEI/ARB prescriptions.

We aimed to detect discontinuation related closely in time to first follow-up monitoring and hence likely resulting from an elevated creatinine or potassium result. We therefore defined continuation as ACEI/ARB use beyond 30 days (the median prescription duration) after the monitoring date. Extending the definition of continuous use beyond 90 days reduced the risk of misclassifying patients as continuing treatment when they had in fact stopped. However, extending the duration also increased the risk of identifying discontinuation due to other reasons than creatinine/potassium increase, *e.g.*, death or cough. Diagnoses recorded in the CPRD generally have been found to have adequate validity for research purposes,[22 23] particularly in the domains assessed by the QOF.[24 25]

In the logistic regression analysis to estimate factors associated with creatinine increase ≥30%, we excluded patients without pre and post measurements (complete case analysis). If the recording of creatinine levels was not missing completely at random, the associations between patient characteristics and creatinine increase may have been underestimated.[26] While this assumption could not be tested directly, examination of baseline characteristics revealed no major differences in age, sex, socioeconomic status, and lifestyle between patients with and without pre- and post-monitoring. Furthermore, the results were consistent for each individual patient group examined. Patients with no testing before or after treatment

initiation (including those with potentially haemolysed samples) only accounted for 10% of all ACEI/ARB initiators.

**Comparison with other studies**

To our knowledge, this is the largest study conducted to date on adherence to monitoring and discontinuation guidelines after ACEI/ARB initiation. Only one previous study[20] examined monitoring according to guideline-recommended intervals (<14 days). All others have used longer intervals (*e.g.*, 30 days[27] or 6 months[28 29]), which make interpretations and implications for clinical practice less clear. Poor adherence to monitoring guidelines after ACEI/ARB initiation is not restricted to the UK,[20 29 30] but has also been reported in the US[31-33], Canada,[34] and the Netherlands.[27 35] Owing to our sample size, we were able to show that the lack of monitoring occurred in all patient groups with an indication for ACEI/ARB therapy.

A recent Dutch study, including 3,353 patients initiating ACEI/ARBs between 2005-2011, found that 19% had creatinine measured within 30 days and 66% within one year.[27] Creatinine increases above 30% occurred in 1.6% of patients, and among these 70% did not discontinue treatment.[27] A Scottish study of 4,056 patients with type 2 diabetes, prescribed an ACEI/ARB between 2005-2009, found that 19% had both a baseline (within 90 days) and follow-up measurement (within 2 weeks) of initiation. Within this cohort, 1.7% had both a creatinine increase of ≥30% and potassium level ≥5.6 mmol/L.

The magnitude of the risk of severe renal impairment, as measured by creatinine increase in these observational studies, was consistent with our findings, but substantially higher than reported in clinical trials (*e.g.*, 0.2% in the ONTARGET trial).[36] It is not clear from the literature how often harm occurs around the time of initiation, when the risk of nephrotoxicity is thought to be greatest.[8] If physicians are to understand why follow-up monitoring within 2 weeks of treatment start matters, the short-term risks need to be clarified.

Until now, most studies have reported only on cumulative risk over entire courses of treatment, such as the 1.1% two-year risk for potassium of >6 mmol/L in the SOLVD trials of heart failure patients.[37] In contrast to clinical trial reviews, reporting a 0.2% (3/1818) risk of potassium >6 mmol/L, we found a 0.4% risk of hyperkalaemia already at time of first retesting after ACEI initiation.

Extending the previous literature, our results support that advanced age, advanced CKD, and heart failure, but not sex, increase the likelihood of being monitored.[20 27 31] Consistent with some,[27 31] but not all, previous studies,[29] we found no association for diabetes. However, these previous studies reporting an association for diabetes focused on monitoring within broader intervals (*e.g.*, 6 months),[29] where diabetes patients, irrespective of ACEI/ARB initiation, were likely to receive blood testing owing to the diabetes QOF programme.

Determinants of increases in creatinine levels after ACEI/ARB initiation are less well understood than for hyperkalemia, but increasing age is a consistently reported factor.[20] Advanced CKD and a range of cardiovascular comorbidities (mostly associated with atherosclerosis) were also important determinants in our patient cohort. Consistent with previous studies, we found that the risk of hyperkalemia risk associated with CKD (likely due to impaired ability of the cortical collecting tubule to secrete potassium), heart failure (likely due to decreased delivery of sodium to the distal nephron), and high pre-treatment potassium levels.[6 8 20 38] We did not observe an association with diabetes or increasing age, as could have been expected due to diabetic nephropathy or age-dependent hyporeninemic hypoaldosteronism.[6]

**Clinical relevance**

Several possible explanations exist for the divergence between the clinical guideline recommendations and the observed monitoring and response patterns in clinical practice. The

first is *clinician nonadherence* to ordering tests. This may be due to inconsistent recommendations for timing and frequency of monitoring over time,[6] consensus-based (rather than evidence-based) monitoring guidelines, and a lack of guidelines tailored to particular high-risk patients, such as those with CKD and heart failure. Although we found that follow-up monitoring correlated well with the risk of renal impairment after ACEI/ARB initiation for most patient groups, it was not observed for patients with myocardial infarction or pre-initiation high potassium. The second explanation may be *patient nonadherence* to ordered tests. This is particularly salient in UK primary care where blood samples may be taken in phlebotomy clinics that the patient has to visit rather than the GP practice. Patients may find it burdensome to have blood tests, and GPs have no direct economic incentives to ensure that they are done. A third barrier is *lack of evidence of the clinical importance* of monitoring and its cost-effectiveness. ACEI/ARB-induced renal impairment is rare in clinical trials, even among patients with multiple risk factors for atherosclerotic renal artery stenosis.[8 39] Trial results may therefore have led to a general perception that the rarity of renal impairment obviates the need for close monitoring. However, as observed in our data, the risks in real world practice may be somewhat higher and non-negligible. In addition, previous research has shown that potassium monitoring in high-risk patients with CKD and diabetes may reduce serious hyperkalaemia-associated adverse events.[40] Still, the extent to which an initial creatinine increase ≥30% translates into adverse long-term outcomes in real-world patients remains to be clarified in future studies.

**Generalisability, implications, and conclusions**

The majority of patients initiating treatment with ACEI/ARBs experience only minor changes in renal function. However, substantial increases in creatinine levels after ACEI/ARB initiation may not be as rare as previously suggested, reinforcing the need for adherence to clinical guidelines for both pre- and post-initiating monitoring. Moreover, the post-initiation

creatinine increase and potassium levels used in this study are widely recognised cut-off levels, making the results internationally applicable. The comparison with the previous literature also confirms that the lack of systematic monitoring is not exclusive to the UK. Of particular concern was that even when appropriate monitoring was performed, severe renal impairment only rarely led to treatment discontinuation. Individual patient counselling may also be helpful to ensure that those at highest risk are closely monitored. More work is needed to determine the prognostic importance of the changes in renal function that we have observed.

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**Transparency declaration**: The lead author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

**Contributorship**

LT conceived the study idea and acquired data permissions. MS, KM, and LT designed the study. MS and KM performed data management and established the cohort. MS, KM, and LT reviewed the literature. The analyses were carried out by MS. All authors participated in the discussion and interpretation of the results. MS organised the writing and wrote the initial drafts. All authors critically revised the manuscript for intellectual content and approved the final version. MS is the guarantor.

**Data sharing**: No additional data are available.

**Disclosures:** None

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**Table 1.** Characteristics of patients initiating angiotensin converting-enzyme inhibitors or angiotensin-receptor blockers in the UK primary care during 2004-2014, by monitoring groups

| | Serum creatinine monitoring* | | | | Total |
|---|---|---|---|---|---|
| | No baseline or follow-up tests | Baseline test only | Follow-up test only | Baseline and follow-up test | |
| **Total number** | 21,411 (100) | 63,359 (100) | 33,185 (100) | 105,859 (100) | 223,814 (100) |
| **Female sex** | 8,882 (41) | 27,722 (44) | 14,570 (44) | 49,109 (46) | 100,283 (45) |
| **Age (years)** | | | | | |
| <50 years | 5,019 (23) | 13,697 (22) | 8,732 (26) | 19,910 (19) | 47,358 (21) |
| 50-59 years | 5,485 (26) | 15,135 (24) | 9,115 (27) | 24,866 (23) | 54,601 (24) |
| 60-69 years | 4,863 (23) | 15,586 (25) | 7,776 (23) | 27,790 (26) | 56,015 (25) |
| 70-79 years | 3,579 (17) | 12,193 (19) | 5,066 (15) | 22,152 (21) | 42,990 (19) |
| 80+ years | 2,465 (12) | 6,748 (11) | 2,496 (8) | 11,141 (11) | 22,850 (10) |
| **Calendar period** | | | | | |
| 2004-2008 | 14,814 (69) | 40,667 (64) | 19,808 (60) | 60,902 (58) | 136,191 (61) |
| 2009-2014 | 6,597 (31) | 22,692 (36) | 13,377 (40) | 44,957 (42) | 87,623 (39) |
| **SES quintiles** | | | | | |
| 1 (low) | 5,153 (24) | 15,290 (24) | 8,533 (26) | 25,577 (24) | 54,553 (24) |
| 2 | 4,725 (22) | 14,331 (23) | 7,887 (24) | 24,851 (23) | 51,794 (23) |
| 3 | 4,341 (20) | 13,028 (21) | 6,890 (21) | 22,629 (21) | 46,888 (21) |
| 4 | 4,254 (20) | 12,140 (19) | 5,931 (18) | 19,318 (18) | 41,643 (19) |
| 5 (high) | 2,925 (14) | 8,508 (13) | 3,898 (12) | 13,359 (13) | 28,690 (13) |
| *Missing* | 13 (0) | 62 (0) | 46 (0) | 125 (0) | 246 (0) |
| **Smoking status** | | | | | |
| Never | 7,860 (37) | 22,496 (36) | 12,229 (37) | 36,895 (35) | 79,480 (36) |
| Ever | 13,433 (63) | 40,797 (64) | 20,915 (63) | 68,939 (65) | 144,084 (64) |
| *Missing* | 118 (1) | 66 (0) | 41 (0) | 25 (0) | 250 (0) |
| **Alcohol intake** | | | | | |
| No use | 2,556 (12) | 7,819 (12) | 3,409 (10) | 11,088 (10) | 24,872 (11) |
| Current | 15,495 (72) | 47,322 (75) | 25,656 (77) | 82,870 (78) | 171,343 (77) |
| Former | 1,328 (6) | 4,499 (7) | 1,933 (6) | 7,490 (7) | 15,250 (7) |
| *Missing* | 2,032 (9) | 3,719 (6) | 2,187 (7) | 4,411 (4) | 12,349 (6) |
| **BMI groups** | | | | | |
| Underweight | 282 (1) | 700 (1) | 304 (1) | 1,008 (1) | 2,294 (1) |
| Healthy weight | 5,666 (26) | 15,406 (24) | 8,089 (24) | 24,972 (24) | 54,133 (24) |
| Overweight | 7,677 (36) | 23,755 (37) | 12,484 (38) | 40,556 (38) | 84,472 (38) |
| Obesity | 6,009 (28) | 20,660 (33) | 10,527 (32) | 35,887 (34) | 73,083 (33) |
| *Missing* | 1,777 (8) | 2,838 (4) | 1,781 (5) | 3,436 (3) | 9,832 (4) |
| **CKD (eGFR)†** | | | | | |
| Stage ≤2 (≥60) | 10,326 (48) | 53,773 (85) | 19,470 (59) | 87,484 (83) | 171,053 (76) |
| Stage 3a (45–59) | 1,137 (5) | 7,382 (12) | 1,766 (5) | 13,913 (13) | 24,198 (11) |
| Stage 3b (30–44) | 217 (1) | 1,885 (3) | 265 (1) | 3,854 (4) | 6,221 (3) |
| Stage 4 (15–29) | 24 (0) | 319 (1) | 29 (0) | 608 (1) | 980 (0) |
| *Not measured* | 9,707 (45) | 0 (0) | 11,655 (35) | 0 (0) | 21,362 (10) |
| **CV comorbidities‡** | | | | | |
| Heart failure | 1,568 (7) | 3,270 (5) | 1,386 (4) | 4,583 (4) | 10,807 (5) |
| Myocardial infarction | 3,881 (18) | 4,653 (7) | 3,203 (10) | 4,620 (4) | 16,357 (7) |
| Hypertension | 13,023 (61) | 44,273 (70) | 24,195 (73) | 80,946 (76) | 162,437 (73) |
| Peripheral arterial disease | 471 (2) | 1,590 (3) | 523 (2) | 2,547 (2) | 5,131 (2) |
| Arrhythmia | 2,057 (10) | 4,973 (8) | 2,000 (6) | 7,123 (7) | 16,153 (7) |
| **Diabetes mellitus** | 1,399 (7) | 13,586 (21) | 1,992 (6) | 21,548 (20) | 38,525 (17) |

**Abbreviations**: CV, cardiovascular; CKD, chronic kidney disease; y, year
*Monitoring groups based on baseline (within 12 months before) and follow-up (within 2 months after) serum creatinine monitoring.
†Calculated from most recent creatinine measurement within 12 months before first prescription date.
‡Diagnosis ever registered before ACE/ARB initiation in CRPD or HES.

**Table 2.** Prevalence of baseline and follow-up serum creatinine monitoring among patients initiating angiotensin converting-enzyme inhibitors or angiotensin-receptor blockers, 2004-2014

| | S-Creatinine, ≥1 test |
|---|---|
| **Total number** | n=223,814 (100%) |
| **Baseline testing** | |
| ≤12 months before | 169,218 (76%) |
| ≤3 months before | 115,348 (52%) |
| ≤1 months before | 75,476 (34%) |
| **Follow-up testing** | |
| ≤2 weeks after | 65,090 (29%) |
| ≤1 month after | 114,244 (51%) |
| ≤2 months after | 139,044 (62%) |

**Table 3.** Prevalence of baseline and follow-up serum creatinine monitoring among patients initiating renin-angiotensin system blockade according to clinical guideline recommendations

| | Clinical guidelines | | | | | All initiators n=223,814 (100%) | |
|---|---|---|---|---|---|---|---|
| | NICE Heart Failure | NICE MI | NICE/UKRA Hypertension | NICE CKD | GP Notebook | Wide baseline interval (≤12 month) | Ideal baseline interval (≤1 month) |
| Baseline testing | x | x | x | x | x | 169,218 (76%) | 75,476 (34%) |
| + Follow-up test ≤2 weeks* | x | n/a | x | x | x | 46,486 (21%) | 19,679 (9%) |
| + Follow-up test ≤3 weeks† | | | | | | 70,792 (32%) | 30,451 (14%) |

Abbreviations: CKD, chronic kidney disease; GP, General Practice; MI, myocardial infarction; n/a, not specified; UKRA, UK Renal Association

*Follow-up test among those with baseline measurements

† Sensitivity analysis illustrating the importance of 2 vs. 3-week cut-off interval in follow-up test intervals.

**Table 4.** Proportion of new users of angiotensin converting-enzyme inhibitors or angiotensin-receptor blockers who continue or discontinue treatment according to guideline recommended cut-off levels of serum creatinine and potassium at follow-up testing*

| | Continuation† | Discontinuation† | Total |
|---|---|---|---|
| Total number, % | 42,942 (93.1) | 3,178 (6.9) | 46,120 (100) |
| Serum creatinine increase ≥30%, n (%) | 462 (81.5) | 105 (18.5) | 567 (100) |
| Serum potassium >6 mmol/L, n (%) | 150 (78.5) | 41 (21.5) | 191 (100) |

*Calculated from the most recent measurements within 1 month before and 2 months after drug initiation.

† A patient was considered continuous users when the end date of the first continuous course of therapy was larger than the date of the first follow-up monitoring + 30 days (to allow for stock piling and irregular use)

**Table 5.** Association between patient characteristics and serum creatinine increase ≥30% and follow-up monitoring within 2 weeks following initiation of renin-angiotensin system blockade

| | Odds ratio (95% confidence intervals) | | | | | |
|---|---|---|---|---|---|---|
| **Characteristics** | **S-creatinine monitoring within 2 weeks** | | **S-creatinine increase ≥30%*** | | **S-potassium increase ≥30%*** | |
| | Age- and sex adjusted | Fully adjusted† | Age- and sex adjusted | Fully adjusted† | Age- and sex adjusted | Fully adjusted† |
| **Female sex** | 1.07 (1.04-1.10) | 1.07 (1.04-1.09) | 1.39 (1.26-1.53) | 1.63 (1.47-1.80) | 0.87 (0.66-1.16) | 0.94 (0.70-1.26) |
| **Age (years)** | | | | | | |
| < 50 years | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) |
| 50-59 years | 0.98 (0.94-1.01) | 0.98 (0.95-1.02) | 0.88 (0.74-1.05) | 0.86 (0.72-1.03) | 1.29 (0.79-2.11) | 1.10 (0.67-1.81) |
| 60-69 years | 1.05 (1.02-1.09) | 1.05 (1.01-1.09) | 1.03 (0.88-1.21) | 1.00 (0.85-1.19) | 1.35 (0.84-2.17) | 0.97 (0.60-1.58) |
| 70-79 years | 1.18 (1.14-1.23) | 1.18 (1.13-1.23) | 1.49 (1.27-1.74) | 1.36 (1.15-1.61) | 1.65 (1.02-2.66) | 0.74 (0.43-1.26) |
| 80+ years | 1.20 (1.14-1.25) | 1.17 (1.11-1.23) | 2.72 (2.32-3.20) | 2.02 (1.68-2.44) | 2.75 (1.67-4.53) | 0.73 (0.41-1.32) |
| **CKD stage** | | | | | | |
| No CKD (≥60) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) |
| Stage 3a (45–59) | 1.00 (0.96-1.04) | 1.00 (0.96-1.04) | 0.62 (0.53-0.73) | 0.60 (0.51-0.70) | 2.48 (1.66-3.71) | 2.06 (1.36-3.11) |
| Stage 3b (30–44) | 0.99 (0.93-1.06) | 1.01 (0.94-1.08) | 1.01 (0.82-1.24) | 0.88 (0.71-1.09) | 7.51 (4.75-11.9) | 5.10 (3.16-8.22) |
| Stage 4 (15–29) | 1.42 (1.21-1.67) | 1.41 (1.20-1.66) | 2.16 (1.52-3.05) | 1.72 (1.18-2.51) | 24.0 (13.5-42.6) | 11.4 (6.07-21.4) |
| **Comorbidities*** | | | | | | |
| Heart failure | 1.15 (1.09-1.23) | 1.16 (1.08-1.23) | 4.00 (3.49-4.58) | 2.93 (2.51-3.42) | 2.90 (1.90-4.42) | 2.22 (1.38-3.58) |
| MI | 0.80 (0.75-0.85) | 0.77 (0.72-0.82) | 2.33 (1.98-2.74) | 1.57 (1.32-1.87) | 2.12 (1.33-3.39) | 1.35 (0.80-2.25) |
| Hypertension | 1.00 (0.97-1.02) | 1.05 (1.00-1.11) | 0.62 (0.56-0.68) | 1.58 (1.36-1.84) | 0.60 (0.45-0.80) | 1.02 (0.63-1.65) |
| PAD | 1.09 (1.01-1.18) | 1.11 (1.02-1.20) | 2.10 (1.70-2.60) | 1.87 (1.50-2.33) | 2.14 (1.18-3.86) | 1.53 (0.82-2.88) |
| Arrhythmia | 1.09 (1.03-1.14) | 0.98 (0.95-1.01) | 2.37 (2.07-2.71) | 0.77 (0.69-0.86) | 1.41 (0.90-2.21) | 0.77 (0.56-1.05) |
| Diabetes mellitus | 0.93 (0.90-0.96) | 0.93 (0.90-0.96) | 1.09 (0.97-1.22) | 1.04 (0.92-1.18) | 0.97 (0.69-1.36) | 0.90 (0.63-1.29) |
| **Baseline K>5 mmol/L** | 1.04 (1.00-1.10) | 1.04 (0.99-1.09) | 1.04 (0.86-1.25) | 0.97 (0.80-1.17) | 8.22 (6.14-11.0) | 6.68 (4.94-9.02) |

**Abbreviations:** CKD, chronic kidney disease; MI, myocardial infarction; PAD, peripheral arterial disease

* The increase was based on the difference between the most recent baseline measurements within 12 months before and first follow-up measurement within 2 months after drug initiation. All analyses were restricted to those with both baseline and follow-up measurements (n=105,859).

† Adjusted for sex, age, CKD, heart failure, MI, hypertension, PAD, arrhytmia, diabetes, and calendar period of prescription start

# ONLINE SUPPLEMENTAL MATERIAL

**eTable 1.** Prevalence of baseline and follow-up serum creatinine monitoring among patients initiating renin-angiotensin system blockade according to clinical guideline recommendations, overall and in most recent calendar period (extended version of Table 3)

| | Clinical guidelines | | | | | | All initiators | | Continuing users* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | NICE Heart Failure | NICE CKD | NICE Hypertension | NICE MI | UK Renal Association | GP Notebook | Generous baseline interpretation (≤12 month) | Strict baseline interpretation (≤1 month) | Generous baseline interpretation (≤12 month) | Strict baseline interpretation (≤1 month) |
| **2004-2014** | | | | | | | n=223,814 (100%) | | n=173,244 (100%) | |
| **Baseline testing** | x | x | x | x | x | x | 169,218 (76%) | 75,476 (34%) | 132,156 (76%) | 58,668 (34%) |
| **Follow-up test (≤2 weeks)†** | x | x | n/a | x | x | x | 46,486 (21%) | 19,679 (9%) | 43,420 (25%) | 18,457 (11%) |
| + At least within one year after | | | | x | | | 36,424 (16%) | 15,642 (7%) | 34,336 (20%) | 14,800 (9%) |
| + 1 month thereafter‡ | | | | | | x | 11,866 (5%) | 5,643 (3%) | 11,298 (7%) | 5,388 (3%) |
| + 1 and 3 months thereafter ‡ | | | | | | x | 5,787 (3%) | 2,933 (1%) | 5,516 (3%) | 2,791 (2%) |
| + 1, 3, and 6 months thereafter ‡ | | | | | | x | 3,390 (2%) | 1,807 (1%) | 3,201 (2%) | 1,703 (1%) |
| + 1, 3, 6, and 12 months thereafter‡ | | | | | | x | 2,618 (1%) | 1,439 (1%) | 2,464 (1%) | 1,353 (1%) |
| **Follow-up test (≤3 weeks)§** | | | | | | | 70,792 (32%) | 30,451 (14%) | 66,340 (38%) | 28,644 (17%) |
| **2009-2014** | | | | | | | n=87,623 (100%) | | n=68,042 (100%) | |
| **Baseline testing** | x | x | x | x | x | x | 67,649 (77%) | 30,576 (35%) | 52,760 (78%) | 23,716 (35%) |
| **Follow-up test (≤2 weeks)†** | x | x | n/a | x | x | x | 20,172 (23%) | 8,707 (10%) | 18,862 (28%) | 8,169 (12%) |
| + At least within one year after | | | | x | | | 15,416 (18%) | 6,726 (8%) | 14,557 (21%) | 6,377 (9%) |
| + 1 month thereafter‡ | | | | | | x | 5,373 (6%) | 2,607 (3%) | 5,123 (8%) | 2,500 (4%) |
| + 1 and 3 months thereafter ‡ | | | | | | x | 2,614 (3%) | 1,365 (2%) | 2,492 (4%) | 1,302 (2%) |
| + 1, 3, and 6 months thereafter ‡ | | | | | | x | 1,525 (2%) | 841 (1%) | 1,437 (2%) | 792 (1%) |
| + 1, 3, 6, and 12 months thereafter‡ | | | | | | x | 1,152 (1%) | 650 (1%) | 1,079 (2%) | 606 (1%) |
| **Follow-up test (≤3 weeks)§** | | | | | | | 31,007 (35%) | 13,511 (15%) | 29,081 (43%) | 12,726 (19%) |

Abbreviations: CKD, chronic kidney disease; GP, General Practice; MI, myocardial infarction; n/a, not specified

* A patient was considered continuous users when the end date of the first continuous course of therapy was larger than the date of the first follow-up monitoring + 30 days (to allow for stock piling and irregular use)

†Follow-up test among those with baseline measurements

‡Within additional 1, 3, 6, and 12 months after correspond to within 1.5, 3.5, 6.5, and 12.5 months after ACE/ARB initiation, respectively.

§Sensitivity analysis illustrating the importance of 2 vs. 3 week cut-off interval in follow-up test intervals.

**eTable 2.** Prevalence of baseline and follow-up serum creatinine monitoring among patients initiating angiotensin converting-enzyme inhibitors or angiotensin-receptor blockers, overall and most recent calendar period (extended version of Table 1)

| | S-Creatinine, ≥1 test, n (%) | |
|---|---|---|
| | Total cohort (n=223,814) | 2009-2014 cohort (n=87,623) |
| **Baseline testing** | | |
| ≤12 months before | 169,218 (75.6) | 67,649 (77.2) |
| ≤3 months before | 115,348 (51.5) | 46,925 (53.6) |
| ≤1 months before | 75,476 (33.7) | 30,576 (34.9) |
| **Follow-up testing** | | |
| ≤2 weeks after | 65,090 (29.1) | 27,933 (31.9) |
| ≤1 month after | 114,244 (51.0) | 48,877 (55.8) |
| ≤2 months after | 139,044 (62.1) | 58,334 (66.6) |

**eTable 3.** Prevalence of baseline and follow-up serum creatinine monitoring among patients initiating renin-angiotensin system blockade according to clinical guideline recommendations

| | **All initiators n=223,814 (100%)** | |
|---|---|---|
| | **Generous baseline interpretation** (≤12 month) | **Strict baseline interpretation** (≤1 month) |
| **Overall (n=223,814)** | | |
| Baseline testing | 169,218 (76%) | 75,476 (34%) |
| + Follow-up test ≤2 weeks* | 46,486 (21%) | 19,679 (9%) |
| + Follow-up test ≤3 weeks† | 70,792 (32%) | 30,451 (14%) |
| **Overall, no recent hospitalization (n=197,291)** | | |
| Baseline testing | 153,353 (78%) | 68,883 (35%) |
| + Follow-up test ≤2 weeks* | 42,967 (22%) | 18,222 (9%) |
| + Follow-up test ≤3 weeks† | 65,881 (33%) | 28,375 (14%) |
| **Heart failure patients (n=10,807)** | | |
| Baseline testing | 7,853 (73%) | 3,277 (30%) |
| + Follow-up test ≤2 weeks* | 2,229 (21%) | 951 (9%) |
| + Follow-up test ≤3 weeks† | 3,085 (29%) | 1,340 (12%) |
| **Myocardial infarction patients (n=16,357)** | | |
| Baseline testing | 9,273 (57%) | 3,766 (23%) |
| + Follow-up test ≤2 weeks* | 1,816 (11%) | 726 (4%) |
| + Follow-up test ≤3 weeks† | 2,645 (16%) | 1,078 (7%) |
| **Hypertension patients (n=162,437)** | | |
| Baseline testing | 125,219 (77%) | 54,174 (33%) |
| + Follow-up test ≤2 weeks* | 35,502 (22%) | 14,559 (9%) |
| + Follow-up test ≤3 weeks† | 54,585 (34%) | 22,710 (14%) |
| **CKD patients (n=31,399)** | | |
| Baseline testing | 27,961 (89%) | 13,913 (44%) |
| + Follow-up test ≤2 weeks* | 8,457 (27%) | 4,198 (13%) |
| + Follow-up test ≤3 weeks† | 12,482 (40%) | 6,324 (20%) |
| **PAD patients (n=5,131)** | | |
| Baseline testing | 4,137 (81%) | 1,671 (33%) |
| + Follow-up test ≤2 weeks* | 1,198 (23%) | 458 (9%) |
| + Follow-up test ≤3 weeks† | 1,751 (34%) | 698 (14%) |
| **Diabetes patients (n=38,525)** | | |
| Baseline testing | 35,134 (91%) | 15,907 (41%) |
| + Follow-up test ≤2 weeks* | 9,161 (24%) | 3,794 (10%) |
| + Follow-up test ≤3 weeks† | 14,093 (37%) | 5,994 (16%) |

Abbreviations: CKD, chronic kidney disease; GP, General Practice; MI, myocardial infarction; n/a, not specified; UKRA, UK Renal Association

*Follow-up test among those with baseline measurements

† Sensitivity analysis illustrating the importance of 2 vs. 3-week cut-off interval in follow-up test intervals.

**eTable 4.** Proportion of new users of ACEI/ARB who continue or discontinue treatment according to guideline recommended cut-off levels of serum creatinine and potassium at follow-up testing

| | Wide monitoring interval (12 month before to the first monitoring within 2 month after) | | | Narrow monitoring interval (1 month before to the first monitoring within 2 month after) | | |
|---|---|---|---|---|---|---|
| | Continuation* | Discontinuation* | Total | Continuation* | Discontinuation* | Total |
| **+ 30 day window** | | | | | | |
| Total number, % | 113,210 (92.5) | 9,170 (7.5) | 122,380 (100) | 48,772 (93.0) | 3,676 (7.0) | 52,448 (100) |
| S-creatinine increase ≥30%, n (%) | 1,679 (80.7) | 401 (19.3) | 2,080 (100) | 541 (81.5) | 123 (18.5) | 664 (100) |
| S-potassium >6 mmol/L, n (%) | 472 (81.9) | 104 (18.1) | 576 (100) | 204 (80.6) | 49 (19.4) | 253 (100) |
| **+ 90 day window** | | | | | | |
| Total number, % | 86,620 (81.8) | 19,239 (18.2) | 105,859 (100) | 37,920 (82.2) | 8,200 (17.8) | 46,120 (100) |
| S-creatinine increase ≥30%, n (%) | 1,111 (64.7) | 605 (35.3) | 1,716 (100) | 372 (65.6) | 195 (34.4) | 567 (100) |
| S-potassium >6 mmol/L, n (%) | 261 (61.0) | 167 (39.0) | 428 (100) | 110 (57.6) | 81 (42.4) | 191 (100) |

Calculated from the measurements closest to the first prescription date in the corresponding intervals, i.e., the most recent baseline measurements and the first follow-up measurement.

* A patient was considered continuous users when the end date of the first continuous course of therapy was larger than the date of the first follow-up monitoring + 30 days or + 90days (to allow for stock piling and irregular use)

**eTable 5.** Association between patient characteristics and serum creatinine increase ≥30% and follow-up monitoring within 2 weeks following initiation of renin-angiotensin system blockade

| | Adjusted odds ratio (95% confidence intervals) | | | | | |
|---|---|---|---|---|---|---|
| | Additional adjustment for ethnicity† | | | Excluding patient with hospitalisation within 30 days† | | |
| **Characteristics** | **S-creatinine monitoring within 2 weeks** | **S-creatinine increase ≥30%*** | **S-potassium >6 mmol/L*** | **S-creatinine monitoring within 2 weeks** | **S-creatinine increase ≥30%*** | **S-potassium >6 mmol/L*** |
| **Female sex** | 1.04 (1.01-1.08) | 1.91 (1.64-2.23) | 1.09 (0.70-1.71) | 1.06 (1.04-1.09) | 1.66 (1.48-1.86) | 0.94 (0.69-1.27) |
| **Age (years)** | | | | | | |
| < 50 years | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) |
| 50-59 years | 0.97 (0.92-1.02) | 0.91 (0.71-1.16) | 1.65 (0.77-3.52) | 0.99 (0.95-1.03) | 0.86 (0.71-1.05) | 1.17 (0.70-1.98) |
| 60-69 years | 1.04 (0.99-1.10) | 0.86 (0.68-1.10) | 1.23 (0.57-2.65) | 1.07 (1.02-1.11) | 1.05 (0.87-1.26) | 0.98 (0.58-1.64) |
| 70-79 years | 1.22 (1.15-1.30) | 1.22 (0.96-1.55) | 0.83 (0.36-1.95) | 1.19 (1.14-1.24) | 1.40 (1.16-1.68) | 0.72 (0.41-1.27) |
| 80+ years | 1.15 (1.06-1.24) | 1.61 (1.21-2.14) | 0.58 (0.21-1.58) | 1.17 (1.11-1.24) | 2.16 (1.76-2.66) | 0.71 (0.38-1.33) |
| **CKD stage** | | | | | | |
| No CKD (≥60) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) |
| Stage 3a (45–59) | 1.00 (0.94-1.06) | 0.51 (0.39-0.66) | 1.82 (0.93-3.55) | 1.00 (0.96-1.04) | 0.58 (0.49-0.70) | 2.40 (1.57-3.68) |
| Stage 3b (30–44) | 1.06 (0.95-1.17) | 0.99 (0.71-1.39) | 5.66 (2.70-11.9) | 0.98 (0.92-1.06) | 0.92 (0.73-1.17) | 5.15 (3.09-8.58) |
| Stage 4 (15–29) | 1.51 (1.17-1.94) | 1.65 (0.87-3.12) | 15.0 (5.84-38.8) | 1.42 (1.20-1.70) | 1.86 (1.23-2.81) | 12.2 (6.29-23.7) |
| **Comorbidities*** | | | | | | |
| Heart failure | 1.10 (0.99-1.21) | 3.07 (2.41-3.91) | 2.16 (0.96-4.85) | 1.15 (1.06-1.24) | 2.57 (2.11-3.13) | 2.68 (1.59-4.51) |
| MI | 0.78 (0.72-0.86) | 1.76 (1.35-2.30) | 1.10 (0.46-2.63) | 0.89 (0.82-0.97) | 1.59 (1.23-2.06) | 1.89 (1.05-3.41) |
| Hypertension | 0.97 (0.90-1.05) | 1.51 (1.19-1.92) | 1.01 (0.44-2.30) | 1.04 (0.99-1.11) | 1.40 (1.16-1.68) | 0.81 (0.46-1.42) |
| PAD | 1.09 (0.96-1.23) | 1.63 (1.13-2.35) | 1.52 (0.54-4.29) | 1.16 (1.06-1.26) | 1.74 (1.34-2.27) | 1.75 (0.92-3.32) |
| Arrhythmia | 0.96 (0.92-1.01) | 0.84 (0.71-0.99) | 0.72 (0.44-1.17) | 0.98 (0.94-1.01) | 0.80 (0.71-0.91) | 0.74 (0.53-1.03) |
| Diabetes mellitus | 0.91 (0.87-0.96) | 1.15 (0.96-1.37) | 0.58 (0.31-1.09) | 0.93 (0.90-0.96) | 1.06 (0.93-1.22) | 0.93 (0.64-1.35) |
| **Baseline K>6 mmol/L** | 1.05 (0.98-1.13) | 0.86 (0.63-1.15) | 7.98 (5.06-12.6) | 1.03 (0.98-1.08) | 1.01 (0.82-1.24) | 6.44 (4.69-8.84) |

**Abbreviations**: CKD, chronic kidney disease; MI, myocardial infarction; PAD, peripheral arterial disease

* The increase was based on the difference between the most recent baseline measurements within 12 months before and first follow-up measurement within 2 months after drug initiation. All analyses were restricted to those with both baseline and follow-up measurements (n=105,859).

† The main model was adjusted for sex, age, CKD, heart failure, MI, hypertension, PAD, arrhytmia, diabetes, and calendar period of prescription start

**The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.**

| | Item No. | STROBE items | Location in manuscript where items are reported | RECORD items | Location in manuscript where items are reported |
|---|---|---|---|---|---|
| **Title and abstract** | | | | | |
| | 1 | (a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found | a) 3, 6<br>b) 3 | RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included.<br><br>RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract.<br><br>RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract. | 1.1 3, 5<br>1.2 3<br>1.3 3 |
| **Introduction** | | | | | |
| Background rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 5 | | |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 5 | | |
| **Methods** | | | | | |
| Study Design | 4 | Present key elements of study design early in the paper | 5 | | |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 5-6 | | |
| Participants | 6 | *(a) Cohort study* - Give the eligibility criteria, and the | a) 5-6 | RECORD 6.1: The methods of study population selection (such as codes or | 6.1) 5-6<br>6.2) 5-6, 13-14 |

| | | | | | |
|---|---|---|---|---|---|
| | | sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study* - Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study* - Give the eligibility criteria, and the sources and methods of selection of participants<br><br>*(b) Cohort study* - For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study* - For matched studies, give matching criteria and the number of controls per case | | algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided.<br><br>RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided.<br><br>RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage. | 6.3) Not needed |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable. | 5-7 | RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided. | 7 |
| Data sources/ measurement | 8 | For each variable of interest, give sources of data and details of methods of assessment (measurement).<br>Describe comparability of assessment methods if there is more than one group | 5-7 | | |
| Bias | 9 | Describe any efforts to address potential sources of bias | 8-9 | | |
| Study size | 10 | Explain how the study size was | 6-7 | | |

| | | | | | |
|---|---|---|---|---|---|
| | | arrived at | | | |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why | 5-9 | | |
| Statistical methods | 12 | (a) Describe all statistical methods, including those used to control for confounding<br>(b) Describe any methods used to examine subgroups and interactions<br>(c) Explain how missing data were addressed<br>(d) *Cohort study* - If applicable, explain how loss to follow-up was addressed<br>*Case-control study* - If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study* - If applicable, describe analytical methods taking account of sampling strategy<br>(e) Describe any sensitivity analyses | 8-9 | | |
| Data access and cleaning methods | | .. | | RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population.<br><br>RECORD 12.2: Authors should provide information on the data cleaning methods used in the study. | 12.1) 5-6<br>12.2) 5-6 |
| Linkage | | .. | | RECORD 12.3: State whether the study included person-level, institutional- | 12.3) 5-6 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided. | |
| **Results** | | | | | |
| Participants | 13 | (a) Report the numbers of individuals at each stage of the study (*e.g.*, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed)<br>(b) Give reasons for non-participation at each stage.<br>(c) Consider use of a flow diagram | 5-6, 9-12 | RECORD 13.1: Describe in detail the selection of the persons included in the study (*i.e.,* study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram. | 13.1) 5-6, 9-12 |
| Descriptive data | 14 | (a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential confounders<br>(b) Indicate the number of participants with missing data for each variable of interest<br>(c) *Cohort study* - summarise follow-up time (*e.g.*, average and total amount) | 9-12, Table 1 | | |
| Outcome data | 15 | *Cohort study* - Report numbers of outcome events or summary measures over time<br>*Case-control study* - Report numbers in each exposure category, or summary measures of exposure<br>*Cross-sectional study* - Report numbers of outcome events or summary measures | 9-12 | | |
| Main results | 16 | (a) Give unadjusted estimates | 9-12 | | |

| | | | | | |
|---|---|---|---|---|---|
| | | and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included<br>(b) Report category boundaries when continuous variables were categorized<br>(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | | | |
| Other analyses | 17 | Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses | 9-12 | | |
| **Discussion** | | | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 12 | | |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 12-14 | RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported. | 12-14 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 17 | | |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 17 | | |

| Other Information | | | | | |
|---|---|---|---|---|---|
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 2 | | |
| Accessibility of protocol, raw data, and programming code | | .. | 7, protocol made available for reviewers | RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code. | 7, protocol made available for reviewers |

*Reference: Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press.

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# Adherence to guidelines for creatinine and potassium monitoring and discontinuation following renin-angiotensin system blockade: a UK general practice-based cohort study



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| | |

# Adherence to guidelines for creatinine and potassium monitoring and discontinuation following renin-angiotensin system blockade: a UK general practice-based cohort study

**Running title:** Creatinine and potassium monitoring after ACEI/ARB initiation

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**Key words**: angiotensin-converting enzyme inhibitors; angiotensin receptor antagonists; kidney disease; mortality; myocardial infarction; prognosis

**Word count**: Abstract: 297; Text: 4091; Tables/Figures: 5; References: 40

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**Competing interests:** All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare that (1) no authors have support from any company for the submitted work. The Department of Clinical Epidemiology is involved, however, in studies with funding from various companies as research grants to (and administered by) Aarhus University. None of these studies have any relation to the present study; (2) no authors have relationships with companies that might have an interest in the submitted work in the previous 3 years; (3) their spouses, partners, or children have no financial relationships that may be relevant to the submitted work; and (4) no authors have non-financial interests that may be relevant to the submitted work.

## ABSTRACT

**Objectives** To examine adherence to serum creatinine and potassium monitoring and discontinuation guidelines following initiation of treatment with angiotensin converting-enzyme inhibitors (ACEI) or angiotensin-receptor blockers (ARB); and whether high-risk patients are monitored.

**Design** General practice-based cohort study using electronic health records from the UK Clinical Practice Research Datalink and Hospital Episode Statistics.

**Setting** UK primary care, 2004–2014.

**Subjects** 223,814 new ACEI/ARB users.

**Main outcome measures** Proportion of patients with renal function monitoring before and after ACEI/ARB initiation; creatinine increase ≥30% or potassium levels >6 mmol/L at first follow-up monitoring; and treatment discontinuation after such changes. Using logistic regression models, we also examined patient characteristics associated with these biochemical changes, and with follow-up monitoring within the guideline-recommendation of two weeks after treatment initiation.

**Results** Ten percent of patients had neither baseline nor follow-up monitoring of creatinine within 12 months before and 2 months after initiation of an ACEI/ARB, 28% had monitoring only at baseline, 15% only at follow-up, and 47% both at baseline and follow-up. The median period between the most recent baseline monitoring and drug initiation was 40 days (interquartile range: 12-125 days). 34% of patients had baseline creatinine monitoring within one month before initiating therapy, but less than 10% also had the guideline-recommended follow-up test recorded within two weeks. Among patients experiencing a creatinine increase ≥30% (n=567, 1.2%) or potassium level >6 mmol/L (n=191, 0.4%), 80% continued treatment. Although patients with prior myocardial infarction, hypertension, or baseline potassium >5 mmol/L were at high risk of ≥30% increase in creatinine after ACEI/ARB initiation, there was no evidence that they were more frequently monitored.

**Conclusions** Only one tenth of patients initiating ACEI/ARB therapy receive the guideline-recommended creatinine monitoring. Moreover, the vast majority of the patients fulfilling post-initiation discontinuation criteria for creatinine and potassium increases continue on treatment.

**Article Summary:**

- This is the largest monitoring study to date, examining both adherence to creatinine and potassium monitoring and discontinuation guidelines following initiation of angiotensin converting-enzyme inhibitors or angiotensin-receptor blockers in UK primary care, and whether patients are monitored in accordance with their individual risk profile
- Use of the UK Clinical Practice Research Datalink and Hospital Episode Statistics ensured that the study was population-based and not restricted to specific demographic, hospital, or insurance groups.
- Blood tests performed in hospital systems were not recorded in the Clinical Practice Research Datalink, but the results were consistent for patients with no recent hospital admissions
- If the recording of creatinine levels was not missing completely at random, the associations between patient characteristics and creatinine increase may have been underestimated

## INTRODUCTION

Renin angiotensin system blockade using angiotensin-converting enzyme inhibitors (ACEI) and angiotensin-receptor blockers (ARB) is a mainstay in treatment of hypertension,[1] heart failure,[2] diabetic microalbuminuria or proteinuric renal diseases,[3] and after myocardial infarction.[4] However, some patients experience a sudden decline in kidney function when initiating these drugs, presumably due to antagonism of the angiotensin II-mediated efferent arteriolar constriction or impaired kidney excretion of potassium.[5 6]

The potential impact on kidney function should be evaluated by comparing pre- and post-initiation levels of serum creatinine and potassium.[7] Discontinuation is recommended if the rise in creatinine exceeds 30% above baseline or if hyperkalaemia develops.[8] It is unclear whether these recommendations are routinely followed in clinical practice.[9]

A few studies have compared baseline and follow-up monitoring results,[9] but large studies using contemporary data with reference to current guidelines are lacking, and it is unknown whether patients' individual risk of renal impairment influence their likelihood of being monitored.[9] We therefore examined adherence to creatinine and potassium monitoring and treatment discontinuation guidelines following ACEI/ARB initiation in UK primary care, and whether patients are monitored in accordance with their individual risk profile.

## METHODS

### Data sources

We used the UK's Clinical Practice Research Datalink (CPRD) linked to hospital record data from the Hospital Episode Statistics (HES) database. The CPRD database contains primary care electronic health record data from 7% of the UK population (~15 million patient lives, with ~8 million currently under follow-up).[10] Patients included in the CPRD are largely representative of the UK population in terms of age, sex and ethnicity.[10 11] Information recorded in the database includes demographics such as sex and year of birth, the location of the general practice, medical diagnoses (based on 'Read' codes), drug prescriptions, and a

range of routine laboratory test results. HES records cover all hospital admissions for patients covered by the NHS who receive treatment either from English NHS trusts or independent providers.[10 11] Fifty-eight percent of general practices included in the CPRD have agreed to HES linkage.[10] We obtained linked data on socioeconomic status (index of multiple deprivation) based on area of residence.

**Monitoring guidelines**

Consistent with other international guidelines, the National Institute for Health and Care Excellence (NICE) recommend baseline testing of creatinine when initiating ACEI/ARB therapy in patients with hypertension,[1] heart failure,[2] myocardial infarction,[4] or chronic kidney disease (CKD).[3] The time interval for baseline testing is not further specified.[1-4] Among patients with heart failure, myocardial infarction, and chronic kidney disease, NICE recommends follow-up monitoring within 2 weeks of treatment initiation,[2-4] and for myocardial infarction patients at least annually thereafter.[4] A baseline assessment and follow-up test within 2 weeks are also recommended by the UK Renal Association,[12] as well as the frequently used online web resource General Practice (GP) Notebook.[13] GP Notebook additionally recommends monitoring 1, 3, 6, and 12 months after the first follow-up test.[13] NICE recommends not to initiate ACEI/ARBs in patients with a baseline potassium level >5 mmol/L and to discontinue therapy if potassium rises above 6 mmol/L.

**ACEI/ARB initiators**

We identified a cohort of all HES linked CPRD patients aged ≥18 years, who initiated ACEI/ARB treatment between January 1, 2004 and March 31, 2014. We did not include earlier calendar periods, as laboratory data before 2004 were incomplete due to interface problems between laboratory reporting software and GP practice software.[14] Also, creatinine testing was incentivised in 2004 with the introduction of the diabetes Quality and Outcomes

Framework (QOF) and further in 2006 with the CKD QOF.[14] To rule out any potential influence of incomplete data around 2004, we also examined the most recent 5-year calendar period separately in a sensitivity analysis. New users were defined as persons with at least one year of continuous registration in the CPRD before their first recorded ACEI/ARB prescription.

**Laboratory data**

All creatinine test results were extracted from the general practice records of the study population, using creatinine-specific codes in CPRD. Cross-reference was then made to creatinine test results identified from a broad Read code search. Any irrelevant codes were excluded. Renal function testing in the UK includes creatinine and potassium so it can be inferred that testing frequency is similar to creatinine for potassium. When we conducted analyses related to potassium levels, we repeated the procedure used to identify creatinine levels for potassium test results.

**Patient characteristics**

We obtained information for all patients on age, sex, calendar period of ACEI/ARB initiation (2004–2008 and 2010–2014), socioeconomic status (quintiles of the 2004 index of multiple deprivation scores), lifestyle factors (smoking, alcohol intake, and body mass index), baseline potassium level (≤5 or >5 mmol/L), CKD, cardiovascular comorbidities (heart failure, myocardial infarction, hypertension, peripheral arterial disease, and arrhythmia), and diabetes.[15] We used algorithms for smoking status, alcohol intake, and body mass index based on the most recent records in the CPRD before ACEI/ARB initiation.[16 17] As measures of baseline creatinine and potassium levels, we used the single most recent measurement within 12 months before the first ACEI/ARB prescription. We calculated estimated glomerular filtration rate (eGFR) level from the most recent creatinine measurement and

CKD stage from the CKD-EPI equation.[18] Cardiovascular comorbidities and diabetes were identified from both the CPRD and HES based on diagnoses recorded prior to ACEI/ARB initiation. The code lists for all variables are provided in the Appendix.

**Patient involvement**

The study included no patient involvement

**Statistical analysis**

We described ACEI/ARB users according to patient characteristics, both overall and according to creatinine monitoring status (no baseline or follow-up monitoring, baseline only, follow-up only, and both baseline and follow-up monitoring). Baseline monitoring was defined as a test performed on the date of drug initiation or within either 12 months before (generous interval) or one month before initiation (more ideal interval assumed to be driven by planned ACEI/ARB initiation). To accord with the post-initiation monitoring interval recommended from previous trial data, we considered only follow-up monitoring within the first 2 months after drug initiation.[8]

We calculated the proportion of persons in the total cohort of new users who had baseline and follow-up monitoring (within 1, 3, and 12 months before drug initiation and within 2 weeks, 1 month, and 2 months after initiation). We then computed the proportion of persons with both baseline and initial follow-up monitoring within the guideline-recommended interval of 2 weeks following drug commencement.

We repeated the analyses for continuing users, in order to examine adherence to the stricter guideline recommendations for ongoing monitoring (*i.e.*, monitoring within 1, 3, 6, and 12 months after the first retest).[13] Continuation was defined as ACEI/ARB use beyond 30 days following the monitoring date, *i.e.*, when the end date of the first continuous course of therapy was after the date of the first monitoring date plus 30 days (to allow for stockpiling).

The end date of each prescription was calculated by adding the prescription duration (total number of tablets prescribed divided by the specified number of tablets per day) to the prescription date. In identifying continuous courses of therapy, we allowed for a 30-day gap between the end date of one prescription and the start of the next consecutive prescription.

In sensitivity analyses, we repeated the analyses (1) extending the follow-up window for the first follow-up monitoring from two to three weeks to account for minor delays; (2) including only the most recent calendar period (2009-2014) to account for temporal changes in data completeness and quality of care; (3) excluding patients with a hospital admission or discharge date within 1 month before or after their first ACEI/ARB prescription, in order to account for drug initiation and any subsequent renal function tests occurring in the hospital and therefore not captured in the CPRD; (4) focusing on specific patient subgroups (heart failure, myocardial infarction, hypertension, CKD (eGFR<60mls/min/1.73m$^2$), peripheral arterial disease, and diabetes); and (5) defining drug use continuation as ACEI/ARB use beyond 90 days (instead of 30 days) after the first retest date.

We used the subcohort of patients with both baseline and follow-up monitoring to calculate the proportion of patients with creatinine increases ≥30% or potassium levels >6 mmol/L at the first follow-up monitoring within 2 months after initiation, as well as the proportion of patients continuing treatment despite these contraindications for use.

Finally, we fitted a logistic regression model to identify patient characteristics associated with a severe decline in renal function (creatinine increase ≥30% or potassium level >6 mmol/L) and compared these characteristics with those associated with receiving post-initiation follow-up monitoring within 2 weeks. The model included age, sex, CKD stage, cardiovascular comorbidities, diabetes, and baseline potassium level (>5 vs. ≤5 mmol/L). In three additional model-based sensitivity analyses, we repeated the analyses (1) excluding patients with a recent hospitalization (as defined above); (2) omitting baseline potassium from the model to examine the extent of potential overfitting when both baseline

potassium and CKD stage were kept in the model; and (3) also adjusting additional for ethnicity.

The study protocol was made available to the journal reviewers and approved by the London School of Hygiene and Tropical Medicine Ethics Committee (No. 6536) and the Independent Scientific Advisory Committee (ISAC) for Medicines and Healthcare Products Regulatory Agency (No. 16_025). All analyses were performed using STATA 14 statistical software package.

## RESULTS

### Serum creatinine monitoring before and after ACEI/ARB initiation

We identified 223,814 new users of ACEI/ARB. We compared these patients in four groups: 21,411 (10%) had no baseline or follow-up creatinine tests within 12 months before and 2 months after treatment initiation, 63,359 (28%) had only a baseline test, 33,185 (15%) had only follow-up tests, and 105,859 (47%) had both baseline and follow-up tests. (Table 1). Median age varied only slightly between the groups (60, 62, 59, and 63 years, respectively) and there were no substantial differences in socioeconomic status, lifestyle factors, or peripheral arterial disease. Compared with patients with neither pre- nor post-initiation monitoring, patients with both were more likely to have diagnosed hypertension (76% vs. 61%) and diabetes (20% vs. 7%), but less likely to have diagnosed heart failure (4% vs. 7%), myocardial infarction (4% vs. 18%), and arrhythmia (7% vs. 10%). Among patients with baseline monitoring, 83% did not have CKD, 13% stage 3a, 3% stage 3b, 0.5% stage 4 CKD. In the same population, 7% commenced ACEI/ARB therapy despite baseline potassium above 5 mmol/L. The median number of days between baseline monitoring and first prescription date was 40 days (interquartile range: 12-125 days).

Among all patients initiating ACEI/ARB therapy, the proportion of patients receiving creatinine testing before was 76% within 12 months before treatment initiation, declining to 34% within one month before initiation (Table 2). The proportion with follow-up testing after

treatment initiation was 29% within 2 weeks, increasing to 62% within 2 months. Among ACEI/ARB initiators who had a baseline test within 12 months, 21% also had a follow-up test within 2 weeks after starting treatment (Table 3). However, among patients undergoing testing within one month prior to treatment initiation, only 9% had also the recommended follow-up test within 2 weeks of treatment start. When we extended the follow-up window to three weeks, this proportion increased only to 14% (Table 3). Among patients continuing treatment, only 1% had follow-up measurements at 1, 3, 6, and 12 months after the first retest, in compliance with the strictest recommendation (eTable 1). These results were unchanged when the analysis was restricted to the most recent calendar period (eTable 1-2) and to patients with heart failure, myocardial infarction, hypertension, peripheral arterial disease, diabetes or no recent hospitalization (eTable 3). Only patients with CKD received a slightly higher degree of monitoring (13%) within two weeks following treatment initiation (eTable 3). The proportion with follow-up testing after treatment initiation was also unchanged when results were stratified by date of ACEI/ARB initiation in two-year intervals (eTable 4).

**Serum creatinine and potassium changes after ACEI/ARB initiation**

Among patients receiving the recommended renal function monitoring, 567 (1.2%) experienced a creatinine increase ≥30% and 191 (0.4%) a potassium level >6 mmol/L at their first follow-up test within two months of treatment initiation (1.4% received in total either) (Table 4). Among these patients, 80% continued treatment beyond 30 days following the monitoring date (Table 4). The sensitivity analysis showed that 65% of patients with a creatinine increase ≥30% and 60% of those with a potassium level >6 mmol/L continued also treatment beyond 90 days after the monitoring date (eTable 5). The results remained consistent for longer baseline monitoring intervals (eTable 5).

**Patients at high risk for creatinine increases ≥30%**

When we examined patient characteristics associated with a creatinine increase ≥30% and adjusted for the other characteristics in a multivariable analysis (Table 5), we found an increased odds ratio (OR) for women (1.6-fold increased), for age above 70 years (at least 1.3-fold increased), for CKD stage 4 (1.6-fold increased), heart failure (2.9-fold increased), peripheral arterial disease (1.9-fold increased), myocardial infarction (1.6-fold increased), and hypertension (1.6-fold increased).

**Patients at high risk for potassium >6 mmol/L**

Baseline potassium level and CKD stage, but not age and sex, were associated with potassium levels >6 mmol/L after ACEI/ARB initiation. Thus, the OR was 7-fold increased for baseline potassium >5 mmol/L, two-fold increased for CKD stage 3a, 5-fold increased for stage 3b, and 11-fold increased for stage 4 (Table 5). Among cardiovascular comorbidities, heart failure was associated with the strongest OR of a potassium level >6 mmol/L (2.22, 95% CI: 1.38-3.58).

**Monitoring high-risk patients**

Some characteristics associated with an increased odds of having ≥30% rise in creatinine were also associated with a greater likelihood of having a follow-up test within 2 weeks following drug initiation. These included older age: persons aged 70 years or above compared with ≤50 years (1.18, 95% CI: 1.13-1.23 for 70-79 years and 1.17, 95% CI: 1.11-1.23 for 80+ years), CKD stage 4 compared to no CKD (1.41, 95% CI: 1.20-1.66), heart failure (1.16, 95% CI: 1.08-1.23), and peripheral arterial disease (1.11, 95% CI: 1.02-1.20). However, other characteristics associated with an increased odds of having ≥30% rise in creatinine were not associated with a greater likelihood of having a follow-up test within 2 weeks following drug initiation: there was no substantially increased OR (>10%) associated with female sex (1.07,

95% CI: 1.04-1.09), prior history of myocardial infarction (0.77, 95% CI: 0.72-0.82), hypertension (1.05, 95% CI: 1.00-1.11), or baseline potassium >5 mmol/L (1.04, 95% CI: 0.99-1.09). When we excluded patients with a recent hospital admission, the reduced OR for myocardial infarction was no longer observed (0.93, 95% CI: 0.80-1.08) (eTable 6). Finally, the results remained consistent when we omitted adjustment for baseline potassium (data not shown) and when we adjusted additionally for ethnicity (eTable 6).

## DISCUSSION

Only one tenth of patients initiating ACEI/ARBs in UK primary care appear to receive the guideline-recommended creatinine monitoring. One in 15 patients commenced ACEI/ARBs despite baseline potassium above the recommended level, which was also shown to be a strong predictor for severe post-initiation hyperkalaemia. Among monitored patients, a creatinine increase ≥30% or a potassium level >6 mmol/L occurred in almost 1.5% of patients, and most did not discontinue therapy despite guideline recommendations to stop. Although patients with prior myocardial infarction, hypertension, or a high baseline potassium level were at higher risk of sudden decline in kidney function after ACEI/ARB initiation, there was no evidence that these patient groups were monitored more frequently while initiating the drugs.

### Strengths and limitations

Several issues should be considered when interpreting our study results. Its large sample size increased precision. Use of the CPRD ensured that the study was general practice-based and not restricted to specific demographic, hospital, or insurance groups.

Over the time course of this study multiple factors have impacted on prescribing of ACEI/ARB and measurement of renal function in primary care, for example the introduction of the relevant NICE guidelines, and QOF reimbursement for testing in certain sub-groups. We also did not have information about clinical initiatives such as heart failure nurses and

ACEI/ARB stopping rules ('sick-day rules'). While our main results provide summary measures over a ten-year period, sensitivity analyses confirm that despite these changes, the proportion receiving the guideline suggested biochemical monitoring does not vary during the study period. We did not have access to blood tests performed in hospital systems, which may have been reported to GPs, but not recorded in CPRD. However, restricting the analysis to patients with no recent hospital admissions who were most likely to have had renal function measured and acted upon in secondary care had little effect on our findings. We did not examine testing during initiation of dual blockade with ACEI and ARB as this combination is now used very infrequently for patients with severe comorbidities who are likely to be monitored in secondary care. Although some patients may also have been seen in outpatient specialty clinics, it is common practice for specialists to ask GPs to initiate new drugs such as ACEI/ARBs, with local biochemical monitoring, limiting misclassification.

Consistent with findings from other studies,[19] we found that approximately 50% of all ACEI/ARB initiators were monitored both before and after treatment start. If GPs are retesting renal function in patients at higher risk of substantial biochemical changes, we may have overestimated the proportion of patients with high potassium levels or creatinine increases compared with the untested lower-risk general population.

GP system software is used for issuing prescriptions, ensuring the accuracy of prescription data. However, it cannot be inferred that all patients actually redeemed their prescription at the pharmacy and start medication on the same day that it was prescribed.[18 20] Similarly, the estimated coverage of prescriptions may not be completely accurate due to such factors as stockpiling and irregular use. We also do not know whether GPs contacted patients with elevated laboratory results to advise them to stop taking the medication prior to the end of their prescriptions. However, 80% of patients who developed creatinine increase ≥30% after ACEI/ARB initiation were still issued a subsequent ACEI/ARB prescription.

We aimed to detect discontinuation related closely in time to first follow-up monitoring

and hence likely resulting from an elevated creatinine or potassium result. We therefore defined continuation as ACEI/ARB use beyond 30 days (the median prescription duration) after the monitoring date. Extending the definition of continuous use beyond 90 days reduced the risk of misclassifying patients as continuing treatment when they had in fact stopped. However, extending the duration also increased the risk of identifying discontinuation due to other reasons than creatinine/potassium increase, *e.g.*, death or cough. Diagnoses recorded in the CPRD generally have been found to have adequate validity for research purposes,[21 22] particularly in the domains assessed by the QOF.[23 24]

In the logistic regression analysis to estimate factors associated with creatinine increase ≥30%, we excluded patients without pre and post measurements (complete case analysis). If the recording of creatinine levels was not missing completely at random, the associations between patient characteristics and creatinine increase may have been underestimated.[25] While this assumption could not be tested directly, examination of baseline characteristics revealed no major differences in age, sex, socioeconomic status, and lifestyle between patients with and without pre- and post-monitoring. Furthermore, the results were consistent for each individual patient group examined. Patients with no testing before or after treatment initiation (including those with potentially haemolysed samples) only accounted for 10% of all ACEI/ARB initiators.

**Comparison with other studies**

To our knowledge, this is the largest study conducted to date on adherence to monitoring and discontinuation guidelines after ACEI/ARB initiation. Only one previous study[19] examined monitoring according to guideline-recommended intervals (<14 days). All others have used longer intervals (*e.g.*, 30 days[26] or 6 months[27 28]), which make interpretations and implications for clinical practice less clear. Poor adherence to monitoring guidelines after ACEI/ARB initiation is not restricted to the UK,[19 28 29] but has also been reported in the US[30-

[32], Canada,[33] and the Netherlands.[26 34] Owing to our sample size, we were able to show that the lack of monitoring occurred in all patient groups with an indication for ACEI/ARB therapy.

A recent Dutch study, including 3,353 patients initiating ACEI/ARBs between 2005-2011, found that 19% had creatinine measured within 30 days and 66% within one year.[26] Creatinine increases above 30% occurred in 1.6% of patients, and among these 70% did not discontinue treatment.[26] A Scottish study of 4,056 patients with type 2 diabetes, prescribed an ACEI/ARB between 2005-2009, found that 19% had both a baseline (within 90 days) and follow-up measurement (within 2 weeks) of initiation. Within this cohort, 1.7% had both a creatinine increase of ≥30% and potassium level ≥5.6 mmol/L.

The magnitude of the risk of severe renal impairment, as measured by creatinine increase in these observational studies, was consistent with our findings, but substantially higher than reported in clinical trials (*e.g.*, 0.2% in the ONTARGET trial).[35] It is not clear from the literature how often harm occurs around the time of initiation, when the risk of nephrotoxicity is thought to be greatest.[8] If physicians are to understand why follow-up monitoring within 2 weeks of treatment start matters, the short-term risks need to be clarified. Until now, most studies have reported only on cumulative risk over entire courses of treatment, such as the 1.1% two-year risk for potassium of >6 mmol/L in the SOLVD trials of heart failure patients.[36] In contrast to clinical trial reviews, reporting a 0.2% (3/1818) risk of potassium >6 mmol/L, we found a 0.4% risk of hyperkalaemia already at time of first retesting after ACEI initiation.

Extending the previous literature, our results support that advanced age, advanced CKD, and heart failure, but not sex, increase the likelihood of being monitored.[19 26 30] Consistent with some,[26 30] but not all, previous studies,[28] we found no association for diabetes. However, these previous studies reporting an association for diabetes focused on monitoring within broader intervals (*e.g.*, 6 months),[28] where diabetes patients, irrespective of

ACEI/ARB initiation, were likely to receive blood testing owing to the diabetes QOF programme.

Determinants of increases in creatinine levels after ACEI/ARB initiation are less well understood than for hyperkalaemia, but increasing age is a consistently reported factor.[19] Advanced CKD and a range of cardiovascular comorbidities (mostly associated with atherosclerosis) were also important determinants in our patient cohort. Consistent with previous studies, we found that the risk of hyperkalaemia was associated with CKD (likely due to impaired ability of the cortical collecting tubule to secrete potassium), heart failure (likely due to decreased delivery of sodium to the distal nephron), and high pre-treatment potassium levels.[6 8 19 37] We did not observe an association with diabetes or increasing age, as could have been expected due to diabetic nephropathy or age-dependent hyporeninemic hypoaldosteronism.[6]

**Clinical relevance**

Several possible explanations exist for the divergence between the clinical guideline recommendations and the observed monitoring and response patterns in clinical practice. The first is *clinician nonadherence* to ordering tests. This may be due to inconsistent recommendations for timing and frequency of monitoring over time,[6] consensus-based (rather than evidence-based) monitoring guidelines, and a lack of guidelines tailored to particular high-risk patients, such as those with CKD and heart failure. Although we found that follow-up monitoring correlated well with the risk of renal impairment after ACEI/ARB initiation for most patient groups, it was not observed for patients with myocardial infarction or pre-initiation high potassium. The second explanation may be *patient nonadherence* to ordered tests. This is particularly salient in UK primary care where blood samples may be taken in phlebotomy clinics that the patient has to visit rather than the GP practice. Patients may find it burdensome to have blood tests, and GPs have no direct economic incentives to ensure that

they are done. A third barrier is *lack of evidence of the clinical importance* of monitoring and its cost-effectiveness. ACEI/ARB-induced renal impairment is rare in clinical trials, even among patients with multiple risk factors for atherosclerotic renal artery stenosis.[8 38] Trial results may therefore have led to a general perception that the rarity of renal impairment obviates the need for close monitoring. However, as observed in our data, the risks in real world practice may be somewhat higher and non-negligible. In addition, previous research has shown that potassium monitoring in high-risk patients with CKD and diabetes may reduce serious hyperkalaemia-associated adverse events.[39] Still, the extent to which an initial creatinine increase ≥30% translates into adverse long-term outcomes in real-world patients remains to be clarified in future studies.

**Generalisability, implications, and conclusions**

The majority of patients initiating treatment with ACEI/ARBs experience only minor changes in renal function. However, substantial increases in creatinine levels after ACEI/ARB initiation may not be as rare as previously suggested, reinforcing the need for adherence to clinical guidelines for both pre- and post-initiating monitoring. Moreover, the post-initiation creatinine increase and potassium levels used in this study are widely recognised cut-off levels, making the results internationally applicable. The comparison with the previous literature also confirms that the lack of systematic monitoring is not exclusive to the UK. Of particular concern was that even when appropriate monitoring was performed, severe renal impairment only rarely led to treatment discontinuation. Individual patient counselling may also be helpful to ensure that those at highest risk are closely monitored. More work is needed to determine the prognostic importance of the changes in renal function that we have observed.

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**Transparency declaration**: The lead author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

**Contributions**

LT conceived the study idea and acquired data permissions. MS, KM, and LT designed the study. MS and KM performed data management and established the cohort. MS, KM, and LT reviewed the literature. The analyses were carried out by MS. All authors participated in the discussion and interpretation of the results. MS organised the writing and wrote the initial drafts. All authors critically revised the manuscript for intellectual content and approved the final version. MS is the guarantor.

**Data sharing**: No additional data are available.

**Disclosures:** None

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**Table 1.** Characteristics of patients initiating angiotensin converting-enzyme inhibitors or angiotensin-receptor blockers in the UK primary care during 2004-2014, by monitoring groups

| | Serum creatinine monitoring* | | | | Total |
|---|---|---|---|---|---|
| | No baseline or follow-up tests | Baseline test only | Follow-up test only | Baseline and follow-up test | |
| **Total number** | 21,411 (100) | 63,359 (100) | 33,185 (100) | 105,859 (100) | 223,814 (100) |
| **Female sex** | 8,882 (41) | 27,722 (44) | 14,570 (44) | 49,109 (46) | 100,283 (45) |
| **Age (years)** | | | | | |
| <50 years | 5,019 (23) | 13,697 (22) | 8,732 (26) | 19,910 (19) | 47,358 (21) |
| 50-59 years | 5,485 (26) | 15,135 (24) | 9,115 (27) | 24,866 (23) | 54,601 (24) |
| 60-69 years | 4,863 (23) | 15,586 (25) | 7,776 (23) | 27,790 (26) | 56,015 (25) |
| 70-79 years | 3,579 (17) | 12,193 (19) | 5,066 (15) | 22,152 (21) | 42,990 (19) |
| 80+ years | 2,465 (12) | 6,748 (11) | 2,496 (8) | 11,141 (11) | 22,850 (10) |
| **Calendar period** | | | | | |
| 2004-2008 | 14,814 (69) | 40,667 (64) | 19,808 (60) | 60,902 (58) | 136,191 (61) |
| 2009-2014 | 6,597 (31) | 22,692 (36) | 13,377 (40) | 44,957 (42) | 87,623 (39) |
| **SES quintiles** | | | | | |
| 1 (low) | 5,153 (24) | 15,290 (24) | 8,533 (26) | 25,577 (24) | 54,553 (24) |
| 2 | 4,725 (22) | 14,331 (23) | 7,887 (24) | 24,851 (23) | 51,794 (23) |
| 3 | 4,341 (20) | 13,028 (21) | 6,890 (21) | 22,629 (21) | 46,888 (21) |
| 4 | 4,254 (20) | 12,140 (19) | 5,931 (18) | 19,318 (18) | 41,643 (19) |
| 5 (high) | 2,925 (14) | 8,508 (13) | 3,898 (12) | 13,359 (13) | 28,690 (13) |
| *Missing* | 13 (0) | 62 (0) | 46 (0) | 125 (0) | 246 (0) |
| **Smoking status** | | | | | |
| Never | 7,860 (37) | 22,496 (36) | 12,229 (37) | 36,895 (35) | 79,480 (36) |
| Ever | 13,433 (63) | 40,797 (64) | 20,915 (63) | 68,939 (65) | 144,084 (64) |
| *Missing* | 118 (1) | 66 (0) | 41 (0) | 25 (0) | 250 (0) |
| **Alcohol intake** | | | | | |
| No use | 2,556 (12) | 7,819 (12) | 3,409 (10) | 11,088 (10) | 24,872 (11) |
| Current | 15,495 (72) | 47,322 (75) | 25,656 (77) | 82,870 (78) | 171,343 (77) |
| Former | 1,328 (6) | 4,499 (7) | 1,933 (6) | 7,490 (7) | 15,250 (7) |
| *Missing* | 2,032 (9) | 3,719 (6) | 2,187 (7) | 4,411 (4) | 12,349 (6) |
| **BMI groups** | | | | | |
| Underweight | 282 (1) | 700 (1) | 304 (1) | 1,008 (1) | 2,294 (1) |
| Healthy weight | 5,666 (26) | 15,406 (24) | 8,089 (24) | 24,972 (24) | 54,133 (24) |
| Overweight | 7,677 (36) | 23,755 (37) | 12,484 (38) | 40,556 (38) | 84,472 (38) |
| Obesity | 6,009 (28) | 20,660 (33) | 10,527 (32) | 35,887 (34) | 73,083 (33) |
| *Missing* | 1,777 (8) | 2,838 (4) | 1,781 (5) | 3,436 (3) | 9,832 (4) |
| **CKD (eGFR)†** | | | | | |
| Stage ≤2 (≥60) | 10,326 (48) | 53,773 (85) | 19,470 (59) | 87,484 (83) | 171,053 (76) |
| Stage 3a (45–59) | 1,137 (5) | 7,382 (12) | 1,766 (5) | 13,913 (13) | 24,198 (11) |
| Stage 3b (30–44) | 217 (1) | 1,885 (3) | 265 (1) | 3,854 (4) | 6,221 (3) |
| Stage 4 (15–29) | 24 (0) | 319 (1) | 29 (0) | 608 (1) | 980 (0) |
| *Not measured* | 9,707 (45) | 0 (0) | 11,655 (35) | 0 (0) | 21,362 (10) |
| **CV comorbidities‡** | | | | | |
| Heart failure | 1,568 (7) | 3,270 (5) | 1,386 (4) | 4,583 (4) | 10,807 (5) |
| Myocardial infarction | 3,881 (18) | 4,653 (7) | 3,203 (10) | 4,620 (4) | 16,357 (7) |
| Hypertension | 13,023 (61) | 44,273 (70) | 24,195 (73) | 80,946 (76) | 162,437 (73) |
| Peripheral arterial disease | 471 (2) | 1,590 (3) | 523 (2) | 2,547 (2) | 5,131 (2) |
| Arrhythmia | 2,057 (10) | 4,973 (8) | 2,000 (6) | 7,123 (7) | 16,153 (7) |
| **Diabetes mellitus** | 1,399 (7) | 13,586 (21) | 1,992 (6) | 21,548 (20) | 38,525 (17) |

**Abbreviations**: CV, cardiovascular; CKD, chronic kidney disease; y, year

*Monitoring groups based on baseline (within 12 months before) and follow-up (within 2 months after) serum creatinine monitoring.

†Calculated from most recent creatinine measurement within 12 months before first prescription date.

‡Diagnosis ever registered before ACE/ARB initiation in CRPD or HES.

**Table 2.** Prevalence of baseline and follow-up serum creatinine monitoring among patients initiating angiotensin converting-enzyme inhibitors or angiotensin-receptor blockers, 2004-2014

| | S-Creatinine, ≥1 test |
|---|---|
| **Total number** | n=223,814 (100%) |
| **Baseline testing** | |
| ≤12 months before | 169,218 (76%) |
| ≤3 months before | 115,348 (52%) |
| ≤1 months before | 75,476 (34%) |
| **Follow-up testing** | |
| ≤2 weeks after | 65,090 (29%) |
| ≤1 month after | 114,244 (51%) |
| ≤2 months after | 139,044 (62%) |

**Table 3.** Prevalence of baseline and follow-up serum creatinine monitoring among patients initiating renin-angiotensin system blockade according to clinical guideline recommendations

| | Clinical guidelines | | | | | All initiators n=223,814 (100%) | |
|---|---|---|---|---|---|---|---|
| | NICE Heart Failure | NICE MI | NICE/UKRA Hypertension | NICE CKD | GP Notebook | Wide baseline interval (≤12 month) | Ideal baseline interval (≤1 month) |
| Baseline testing | x | x | x | x | x | 169,218 (76%) | 75,476 (34%) |
| + Follow-up test ≤2 weeks* | x | n/a | x | x | x | 46,486 (21%) | 19,679 (9%) |
| + Follow-up test ≤3 weeks† | | | | | | 70,792 (32%) | 30,451 (14%) |

Abbreviations: CKD, chronic kidney disease; GP, General Practice; MI, myocardial infarction
*Follow-up test among those with baseline measurements
† Sensitivity analysis illustrating the importance of 2 vs. 3-week cut-off interval in follow-up test intervals.

**Table 4.** Proportion of new users of angiotensin converting-enzyme inhibitors or angiotensin-receptor blockers who continue or discontinue treatment according to guideline recommended cut-off levels of serum creatinine and potassium at follow-up testing*

| | Continuation† | Discontinuation† | Total |
|---|---|---|---|
| Total number, % | 42,942 (93.1) | 3,178 (6.9) | 46,120 (100) |
| Serum creatinine increase ≥30%, n (%) | 462 (81.5) | 105 (18.5) | 567 (100) |
| Serum potassium >6 mmol/L, n (%) | 150 (78.5) | 41 (21.5) | 191 (100) |

*Calculated from the most recent measurements within 1 month before and 2 months after drug initiation.
† A patient was considered continuous users when the end date of the first continuous course of therapy was larger than the date of the first follow-up monitoring + 30 days (to allow for stock piling and irregular use)

**Table 5.** Association between patient characteristics and serum creatinine increase ≥30% and follow-up monitoring within 2 weeks following initiation of renin-angiotensin system blockade

| | Odds ratio (95% confidence intervals) | | | | | |
|---|---|---|---|---|---|---|
| **Characteristics** | **S-creatinine monitoring within 2 weeks** | | **S-creatinine increase ≥30%*** | | **S-potassium increase ≥30%*** | |
| | Age- and sex adjusted | Fully adjusted† | Age- and sex adjusted | Fully adjusted† | Age- and sex adjusted | Fully adjusted† |
| **Female sex** | 1.07 (1.04-1.10) | 1.07 (1.04-1.09) | 1.39 (1.26-1.53) | 1.63 (1.47-1.80) | 0.87 (0.66-1.16) | 0.94 (0.70-1.26) |
| **Age (years)** | | | | | | |
| < 50 years | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) |
| 50-59 years | 0.98 (0.94-1.01) | 0.98 (0.95-1.02) | 0.88 (0.74-1.05) | 0.86 (0.72-1.03) | 1.29 (0.79-2.11) | 1.10 (0.67-1.81) |
| 60-69 years | 1.05 (1.02-1.09) | 1.05 (1.01-1.09) | 1.03 (0.88-1.21) | 1.00 (0.85-1.19) | 1.35 (0.84-2.17) | 0.97 (0.60-1.58) |
| 70-79 years | 1.18 (1.14-1.23) | 1.18 (1.13-1.23) | 1.49 (1.27-1.74) | 1.36 (1.15-1.61) | 1.65 (1.02-2.66) | 0.74 (0.43-1.26) |
| 80+ years | 1.20 (1.14-1.25) | 1.17 (1.11-1.23) | 2.72 (2.32-3.20) | 2.02 (1.68-2.44) | 2.75 (1.67-4.53) | 0.73 (0.41-1.32) |
| **CKD stage** | | | | | | |
| No CKD (≥60) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) |
| Stage 3a (45–59) | 1.00 (0.96-1.04) | 1.00 (0.96-1.04) | 0.62 (0.53-0.73) | 0.60 (0.51-0.70) | 2.48 (1.66-3.71) | 2.06 (1.36-3.11) |
| Stage 3b (30–44) | 0.99 (0.93-1.06) | 1.01 (0.94-1.08) | 1.01 (0.82-1.24) | 0.88 (0.71-1.09) | 7.51 (4.75-11.9) | 5.10 (3.16-8.22) |
| Stage 4 (15–29) | 1.42 (1.21-1.67) | 1.41 (1.20-1.66) | 2.16 (1.52-3.05) | 1.72 (1.18-2.51) | 24.0 (13.5-42.6) | 11.4 (6.07-21.4) |
| **Comorbidities*** | | | | | | |
| Heart failure | 1.15 (1.09-1.23) | 1.16 (1.08-1.23) | 4.00 (3.49-4.58) | 2.93 (2.51-3.42) | 2.90 (1.90-4.42) | 2.22 (1.38-3.58) |
| MI | 0.80 (0.75-0.85) | 0.77 (0.72-0.82) | 2.33 (1.98-2.74) | 1.57 (1.32-1.87) | 2.12 (1.33-3.39) | 1.35 (0.80-2.25) |
| Hypertension | 1.00 (0.97-1.02) | 1.05 (1.00-1.11) | 0.62 (0.56-0.68) | 1.58 (1.36-1.84) | 0.60 (0.45-0.80) | 1.02 (0.63-1.65) |
| PAD | 1.09 (1.01-1.18) | 1.11 (1.02-1.20) | 2.10 (1.70-2.60) | 1.87 (1.50-2.33) | 2.14 (1.18-3.86) | 1.53 (0.82-2.88) |
| Arrhythmia | 1.09 (1.03-1.14) | 0.98 (0.95-1.01) | 2.37 (2.07-2.71) | 0.77 (0.69-0.86) | 1.41 (0.90-2.21) | 0.77 (0.56-1.05) |
| Diabetes mellitus | 0.93 (0.90-0.96) | 0.93 (0.90-0.96) | 1.09 (0.97-1.22) | 1.04 (0.92-1.18) | 0.97 (0.69-1.36) | 0.90 (0.63-1.29) |
| **Baseline K>5 mmol/L** | 1.04 (1.00-1.10) | 1.04 (0.99-1.09) | 1.04 (0.86-1.25) | 0.97 (0.80-1.17) | 8.22 (6.14-11.0) | 6.68 (4.94-9.02) |

**Abbreviations:** CKD, chronic kidney disease; MI, myocardial infarction; PAD, peripheral arterial disease

* The increase was based on the difference between the most recent baseline measurements within 12 months before and first follow-up measurement within 2 months after drug initiation. All analyses were restricted to those with both baseline and follow-up measurements (n=105,859).

† Adjusted for sex, age, CKD, heart failure, MI, hypertension, PAD, arrhythmia, diabetes, and calendar period of prescription start

# ONLINE SUPPLEMENTAL MATERIAL

**eTable 1.** Prevalence of baseline and follow-up serum creatinine monitoring among patients initiating renin-angiotensin system blockade according to clinical guideline recommendations, overall and in most recent calendar period (extended version of Table 3)

| | Clinical guidelines | | | | | | All initiators | | Continuing users* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | NICE Heart Failure | NICE CKD | NICE Hypertension | NICE MI | UK Renal Association | GP Notebook | Generous baseline interpretation (≤12 month) | Strict baseline interpretation (≤1 month) | Generous baseline interpretation (≤12 month) | Strict baseline interpretation (≤1 month) |
| **2004-2014** | | | | | | | n=223,814 (100%) | | n=173,244 (100%) | |
| **Baseline testing** | x | x | x | x | x | x | 169,218 (76%) | 75,476 (34%) | 131,756 (76%) | 58,668 (34%) |
| **Follow-up test (≤2 weeks)†** | x | x | n/a | x | x | x | 46,486 (21%) | 19,679 (9%) | 43,420 (25%) | 18,457 (11%) |
| + At least within one year after | | | | x | | | 36,424 (16%) | 15,642 (7%) | 34,336 (20%) | 14,800 (9%) |
| + 1 month thereafter‡ | | | | | | x | 11,866 (5%) | 5,643 (3%) | 11,398 (7%) | 5,388 (3%) |
| + 1 and 3 months thereafter ‡ | | | | | | x | 5,787 (3%) | 2,933 (1%) | 5,556 (3%) | 2,791 (2%) |
| + 1, 3, and 6 months thereafter ‡ | | | | | | x | 3,390 (2%) | 1,807 (1%) | 3,281 (2%) | 1,703 (1%) |
| + 1, 3, 6, and 12 months thereafter‡ | | | | | | x | 2,618 (1%) | 1,439 (1%) | 2,484 (1%) | 1,353 (1%) |
| **Follow-up test (≤3 weeks)§** | | | | | | | 70,792 (32%) | 30,451 (14%) | 66,340 (38%) | 28,644 (17%) |
| **2009-2014** | | | | | | | n=87,623 (100%) | | n=68,042 (100%) | |
| **Baseline testing** | x | x | x | x | x | x | 67,649 (77%) | 30,576 (35%) | 52,780 (78%) | 23,716 (35%) |
| **Follow-up test (≤2 weeks)†** | x | x | n/a | x | x | x | 20,172 (23%) | 8,707 (10%) | 18,862 (28%) | 8,169 (12%) |
| + At least within one year after | | | | x | | | 15,416 (18%) | 6,726 (8%) | 14,557 (21%) | 6,377 (9%) |
| + 1 month thereafter‡ | | | | | | x | 5,373 (6%) | 2,607 (3%) | 5,153 (8%) | 2,500 (4%) |
| + 1 and 3 months thereafter ‡ | | | | | | x | 2,614 (3%) | 1,365 (2%) | 2,492 (4%) | 1,302 (2%) |
| + 1, 3, and 6 months thereafter ‡ | | | | | | x | 1,525 (2%) | 841 (1%) | 1,457 (2%) | 792 (1%) |
| + 1, 3, 6, and 12 months thereafter‡ | | | | | | x | 1,152 (1%) | 650 (1%) | 1,089 (2%) | 606 (1%) |
| **Follow-up test (≤3 weeks)§** | | | | | | | 31,007 (35%) | 13,511 (15%) | 29,091 (43%) | 12,726 (19%) |

Abbreviations: CKD, chronic kidney disease; GP, General Practice; MI, myocardial infarction; n/a, not specified

* A patient was considered continuous users when the end date of the first continuous course of therapy was larger than the date of the first follow-up monitoring + 30 days (to allow for stock piling and irregular use)

†Follow-up test among those with baseline measurements

‡Within additional 1, 3, 6, and 12 months after correspond to within 1.5, 3.5, 6.5, and 12.5 months after ACE/ARB initiation, respectively.

§Sensitivity analysis illustrating the importance of 2 vs. 3-week cut-off interval in follow-up test intervals.

**eTable 2.** Prevalence of baseline and follow-up serum creatinine monitoring among patients initiating angiotensin converting-enzyme inhibitors or angiotensin-receptor blockers, overall and most recent calendar period (extended version of Table 1)

| | S-Creatinine, ≥1 test, n (%) | |
|---|---|---|
| | Total cohort (n=223,814) | 2009-2014 cohort (n=87,623) |
| **Baseline testing** | | |
| ≤12 months before | 169,218 (75.6) | 67,649 (77.2) |
| ≤3 months before | 115,348 (51.5) | 46,925 (53.6) |
| ≤1 months before | 75,476 (33.7) | 30,576 (34.9) |
| **Follow-up testing** | | |
| ≤2 weeks after | 65,090 (29.1) | 27,933 (31.9) |
| ≤1 month after | 114,244 (51.0) | 48,877 (55.8) |
| ≤2 months after | 139,044 (62.1) | 58,334 (66.6) |

**eTable 3.** Prevalence of baseline and follow-up serum creatinine monitoring among patients initiating renin-angiotensin system blockade according to clinical guideline recommendations

| | **All initiators n=223,814 (100%)** | |
|---|---|---|
| | **Generous baseline interpretation** (≤12 month) | **Strict baseline interpretation** (≤1 month) |
| **Overall (n=223,814)** | | |
| Baseline testing | 169,218 (76%) | 75,476 (34%) |
| + Follow-up test ≤2 weeks* | 46,486 (21%) | 19,679 (9%) |
| + Follow-up test ≤3 weeks† | 70,792 (32%) | 30,451 (14%) |
| **Overall, no recent hospitalization (n=197,291)** | | |
| Baseline testing | 153,353 (78%) | 68,883 (35%) |
| + Follow-up test ≤2 weeks* | 42,967 (22%) | 18,222 (9%) |
| + Follow-up test ≤3 weeks† | 65,881 (33%) | 28,375 (14%) |
| **Heart failure patients (n=10,807)** | | |
| Baseline testing | 7,853 (73%) | 3,277 (30%) |
| + Follow-up test ≤2 weeks* | 2,229 (21%) | 951 (9%) |
| + Follow-up test ≤3 weeks† | 3,085 (29%) | 1,340 (12%) |
| **Myocardial infarction patients (n=16,357)** | | |
| Baseline testing | 9,273 (57%) | 3,766 (23%) |
| + Follow-up test ≤2 weeks* | 1,816 (11%) | 726 (4%) |
| + Follow-up test ≤3 weeks† | 2,645 (16%) | 1,078 (7%) |
| **Hypertension patients (n=162,437)** | | |
| Baseline testing | 125,219 (77%) | 54,174 (33%) |
| + Follow-up test ≤2 weeks* | 35,502 (22%) | 14,559 (9%) |
| + Follow-up test ≤3 weeks† | 54,585 (34%) | 22,710 (14%) |
| **CKD patients (n=31,399)** | | |
| Baseline testing | 27,961 (89%) | 13,913 (44%) |
| + Follow-up test ≤2 weeks* | 8,457 (27%) | 4,198 (13%) |
| + Follow-up test ≤3 weeks† | 12,482 (40%) | 6,324 (20%) |
| **PAD patients (n=5,131)** | | |
| Baseline testing | 4,137 (81%) | 1,671 (33%) |
| + Follow-up test ≤2 weeks* | 1,198 (23%) | 458 (9%) |
| + Follow-up test ≤3 weeks† | 1,751 (34%) | 698 (14%) |
| **Diabetes patients (n=38,525)** | | |
| Baseline testing | 35,134 (91%) | 15,907 (41%) |
| + Follow-up test ≤2 weeks* | 9,161 (24%) | 3,794 (10%) |
| + Follow-up test ≤3 weeks† | 14,093 (37%) | 5,994 (16%) |

Abbreviations: CKD, chronic kidney disease

*Follow-up test among those with baseline measurements

† Sensitivity analysis illustrating the importance of 2 vs. 3-week cut-off interval in follow-up test intervals.

**eTable 4**: Prevalence of baseline and follow-up serum creatinine monitoring among patients initiating renin-angiotensin system blockade according to clinical guideline recommendations, stratified by year of ACEI/ARB initiation, 2004-2014

| | **All initiators** n=223,814 | | **2004/2005** n=51,529 | | **2006/2007** n=59,881 | | **2008/2009** n=47,472 | | **2010/2011** n=37,183 | | **2012/2014** n=27,749 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wide baseline interval (≤12 month) | Ideal baseline interval (≤1 month) | Wide baseline interval (≤12 month) | Ideal baseline interval (≤1 month) | Wide baseline interval (≤12 month) | Ideal baseline interval (≤1 month) | Wide baseline interval (≤12 month) | Ideal baseline interval (≤1 month) | Wide baseline interval (≤12 month) | Ideal baseline interval (≤1 month) | Wide baseline interval (≤12 month) | Ideal baseline interval (≤1 month) |
| **Baseline testing** | 169,218 (76%) | 75,476 (34%) | 36,649 (71%) | 14,710 (29%) | 45,801 (76%) | 21,079 (35%) | 36,585 (77%) | 17,265 (36%) | 28,742 (77%) | 13,045 (35%) | 21,443 (77%) | 9,377 (34%) |
| + Follow-up test ≤2 weeks* | 46,486 (21%) | 19,679 (9%) | 8,139 (16%) | 2,929 ( 6%) | 12,587 (21%) | 5,509 ( 9%) | 10,595 (22%) | 4,769 (10%) | 8,623 (23%) | 3,720 (10%) | 6,556 (24%) | 2,752 (10%) |
| + Follow-up test ≤3 weeks† | 70,792 (32%) | 30,451 (14%) | 12,222 (24%) | 4,550 ( 9%) | 19,102 (32%) | 8,504 (14%) | 16,229 (34%) | 7,392 (16%) | 13,031 (35%) | 5,768 (16%) | 10,054 (36%) | 4,237 (15%) |

*Follow-up test among those with baseline measurements

† Sensitivity analysis illustrating the importance of 2 vs. 3-week cut-off interval in follow-up test intervals.

**eTable 5.** Proportion of new users of ACEI/ARB who continue or discontinue treatment according to guideline recommended cut-off levels of serum creatinine and potassium at follow-up testing

| | Wide monitoring interval (12 month before to the first monitoring within 2 month after) | | | Narrow monitoring interval (1 month before to the first monitoring within 2 month after) | | |
|---|---|---|---|---|---|---|
| | Continuation* | Discontinuation* | Total | Continuation* | Discontinuation* | Total |
| **+ 30 day window** | | | | | | |
| Total number, % | 113,210 (92.5) | 9,170 (7.5) | 122,380 (100) | 48,772 (93.0) | 3,676 (7.0) | 52,448 (100) |
| S-creatinine increase ≥30%, n (%) | 1,679 (80.7) | 401 (19.3) | 2,080 (100) | 541 (81.5) | 123 (18.5) | 664 (100) |
| S-potassium >6 mmol/L, n (%) | 472 (81.9) | 104 (18.1) | 576 (100) | 204 (80.6) | 49 (19.4) | 253 (100) |
| **+ 90 day window** | | | | | | |
| Total number, % | 86,620 (81.8) | 19,239 (18.2) | 105,859 (100) | 37,920 (82.2) | 8,200 (17.8) | 46,120 (100) |
| S-creatinine increase ≥30%, n (%) | 1,111 (64.7) | 605 (35.3) | 1,716 (100) | 372 (65.6) | 195 (34.4) | 567 (100) |
| S-potassium >6 mmol/L, n (%) | 261 (61.0) | 167 (39.0) | 428 (100) | 110 (57.6) | 81 (42.4) | 191 (100) |

Calculated from the measurements closest to the first prescription date in the corresponding intervals, i.e., the most recent baseline measurements and the first follow-up measurement.

* A patient was considered continuous users when the end date of the first continuous course of therapy was larger than the date of the first follow-up monitoring + 30 days or + 90days (to allow for stock piling and irregular use)

**eTable 6.** Association between patient characteristics and serum creatinine increase ≥30% and follow-up monitoring within 2 weeks following initiation of renin-angiotensin system blockade

| | Adjusted odds ratio (95% confidence intervals) | | | | | |
|---|---|---|---|---|---|---|
| | Additional adjustment for ethnicity† | | | Excluding patient with hospitalisation within 30 days† | | |
| **Characteristics** | **S-creatinine monitoring within 2 weeks** | **S-creatinine increase ≥30%*** | **S-potassium >6 mmol/L*** | **S-creatinine monitoring within 2 weeks** | **S-creatinine increase ≥30%*** | **S-potassium >6 mmol/L*** |
| **Female sex** | 1.04 (1.01-1.08) | 1.91 (1.64-2.23) | 1.09 (0.70-1.71) | 1.06 (1.04-1.09) | 1.66 (1.46-1.86) | 0.94 (0.69-1.27) |
| **Age (years)** | | | | | | |
| < 50 years | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) |
| 50-59 years | 0.97 (0.92-1.02) | 0.91 (0.71-1.16) | 1.65 (0.77-3.52) | 0.99 (0.95-1.03) | 0.86 (0.74-1.05) | 1.17 (0.70-1.98) |
| 60-69 years | 1.04 (0.99-1.10) | 0.86 (0.68-1.10) | 1.23 (0.57-2.65) | 1.07 (1.02-1.11) | 1.05 (0.88-1.26) | 0.98 (0.58-1.64) |
| 70-79 years | 1.22 (1.15-1.30) | 1.22 (0.96-1.55) | 0.83 (0.36-1.95) | 1.19 (1.14-1.24) | 1.40 (1.18-1.68) | 0.72 (0.41-1.27) |
| 80+ years | 1.15 (1.06-1.24) | 1.61 (1.21-2.14) | 0.58 (0.21-1.58) | 1.17 (1.11-1.24) | 2.16 (1.76-2.66) | 0.71 (0.38-1.33) |
| **CKD stage** | | | | | | |
| No CKD (≥60) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) |
| Stage 3a (45–59) | 1.00 (0.94-1.06) | 0.51 (0.39-0.66) | 1.82 (0.93-3.55) | 1.00 (0.96-1.04) | 0.58 (0.49-0.70) | 2.40 (1.57-3.68) |
| Stage 3b (30–44) | 1.06 (0.95-1.17) | 0.99 (0.71-1.39) | 5.66 (2.70-11.9) | 0.98 (0.92-1.06) | 0.92 (0.79-1.07) | 5.15 (3.09-8.58) |
| Stage 4 (15–29) | 1.51 (1.17-1.94) | 1.65 (0.87-3.12) | 15.0 (5.84-38.8) | 1.42 (1.20-1.70) | 1.86 (1.52-2.31) | 12.2 (6.29-23.7) |
| **Comorbidities*** | | | | | | |
| Heart failure | 1.10 (0.99-1.21) | 3.07 (2.41-3.91) | 2.16 (0.96-4.85) | 1.15 (1.06-1.24) | 2.57 (2.19-3.03) | 2.68 (1.59-4.51) |
| MI | 0.78 (0.72-0.86) | 1.76 (1.35-2.30) | 1.10 (0.46-2.63) | 0.89 (0.82-0.97) | 1.59 (1.23-2.06) | 1.89 (1.05-3.41) |
| Hypertension | 0.97 (0.90-1.05) | 1.51 (1.19-1.92) | 1.01 (0.44-2.30) | 1.04 (0.99-1.11) | 1.40 (1.11-1.68) | 0.81 (0.46-1.42) |
| PAD | 1.09 (0.96-1.23) | 1.63 (1.13-2.35) | 1.52 (0.54-4.29) | 1.16 (1.06-1.26) | 1.74 (1.33-2.27) | 1.75 (0.92-3.32) |
| Arrhythmia | 0.96 (0.92-1.01) | 0.84 (0.71-0.99) | 0.72 (0.44-1.17) | 0.98 (0.94-1.01) | 0.80 (0.71-0.91) | 0.74 (0.53-1.03) |
| Diabetes mellitus | 0.91 (0.87-0.96) | 1.15 (0.96-1.37) | 0.58 (0.31-1.09) | 0.93 (0.90-0.96) | 1.06 (0.93-1.22) | 0.93 (0.64-1.35) |
| **Baseline K>6 mmol/L** | 1.05 (0.98-1.13) | 0.86 (0.63-1.15) | 7.98 (5.06-12.6) | 1.03 (0.98-1.08) | 1.01 (0.88-1.14) | 6.44 (4.69-8.84) |

**Abbreviations**: CKD, chronic kidney disease; MI, myocardial infarction; PAD, peripheral arterial disease

* The increase was based on the difference between the most recent baseline measurements within 12 months before and first follow-up measurement within 2 months after drug initiation. All analyses were restricted to those with both baseline and follow-up measurements (n=105,859).

† The main model was adjusted for sex, age, CKD, heart failure, MI, hypertension, PAD, arrhythmia, diabetes, and calendar period of prescription start

# Appendix: Code list

## Serum creatinine

| Code | Classification | Description |
|---|---|---|
| 4....00 | Read | laboratory procedures |
| 41...00 | Read | laboratory procedures -general |
| 4....11 | Read | investigation-laboratory |
| 4....12 | Read | test - laboratory |
| 412..00 | Read | laboratory procedure performed |
| 413..00 | Read | laboratory test requested |
| 41B..00 | Read | laboratory test due |
| 41BZ.00 | Read | laboratory test nos due |
| 41G..00 | Read | laboratory administration procedures |
| 41G3.00 | Read | specimen received in laboratory |
| 41H..00 | Read | review of patient laboratory test report |
| 44J..00 | Read | blood urea/renal function |
| 44J3.00 | Read | serum creatinine |
| 44J3000 | Read | serum creatinine abnormal |
| 44J3100 | Read | serum creatinine low |
| 44J3200 | Read | serum creatinine normal |
| 44J3300 | Read | serum creatinine raised |
| 44J3z00 | Read | serum creatinine nos |
| 44JC.00 | Read | corrected plasma creatinine level |
| 44JD.00 | Read | corrected serum creatinine level |
| 44JF.00 | Read | plasma creatinine level |
| 44JZ.00 | Read | blood urea/renal function nos |
| 451..00 | Read | renal function tests |
| 4511 | Read | renal function tests normal |
| 4512 | Read | renal function tests abnormal |
| 4515 | Read | differential renal function |
| 4516 | Read | renal function tests borderline |
| 4519 | Read | deteriorating renal function |
| 451H.00 | Read | recovery of renal function |
| 451Z.00 | Read | renal function test nos |
| 4Q40.00 | Read | creatinine level |
| 4Z...00 | Read | laboratory procedure nos |
| 8A6..00 | Read | renal function monitoring |
| 8H7P.11 | Read | refer to pathology laboratory |
| 8HP..00 | Read | referral for laboratory tests |
| 98F..00 | Read | reason for repeat laboratory test |
| 9b0P.00 | Read | laboratory request |
| 9b0Q.00 | Read | laboratory result |
| 9mG..00 | Read | renal function monitoring invitation |
| 9mG0.00 | Read | renal function monitoring invitation first letter |
| 9N1Q.00 | Read | seen in diabetic clinic |

| | | |
|---|---|---|
| C345.00 | Read | gout due to impairment of renal function |
| K060.11 | Read | impaired renal function |
| K08..00 | Read | impaired renal function disorder |
| K08y.00 | Read | other impaired renal function disorder |
| K08y300 | Read | renal function impairment with growth failure |
| K08yz00 | Read | other impaired renal function disorder nos |
| K08z.00 | Read | impaired renal function disorder nos |
| R144.00 | Read | [d]renal function test abnormal |
| R1yz.11 | Read | [d]unexplained laboratory result |
| ZV72600 | Read | [v]laboratory examination |

## Serum potassium

| Code | Classification | Description |
|---|---|---|
| 44I4.00 | Read | serum potassium |
| 4....12 | Read | test - laboratory |
| 4Z...00 | Read | laboratory procedure nos |
| 451..00 | Read | renal function tests |
| C368.00 | Read | hypokalaemia |
| 412..00 | Read | laboratory procedure performed |
| 4512.00 | Read | renal function tests abnormal |
| 4511.00 | Read | renal function tests normal |
| 8A6..00 | Read | renal function monitoring |
| C367.00 | Read | hyperkalaemia |
| K060.11 | Read | impaired renal function |
| 4....11 | Read | investigation-laboratory |
| K08..00 | Read | impaired renal function disorder |
| R144.00 | Read | [d]renal function test abnormal |
| 8HP..00 | Read | referral for laboratory tests |
| 4....00 | Read | laboratory procedures |
| 44J..00 | Read | blood urea/renal function |
| 44h8.00 | Read | plasma potassium level |
| 44h0.00 | Read | blood potassium level |
| 4I46.00 | Read | sweat potassium level |
| 413..00 | Read | laboratory test requested |
| C345.00 | Read | gout due to impairment of renal function |
| 41...00 | Read | laboratory procedures -general |
| 41B..00 | Read | laboratory test due |
| 411..00 | Read | laboratory test not necessary |
| 4516.00 | Read | renal function tests borderline |
| K08z.00 | Read | impaired renal function disorder nos |
| 4519.00 | Read | deteriorating renal function |
| 44I4200 | Read | low serum potassium level |
| 44I4000 | Read | normal serum potassium level |
| 44I4100 | Read | raised serum potassium level |
| 44JZ.00 | Read | blood urea/renal function nos |

| | | |
|---|---|---|
| 1F34.00 | Read | dietary potassium - low |
| 1F3..11 | Read | dietary potassium intake |
| 41BZ.00 | Read | laboratory test nos due |
| ZC61c00 | Read | potassium supplementation |
| ZV72600 | Read | [v]laboratory examination |
| 451Z.00 | Read | renal function test nos |
| K08y.00 | Read | other impaired renal function disorder |
| 4Q42.00 | Read | potassium level |
| R1yz.11 | Read | [d]unexplained laboratory result |
| ZC28.00 | Read | advice to change potassium intake |
| 4I34.11 | Read | potassium in sample |
| 9b0Q.00 | Read | laboratory result |
| K08yz00 | Read | other impaired renal function disorder nos |
| 4515.00 | Read | differential renal function |
| 1F36.00 | Read | dietary potassium - high |
| 4I34.00 | Read | fluid sample potassium |
| 1F35.00 | Read | dietary potassium - average |
| 5714.00 | Read | potassium 40 whole body count |
| 41G..00 | Read | laboratory administration procedures |
| 41H..00 | Read | review of patient laboratory test report |
| 9b0P.00 | Read | laboratory request |
| 8B77.00 | Read | potassium supplementation |
| 451H.00 | Read | recovery of renal function |
| 9mG..00 | Read | renal function monitoring invitation |
| 98F..00 | Read | reason for repeat laboratory test |
| 13BD.00 | Read | low potassium diet |
| 9mG0.00 | Read | renal function monitoring invitation first letter |
| 41G3.00 | Read | specimen received in laboratory |
| 4IA5.00 | Read | unsatisfactory laboratory analysis |

## End stage renal disease

| Code | Classification | Description |
|---|---|---|
| 14S2.00 | Read | h/o: kidney recipient |
| 14V2.00 | Read | h/o: renal dialysis |
| 14V2.11 | Read | h/o: kidney dialysis |
| 1Z14.00 | Read | chronic kidney disease stage 5 |
| 1Z1K.00 | Read | chronic kidney disease stage 5 with proteinuria |
| 1Z1K.11 | Read | ckd stage 5 with proteinuria |
| 1Z1L.00 | Read | chronic kidney disease stage 5 without proteinuria |
| 1Z1L.11 | Read | ckd stage 5 without proteinuria |
| 4I29.00 | Read | peritoneal dialysis sample |
| 4N0..00 | Read | dialysis fluid urea level |
| 4N2..00 | Read | dialysis fluid glucose level |
| 67P4100 | Read | discussion about kidney transplantation |
| 7A60.00 | Read | arteriovenous shunt |

| | | |
|---|---|---|
| 7A60000 | Read | insertion of arteriovenous prosthesis |
| 7A60100 | Read | creation of arteriovenous fistula nec |
| 7A60111 | Read | creation of radial-cephalic fistula |
| 7A60112 | Read | creation of brachial-cephalic fistula |
| 7A60200 | Read | attention to arteriovenous shunt |
| 7A60300 | Read | removal of infected arteriovenous shunt |
| 7A60400 | Read | banding of arteriovenous fistula |
| 7A60500 | Read | thrombectomy of arteriovenous fistula |
| 7A60600 | Read | creation of graft fistula for dialysis |
| 7A60y00 | Read | other specified arteriovenous shunt |
| 7A60z00 | Read | arteriovenous shunt nos |
| 7A61100 | Read | repair of acquired arteriovenous fistula |
| 7A61111 | Read | ligation of acquired arteriovenous fistula |
| 7A61400 | Read | ligation of acquired arteriovenous fistula |
| 7A61900 | Read | ligation of arteriovenous dialysis fistula |
| 7A61A00 | Read | ligation of arteriovenous dialysis graft |
| 7B00.00 | Read | transplantation of kidney |
| 7B00100 | Read | transplantation of kidney from live donor |
| 7B00111 | Read | allotransplantation of kidney from live donor |
| 7B00200 | Read | transplantation of kidney from cadaver |
| 7B00211 | Read | allotransplantation of kidney from cadaver |
| 7B00212 | Read | cadaveric renal transplant |
| 7B00300 | Read | allotransplantation of kidney from cadaver heart-beating |
| 7B00400 | Read | allotransplantation kidney from cadaver heart non-beating |
| 7B00600 | Read | xenograft renal transplant |
| 7B00y00 | Read | other specified transplantation of kidney |
| 7B00z00 | Read | transplantation of kidney nos |
| 7B01500 | Read | transplant nephrectomy |
| 7B01511 | Read | excision of rejected transplanted kidney |
| 7B06300 | Read | exploration of renal transplant |
| 7B0F.00 | Read | interventions associated with transplantation of kidney |
| 7B0F100 | Read | pre-transplantation of kidney work-up |
| 7B0F300 | Read | post-transplantation of kidney examination |
| 7B0Fy00 | Read | os interventions associated with transplantation of kidney |
| 7B0Fz00 | Read | interventions associated with transplantation of kidney nos |
| 7L1A.00 | Read | compensation for renal failure |
| 7L1A000 | Read | renal dialysis |
| 7L1A011 | Read | thomas intravascular shunt for dialysis |
| 7L1A100 | Read | peritoneal dialysis |
| 7L1A.11 | Read | dialysis for renal failure |
| 7L1A200 | Read | haemodialysis nec |
| 7L1A300 | Read | haemofiltration |
| 7L1A400 | Read | automated peritoneal dialysis |
| 7L1A500 | Read | continuous ambulatory peritoneal dialysis |
| 7L1A600 | Read | peritoneal dialysis nec |

| | | |
|---|---|---|
| 7L1Ay00 | Read | other specified compensation for renal failure |
| 7L1Az00 | Read | compensation for renal failure nos |
| 7L1B.00 | Read | placement ambulatory apparatus compensation renal failure |
| 7L1B000 | Read | insertion of ambulatory peritoneal dialysis catheter |
| 7L1B100 | Read | removal of ambulatory peritoneal dialysis catheter |
| 7L1B.11 | Read | placement ambulatory dialysis apparatus - compens renal fail |
| 7L1B200 | Read | flushing of peritoneal dialysis catheter |
| 7L1By00 | Read | placement ambulatory apparatus- compensate renal failure os |
| 7L1C.00 | Read | placement other apparatus for compensation for renal failure |
| 7L1C000 | Read | insertion of temporary peritoneal dialysis catheter |
| 7L1Cy00 | Read | placement other apparatus- compensate for renal failure os |
| 7L1Cz00 | Read | placement other apparatus- compensate for renal failure nos |
| 8L50.00 | Read | renal transplant planned |
| 9b8K.00 | Read | transplantation surgery |
| 9Ot5.00 | Read | predicted stage chronic kidney disease |
| G72C.00 | Read | ruptured aneurysm of dialysis vascular access |
| G72D.00 | Read | aneurysm of dialysis arteriovenous fistula |
| G72D100 | Read | aneurysm of needle site of dialysis arteriovenous fistula |
| G72D200 | Read | aneurysm of anastomotic site of dialysis av fistula |
| G760.00 | Read | acquired arteriovenous fistula |
| Gy1..00 | Read | stenosis of dialysis vascular access |
| Gy21.00 | Read | thrombosis of dialysis arteriovenous fistula |
| Gy3..00 | Read | occlusion of dialysis vascular access |
| Gy31.00 | Read | occlusion of dialysis arteriovenous fistula |
| Gy40.00 | Read | infection of dialysis arteriovenous graft |
| Gy41.00 | Read | infection of dialysis arteriovenous fistula |
| Gy51.00 | Read | haemorrhage of dialysis arteriovenous fistula |
| Gy60.00 | Read | rupture of dialysis arteriovenous graft |
| K050.00 | Read | end stage renal failure |
| K05..12 | Read | end stage renal failure |
| K055.00 | Read | chronic kidney disease stage 5 |
| K0B5.00 | Read | renal tubulo-interstitial disordrs in transplant rejectn |
| K0D..00 | Read | end-stage renal disease |
| Kyu1C00 | Read | [x]renal tubulo-interstitial disorders/transplant rejection |
| SP01500 | Read | mechanical complication of dialysis catheter |
| SP01700 | Read | mechanical complication of arterio-venous surgical fistula |
| SP05613 | Read | [x] peritoneal dialysis associated peritonitis |
| SP06B00 | Read | continuous ambulatory peritoneal dialysis associated perit |
| SP07G00 | Read | stenosis of arteriovenous dialysis fistula |
| SP07N00 | Read | arteriovenous fistula thrombosis |
| SP08011 | Read | det.ren.func.after ren.transpl |
| SP08300 | Read | kidney transplant failure and rejection |
| SP08J00 | Read | chronic rejection of renal transplant |
| SP08N00 | Read | unexplained episode of renal transplant dysfunction |
| SP08R00 | Read | renal transplant rejection |

| | | |
|---|---|---|
| SP08T00 | Read | urological complication of renal transplant |
| SP08W00 | Read | vascular complication of renal transplant |
| SP0E.00 | Read | disorders associated with peritoneal dialysis |
| SP0G.00 | Read | anaphylactoid reaction due to haemodialysis |
| TA02000 | Read | accid cut |
| TA22.00 | Read | failure of sterile precautions during perfusion |
| TA22000 | Read | failure of sterile precautions during kidney dialysis |
| TB00100 | Read | kidney transplant with complication |
| TB00111 | Read | renal transplant with complication |
| TB11.00 | Read | kidney dialysis with complication |
| TB11.11 | Read | renal dialysis with complication |
| U612200 | Read | [x]failure sterile precautions dur kidney dialys/other perf |
| Z1A..00 | Read | dialysis training |
| Z1A1.00 | Read | peritoneal dialysis training |
| Z1A2.00 | Read | haemodialysis training |
| Z919.00 | Read | care of haemodialysis equipment |
| Z919100 | Read | priming haemodialysis lines |
| Z919300 | Read | reversing haemodialysis lines |
| Z91A.00 | Read | peritoneal dialysis bag procedure |
| ZV42000 | Read | [v]kidney transplanted |
| ZV45100 | Read | [v]renal dialysis status |
| ZV56.00 | Read | [v]aftercare involving intermittent dialysis |
| ZV56000 | Read | [v]aftercare involving extracorporeal dialysis |
| ZV56011 | Read | [v]aftercare involving renal dialysis nos |
| ZV56100 | Read | [v]preparatory care for dialysis |
| ZV56y00 | Read | [v]other specified aftercare involving intermittent dialysis |
| ZV56y11 | Read | [v]aftercare involving peritoneal dialysis |
| ZVu3G00 | Read | [x]other dialysis |
| I77.0 | ICD-10 | arteriovenous fistula |
| N16.5 | ICD-10 | renal tubulo-interstitial disorders in transplant rejection |
| N18.5 | ICD-10 | chronic kidney disease |
| T82.4 | ICD-10 | mechanical complication of vascular dialysis catheter |
| T86.1 | ICD-10 | kidney transplant failure and rejection |
| Y60.2 | ICD-10 | during kidney dialysis or other perfusion |
| Y61.2 | ICD-10 | during kidney dialysis or other perfusion |
| Y62.2 | ICD-10 | during kidney dialysis or other perfusion |
| Y84.1 | ICD-10 | kidney dialysis |
| Z49 | ICD-10 | care involving dialysis |
| Z49.0 | ICD-10 | preparatory care for dialysis |
| Z49.1 | ICD-10 | extracorporeal dialysis |
| Z49.2 | ICD-10 | other dialysis |
| Z94.0 | ICD-10 | kidney transplant status |
| Z99.2 | ICD-10 | dependence on renal dialysis |

## Ischemic heart disease

| Code | Classification | Description |
|---|---|---|
| 14A3.00 | Read | h/o: myocardial infarct <60 |
| 14A4.00 | Read | h/o: myocardial infarct >60 |
| 14A5.00 | Read | h/o: angina pectoris |
| 14AA.00 | Read | h/o: heart disease nos |
| 14AH.00 | Read | h/o: myocardial infarction in last year |
| 14AJ.00 | Read | h/o: angina in last year |
| 14AL.00 | Read | h/o: treatment for ischaemic heart disease |
| 14AT.00 | Read | history of myocardial infarction |
| 14AW.00 | Read | h/o acute coronary syndrome |
| 182A.00 | Read | Chest pain on exertion |
| 187..00 | Read | frequency of angina |
| 1J61.00 | Read | suspected ischaemic heart disease |
| 3213111 | Read | Positive exercise ECG test |
| 322..00 | Read | ecg: myocardial ischaemia |
| 3222 | Read | ecg:shows myocardial ischaemia |
| 322Z.00 | Read | ecg: myocardial ischaemia nos |
| 323..00 | Read | ecg: myocardial infarction |
| 3232 | Read | ecg: old myocardial infarction |
| 3233 | Read | ecg: antero-septal infarct. |
| 3234 | Read | ecg:posterior/inferior infarct |
| 3235 | Read | ecg: subendocardial infarct |
| 3236 | Read | ecg: lateral infarction |
| 323Z.00 | Read | ecg: myocardial infarct nos |
| 32B..00 | Read | ecg: q wave |
| 32B2.00 | Read | ecg: q wave abnormal |
| 32B3.00 | Read | ecg: q wave pathological |
| 32BZ.00 | Read | ecg: q wave nos |
| 32E4.00 | Read | ecg: s-t depression |
| 44H3.00 | Read | cardiac enzymes abnormal |
| 44H3000 | Read | cardiac enzymes abnormal - first set |
| 44HJ.00 | Read | Plasma creatinine phosphokinase MB isoenzyme level |
| 44MH.00 | Read | Plasma troponin T level |
| 44p2.00 | Read | cardiac troponin positive |
| 5533 | Read | angiocardiography abnormal |
| 5543 | Read | coronary arteriograph.abnormal |
| 5C11.00 | Read | radionuclide heart study abnormal |
| 661M000 | Read | angina self-management plan agreed |
| 662..00 | Read | Cardiac disease monitoring |
| 662..11 | Read | Heart disease monitoring |
| 662K.00 | Read | angina control |
| 662K000 | Read | angina control - good |
| 662K100 | Read | angina control - poor |
| 662K200 | Read | angina control - improving |
| 662K300 | Read | angina control - worsening |

| | | |
|---|---|---|
| 662Kz00 | Read | angina control nos |
| 662N.00 | Read | CHD monitoring |
| 662Z.00 | Read | Cardiac disease monitoring NOS |
| 66f..00 | Read | Cardiovascular disease monitoring |
| 66f1.00 | Read | Cardiovascular disease interim monitoring |
| 6A2..00 | Read | coronary heart disease annual review |
| 6A4..00 | Read | coronary heart disease review |
| 7920 | Read | saphenous vein graft replacement of coronary artery |
| 7920000 | Read | saphenous vein graft replacement of one coronary artery |
| 7920100 | Read | saphenous vein graft replacement of two coronary arteries |
| 7920.11.00 | Read | saphenous vein graft bypass of coronary artery |
| 7920200 | Read | saphenous vein graft replacement of three coronary arteries |
| 7920300 | Read | saphenous vein graft replacement of four+ coronary arteries |
| 7920y00 | Read | saphenous vein graft replacement of coronary artery os |
| 7920z00 | Read | saphenous vein graft replacement coronary artery nos |
| 7921 | Read | other autograft replacement of coronary artery |
| 7921000 | Read | autograft replacement of one coronary artery nec |
| 792..11 | Read | coronary artery bypass graft operations |
| 7921100 | Read | autograft replacement of two coronary arteries nec |
| 7921.11.00 | Read | other autograft bypass of coronary artery |
| 7921200 | Read | autograft replacement of three coronary arteries nec |
| 7921300 | Read | autograft replacement of four of more coronary arteries nec |
| 7921y00 | Read | other autograft replacement of coronary artery os |
| 7921z00 | Read | other autograft replacement of coronary artery nos |
| 7922 | Read | allograft replacement of coronary artery |
| 7922000 | Read | allograft replacement of one coronary artery |
| 7922100 | Read | allograft replacement of two coronary arteries |
| 7922.11.00 | Read | allograft bypass of coronary artery |
| 7922200 | Read | allograft replacement of three coronary arteries |
| 7922300 | Read | allograft replacement of four or more coronary arteries |
| 7922y00 | Read | other specified allograft replacement of coronary artery |
| 7922z00 | Read | allograft replacement of coronary artery nos |
| 7923 | Read | prosthetic replacement of coronary artery |
| 7923000 | Read | prosthetic replacement of one coronary artery |
| 7923100 | Read | prosthetic replacement of two coronary arteries |
| 7923.11.00 | Read | prosthetic bypass of coronary artery |
| 7923200 | Read | prosthetic replacement of three coronary arteries |
| 7923300 | Read | prosthetic replacement of four or more coronary arteries |
| 7923z00 | Read | prosthetic replacement of coronary artery nos |
| 7924 | Read | revision of bypass for coronary artery |
| 7924000 | Read | revision of bypass for one coronary artery |
| 7924100 | Read | revision of bypass for two coronary arteries |
| 7924200 | Read | revision of bypass for three coronary arteries |
| 7924y00 | Read | other specified revision of bypass for coronary artery |
| 7924z00 | Read | revision of bypass for coronary artery nos |

| | | |
|---|---|---|
| 7925 | Read | connection of mammary artery to coronary artery |
| 7925000 | Read | double anastomosis of mammary arteries to coronary arteries |
| 7925100 | Read | double implant of mammary arteries into coronary arteries |
| 7925.11.00 | Read | creation of bypass from mammary artery to coronary artery |
| 7925300 | Read | single anastomosis of mammary artery to coronary artery nec |
| 7925311 | Read | lima single anastomosis |
| 7925312 | Read | rima single anastomosis |
| 7925400 | Read | single implantation of mammary artery into coronary artery |
| 7925y00 | Read | connection of mammary artery to coronary artery os |
| 7925z00 | Read | connection of mammary artery to coronary artery nos |
| 7926 | Read | connection of other thoracic artery to coronary artery |
| 7926000 | Read | double anastom thoracic arteries to coronary arteries nec |
| 7926200 | Read | single anastomosis of thoracic artery to coronary artery nec |
| 7926300 | Read | single implantation thoracic artery into coronary artery nec |
| 7926z00 | Read | connection of other thoracic artery to coronary artery nos |
| 7927500 | Read | open angioplasty of coronary artery |
| 7928 | Read | transluminal balloon angioplasty of coronary artery |
| 7928000 | Read | percut transluminal balloon angioplasty one coronary artery |
| 7928100 | Read | percut translum balloon angioplasty mult coronary arteries |
| 7928.11.00 | Read | percutaneous balloon coronary angioplasty |
| 7928200 | Read | percut translum balloon angioplasty bypass graft coronary a |
| 7928300 | Read | percut translum cutting balloon angioplasty coronary artery |
| 7928y00 | Read | transluminal balloon angioplasty of coronary artery os |
| 7928z00 | Read | transluminal balloon angioplasty of coronary artery nos |
| 7929000 | Read | percutaneous transluminal laser coronary angioplasty |
| 7929100 | Read | percut transluminal coronary thrombolysis with streptokinase |
| 7929111 | Read | percut translum coronary thrombolytic therapy- streptokinase |
| 7929300 | Read | rotary blade coronary angioplasty |
| 7929400 | Read | insertion of coronary artery stent |
| 7929500 | Read | insertion of drug-eluting coronary artery stent |
| 7929600 | Read | percutaneous transluminal atherectomy of coronary artery |
| 792B000 | Read | endarterectomy of coronary artery nec |
| 792C.00 | Read | other replacement of coronary artery |
| 792C000 | Read | replacement of coronary arteries using multiple methods |
| 792Cy00 | Read | other specified replacement of coronary artery |
| 792Cz00 | Read | replacement of coronary artery nos |
| 792D.00 | Read | other bypass of coronary artery |
| 792Dy00 | Read | other specified other bypass of coronary artery |
| 792Dz00 | Read | other bypass of coronary artery nos |
| 793G.00 | Read | perc translumin balloon angioplasty stenting coronary artery |
| 793G000 | Read | perc translum ball angio insert 1-2 drug elut stents cor art |
| 793G100 | Read | perc tran ball angio ins 3 or more drug elut stents cor art |
| 793G200 | Read | perc translum balloon angioplasty insert 1-2 stents cor art |
| 793G300 | Read | percutaneous cor balloon angiop 3 more stents cor art nec |
| 793Gy00 | Read | os perc translumina balloon angioplast stenting coronary art |

| | | |
|---|---|---|
| 793Gz00 | Read | perc translum balloon angioplasty stenting coronary art nos |
| 7A4B800 | Read | percut translum thrombolysis femoral graft streptokinase |
| 7A54000 | Read | percutaneous transluminal angioplasty of artery nec |
| 7A54500 | Read | rotary blade angioplasty |
| 7A54700 | Read | percutaneous transluminal thrombolysis of artery |
| 7A54800 | Read | percutaneous transluminal atherectomy |
| 7A56000 | Read | percutaneous transluminal arterial thrombolysis reconstruct |
| 7A56400 | Read | percutaneous transluminal balloon angioplasty of artery |
| 7A6G100 | Read | peroperative angioplasty |
| 7A6H300 | Read | prosthetic graft patch angioplasty |
| 7A6H400 | Read | percutaneous transluminal angioplasty of vascular graft |
| 7A6S300 | Read | percutaneous transluminal venous thrombolysis nec |
| 889A.00 | Read | diab mellit insulin-glucose infus acute myocardial infarct |
| 8B27.00 | Read | antianginal therapy |
| 8B3k.00 | Read | coronary heart disease medication review |
| 8BGC.00 | Read | long term dual antiplatelet drug therapy indicated |
| 8CMP.00 | Read | coronary heart disease care plan |
| 8F9..00 | Read | Cardiac rehabilitation |
| 8F90.00 | Read | Cardiac rehabilitation - phase 1 |
| 8F91.00 | Read | Cardiac rehabilitation - phase 2 |
| 8F92.00 | Read | Cardiac rehabilitation - phase 3 |
| 8F93.00 | Read | Cardiac rehabilitation - phase 4 |
| 8H2V.00 | Read | admit ischaemic heart disease emergency |
| 8H7v.00 | Read | Referral to cardiac rehabilitation nurse |
| 8I37.00 | Read | Coronary heart disease monitoring refused |
| 8I3a.00 | Read | Cardiac rehabilitation declined |
| 8IEY.00 | Read | referral to angina plan self-management programme declined |
| 8L40.00 | Read | coronary artery bypass graft operation planned |
| 8L41.00 | Read | coronary angioplasty planned |
| 8LF..00 | Read | coronary angiography planned |
| 8T04.00 | Read | referral to angina plan self-management programme |
| 9Ob..00 | Read | Coronary heart disease monitoring administration |
| 9Ob0.00 | Read | Attends coronary heart disease monitoring |
| 9Ob1.00 | Read | Refuses coronary heart disease monitoring |
| 9Ob2.00 | Read | Coronary heart disease monitoring default |
| 9Ob3.00 | Read | Coronary heart disease monitoring 1st letter |
| 9Ob4.00 | Read | Coronary heart disease monitoring 2nd letter |
| 9Ob5.00 | Read | Coronary heart disease monitoring 3rd letter |
| 9Ob6.00 | Read | Coronary heart disease monitoring verbal invitation |
| 9Ob8.00 | Read | Coronary heart disease monitoring check done |
| 9Ob9.00 | Read | Coronary heart disease monitoring telephone invite |
| G....12 | Read | Cardiac diseases |
| G....13 | Read | Heart diseases |
| G3...00 | Read | ischaemic heart disease |
| G30..00 | Read | acute myocardial infarction |

| | | |
|---|---|---|
| G300.00 | Read | acute anterolateral infarction |
| G301.00 | Read | other specified anterior myocardial infarction |
| G301000 | Read | acute anteroapical infarction |
| G30..11 | Read | attack - heart |
| G301100 | Read | acute anteroseptal infarction |
| G30..12 | Read | coronary thrombosis |
| G30..13 | Read | cardiac rupture following myocardial infarction (mi) |
| G30..14 | Read | heart attack |
| G30..15 | Read | mi - acute myocardial infarction |
| G30..16 | Read | thrombosis - coronary |
| G30..17 | Read | silent myocardial infarction |
| G301z00 | Read | anterior myocardial infarction nos |
| G302.00 | Read | acute inferolateral infarction |
| G303.00 | Read | acute inferoposterior infarction |
| G304.00 | Read | posterior myocardial infarction nos |
| G305.00 | Read | lateral myocardial infarction nos |
| G306.00 | Read | true posterior myocardial infarction |
| G307.00 | Read | acute subendocardial infarction |
| G307000 | Read | acute non-q wave infarction |
| G307100 | Read | acute non-st segment elevation myocardial infarction |
| G308.00 | Read | inferior myocardial infarction nos |
| G309.00 | Read | acute q-wave infarct |
| G30A.00 | Read | mural thrombosis |
| G30B.00 | Read | acute posterolateral myocardial infarction |
| G30X.00 | Read | acute transmural myocardial infarction of unspecif site |
| G30X000 | Read | acute st segment elevation myocardial infarction |
| G30y.00 | Read | other acute myocardial infarction |
| G30y000 | Read | acute atrial infarction |
| G30y100 | Read | acute papillary muscle infarction |
| G30y200 | Read | acute septal infarction |
| G30yz00 | Read | other acute myocardial infarction nos |
| G30z.00 | Read | acute myocardial infarction nos |
| G31..00 | Read | other acute and subacute ischaemic heart disease |
| G310.00 | Read | postmyocardial infarction syndrome |
| G310.11 | Read | dressler's syndrome |
| G3...11 | Read | arteriosclerotic heart disease |
| G311.00 | Read | preinfarction syndrome |
| G311000 | Read | myocardial infarction aborted |
| G311011 | Read | mi - myocardial infarction aborted |
| G311100 | Read | unstable angina |
| G311.11 | Read | crescendo angina |
| G311.12 | Read | impending infarction |
| G311.13 | Read | unstable angina |
| G311.14 | Read | angina at rest |
| G311200 | Read | angina at rest |

| | | |
|---|---|---|
| G311300 | Read | refractory angina |
| G311400 | Read | worsening angina |
| G311500 | Read | acute coronary syndrome |
| G311z00 | Read | preinfarction syndrome nos |
| G3...12 | Read | atherosclerotic heart disease |
| G312.00 | Read | coronary thrombosis not resulting in myocardial infarction |
| G3...13 | Read | ihd - ischaemic heart disease |
| G31y.00 | Read | other acute and subacute ischaemic heart disease |
| G31y000 | Read | acute coronary insufficiency |
| G31y100 | Read | microinfarction of heart |
| G31y200 | Read | subendocardial ischaemia |
| G31y300 | Read | transient myocardial ischaemia |
| G31yz00 | Read | other acute and subacute ischaemic heart disease nos |
| G32..00 | Read | old myocardial infarction |
| G32..11 | Read | healed myocardial infarction |
| G32..12 | Read | personal history of myocardial infarction |
| G33..00 | Read | angina pectoris |
| G330.00 | Read | angina decubitus |
| G330000 | Read | nocturnal angina |
| G330z00 | Read | angina decubitus nos |
| G331.11 | Read | variant angina pectoris |
| G332.00 | Read | coronary artery spasm |
| G33z.00 | Read | angina pectoris nos |
| G33z000 | Read | status anginosus |
| G33z100 | Read | stenocardia |
| G33z200 | Read | syncope anginosa |
| G33z300 | Read | angina on effort |
| G33z400 | Read | ischaemic chest pain |
| G33z500 | Read | post infarct angina |
| G33z600 | Read | new onset angina |
| G33z700 | Read | stable angina |
| G33zz00 | Read | angina pectoris nos |
| G34..00 | Read | other chronic ischaemic heart disease |
| G340.00 | Read | coronary atherosclerosis |
| G340000 | Read | single coronary vessel disease |
| G340100 | Read | double coronary vessel disease |
| G340.11 | Read | triple vessel disease of the heart |
| G340.12 | Read | coronary artery disease |
| G341.00 | Read | Aneurysm of heart |
| G341000 | Read | Ventricular cardiac aneurysm |
| G341100 | Read | Other cardiac wall aneurysm |
| G341.11 | Read | Cardiac aneurysm |
| G341z00 | Read | Aneurysm of heart NOS |
| G342.00 | Read | atherosclerotic cardiovascular disease |
| G343.00 | Read | Ischaemic cardiomyopathy |

| | | |
|---|---|---|
| G344.00 | Read | silent myocardial ischaemia |
| G34y.00 | Read | other specified chronic ischaemic heart disease |
| G34y000 | Read | chronic coronary insufficiency |
| G34y100 | Read | chronic myocardial ischaemia |
| G34yz00 | Read | other specified chronic ischaemic heart disease nos |
| G34z.00 | Read | other chronic ischaemic heart disease nos |
| G34z000 | Read | asymptomatic coronary heart disease |
| G35..00 | Read | subsequent myocardial infarction |
| G350.00 | Read | subsequent myocardial infarction of anterior wall |
| G351.00 | Read | subsequent myocardial infarction of inferior wall |
| G353.00 | Read | subsequent myocardial infarction of other sites |
| G35X.00 | Read | subsequent myocardial infarction of unspecified site |
| G36..00 | Read | certain current complication follow acute myocardial infarct |
| G360.00 | Read | haemopericardium/current comp folow acut myocard infarct |
| G361.00 | Read | atrial septal defect/curr comp folow acut myocardal infarct |
| G362.00 | Read | ventric septal defect/curr comp fol acut myocardal infarctn |
| G363.00 | Read | ruptur cardiac wall w'out haemopericard/cur comp fol ac mi |
| G364.00 | Read | ruptur chordae tendinae/curr comp fol acute myocard infarct |
| G365.00 | Read | rupture papillary muscle/curr comp fol acute myocard infarct |
| G366.00 | Read | thrombosis atrium |
| G38..00 | Read | postoperative myocardial infarction |
| G380.00 | Read | postoperative transmural myocardial infarction anterior wall |
| G381.00 | Read | postoperative transmural myocardial infarction inferior wall |
| G383.00 | Read | postoperative transmural myocardial infarction unspec site |
| G384.00 | Read | postoperative subendocardial myocardial infarction |
| G38z.00 | Read | postoperative myocardial infarction |
| G39..00 | Read | coronary microvascular disease |
| G3y..00 | Read | other specified ischaemic heart disease |
| G3z..00 | Read | ischaemic heart disease nos |
| G5...00 | Read | other forms of heart disease |
| G501.00 | Read | post infarction pericarditis |
| G574000 | Read | Ventricular fibrillation |
| G5y..00 | Read | other specified heart disease |
| G5yyz00 | Read | Other ill-defined heart disease NOS |
| G5yz.00 | Read | other heart disease nos |
| G5z..00 | Read | heart disease nos |
| Gyu3.00 | Read | [x]ischaemic heart diseases |
| Gyu3000 | Read | [x]other forms of angina pectoris |
| Gyu3200 | Read | [x]other forms of acute ischaemic heart disease |
| Gyu3300 | Read | [x]other forms of chronic ischaemic heart disease |
| Gyu3400 | Read | [x]acute transmural myocardial infarction of unspecif site |
| Gyu3600 | Read | [x]subsequent myocardial infarction of unspecified site |
| Gyu5.00 | Read | [x]other forms of heart disease |
| Gyu7000 | Read | [x]atherosclerosis of other arteries |
| SP00300 | Read | mechanical complication of coronary bypass |

| | | |
|---|---|---|
| SP07600 | Read | coronary artery bypass graft occlusion |
| Z677.00 | Read | Cardiac rehabilitation class |
| ZL22200 | Read | Under care of cardiac rehabilitation nurse |
| ZV45700 | Read | [v]presence of aortocoronary bypass graft |
| ZV45800 | Read | [v]presence of coronary angioplasty implant and graft |
| ZV45K00 | Read | [v]presence of coronary artery bypass graft |
| ZV45K11 | Read | [v]presence of coronary artery bypass graft - cabg |
| ZV45L00 | Read | [v]status following coronary angioplasty nos |
| ZV57900 | Read | [V]Cardiac rehabilitation |
| I20 | ICD-10 | angina pectoris |
| I20.0 | ICD-10 | unstable angina |
| I20.1 | ICD-10 | angina pectoris with documented spasm |
| I20.8 | ICD-10 | other forms of angina pectoris |
| I20.9 | ICD-10 | angina pectoris |
| I21 | ICD-10 | acute myocardial infarction |
| I21.0 | ICD-10 | acute transmural myocardial infarction of anterior wall |
| I21.1 | ICD-10 | acute transmural myocardial infarction of inferior wall |
| I21.2 | ICD-10 | acute transmural myocardial infarction of other sites |
| I21.3 | ICD-10 | acute transmural myocardial infarction of unspecified site |
| I21.4 | ICD-10 | acute subendocardial myocardial infarction |
| I21.9 | ICD-10 | acute myocardial infarction |
| I22 | ICD-10 | subsequent myocardial infarction |
| I22.0 | ICD-10 | subsequent myocardial infarction of anterior wall |
| I22.1 | ICD-10 | subsequent myocardial infarction of inferior wall |
| I22.8 | ICD-10 | subsequent myocardial infarction of other sites |
| I22.9 | ICD-10 | subsequent myocardial infarction of unspecified site |
| I23 | ICD-10 | certain current complications following acute myocardial infarction |
| I23.0 | ICD-10 | haemopericardium as current complication following acute myocardial infarction |
| I23.1 | ICD-10 | atrial septal defect as current complication following acute myocardial infarction |
| I23.2 | ICD-10 | ventricular septal defect as current complication following acute myocardial infarction |
| I23.3 | ICD-10 | rupture of cardiac wall without haemopericardium as current complication following acute myocardial |
| I23.4 | ICD-10 | rupture of chordae tendineae as current complication following acute myocardial infarction |
| I23.5 | ICD-10 | rupture of papillary muscle as current complication following acute myocardial infarction |
| I23.6 | ICD-10 | thrombosis of atrium |
| I23.8 | ICD-10 | other current complications following acute myocardial infarction |
| I24 | ICD-10 | other acute ischaemic heart diseases |
| I24.0 | ICD-10 | coronary thrombosis not resulting in myocardial infarction |
| I24.1 | ICD-10 | dressler's syndrome |
| I24.8 | ICD-10 | other forms of acute ischaemic heart disease |
| I24.9 | ICD-10 | acute ischaemic heart disease |
| I25 | ICD-10 | chronic ischaemic heart disease |
| I25.0 | ICD-10 | atherosclerotic cardiovascular disease |
| I25.1 | ICD-10 | atherosclerotic heart disease |
| I25.2 | ICD-10 | old myocardial infarction |
| I25.5 | ICD-10 | ischaemic cardiomyopathy |

| | | |
|---|---|---|
| I25.6 | ICD-10 | silent myocardial ischaemia |
| I25.8 | ICD-10 | other forms of chronic ischaemic heart disease |
| I25.9 | ICD-10 | chronic ischaemic heart disease |
| T82.2 | ICD-10 | mechanical complication of coronary artery bypass and valve grafts |
| Z95.5 | ICD-10 | presence of coronary angioplasty implant and graft |

## Heart failure

| Code | Classification | Description |
|---|---|---|
| 14A6.00 | Read | h/o: heart failure |
| 14AM.00 | Read | h/o: heart failure in last year |
| 1736 | Read | paroxysmal nocturnal dyspnoea |
| 1J60.00 | Read | suspected heart failure |
| 1O1..00 | Read | heart failure confirmed |
| 388D.00 | Read | new york heart assoc classification heart failure symptoms |
| 585f.00 | Read | echocardiogram shows left ventricular systolic dysfunction |
| 585g.00 | Read | echocardiogram shows left ventricular diastolic dysfunction |
| 661M500 | Read | heart failure self-management plan agreed |
| 662f.00 | Read | new york heart association classification - class i |
| 662g.00 | Read | new york heart association classification - class ii |
| 662h.00 | Read | new york heart association classification - class iii |
| 662i.00 | Read | new york heart association classification - class iv |
| 662p.00 | Read | heart failure 6 month review |
| 662T.00 | Read | congestive heart failure monitoring |
| 662W.00 | Read | heart failure annual review |
| 679W100 | Read | education about deteriorating heart failure |
| 679X.00 | Read | heart failure education |
| 67D4.00 | Read | heart failure information given to patient |
| 8B29.00 | Read | cardiac failure therapy |
| 8CeC.00 | Read | preferred place of care for next exacerbation heart failure |
| 8CL3.00 | Read | heart failure care plan discussed with patient |
| 8CMK.00 | Read | has heart failure management plan |
| 8CMW800 | Read | heart failure clinical pathway |
| 8H2S.00 | Read | admit heart failure emergency |
| 8HBE.00 | Read | heart failure follow-up |
| 8Hg8.00 | Read | discharge from practice nurse heart failure clinic |
| 8HgD.00 | Read | discharge from heart failure nurse service |
| 8HHb.00 | Read | referral to heart failure nurse |
| 8HHz.00 | Read | referral to heart failure exercise programme |
| 8Hk0.00 | Read | referred to heart failure education group |
| 8HTL.00 | Read | referral to heart failure clinic |
| 8HTL000 | Read | referral to rapid access heart failure clinic |
| 8IE0.00 | Read | referral to heart failure education group declined |
| 8IE1.00 | Read | referral to heart failure exercise programme declined |
| 9h1..00 | Read | exception reporting: lvd quality indicators |

| | | |
|---|---|---|
| 9h11.00 | Read | excepted from lvd quality indicators: patient unsuitable |
| 9h12.00 | Read | excepted from lvd quality indicators: informed dissent |
| 9hH..00 | Read | exception reporting: heart failure quality indicators |
| 9hH0.00 | Read | excepted heart failure quality indicators: patient unsuitabl |
| 9hH1.00 | Read | excepted heart failure quality indicators: informed dissent |
| 9N0k.00 | Read | seen in heart failure clinic |
| 9N2p.00 | Read | seen by community heart failure nurse |
| 9N4s.00 | Read | did not attend practice nurse heart failure clinic |
| 9N4w.00 | Read | did not attend heart failure clinic |
| 9N6T.00 | Read | referred by heart failure nurse specialist |
| 9On..00 | Read | left ventricular dysfunction monitoring administration |
| 9On0.00 | Read | left ventricular dysfunction monitoring first letter |
| 9On1.00 | Read | left ventricular dysfunction monitoring second letter |
| 9On2.00 | Read | left ventricular dysfunction monitoring third letter |
| 9On3.00 | Read | left ventricular dysfunction monitoring verbal invite |
| 9On4.00 | Read | left ventricular dysfunction monitoring telephone invite |
| 9Or..00 | Read | heart failure monitoring administration |
| 9Or0.00 | Read | heart failure review completed |
| 9Or1.00 | Read | heart failure monitoring telephone invite |
| 9Or2.00 | Read | heart failure monitoring verbal invite |
| 9Or3.00 | Read | heart failure monitoring first letter |
| 9Or4.00 | Read | heart failure monitoring second letter |
| 9Or5.00 | Read | heart failure monitoring third letter |
| G1yz100 | Read | rheumatic left ventricular failure |
| G210.00 | Read | malignant hypertensive heart disease |
| G210100 | Read | malignant hypertensive heart disease with ccf |
| G211100 | Read | benign hypertensive heart disease with ccf |
| G21z100 | Read | hypertensive heart disease nos with ccf |
| G230.00 | Read | malignant hypertensive heart and renal disease |
| G232.00 | Read | hypertensive heart&renal dis wth (congestive) heart failure |
| G234.00 | Read | hyperten heart&renal dis+both(congestv)heart and renal fail |
| G400.00 | Read | acute cor pulmonale |
| G41z.11 | Read | chronic cor pulmonale |
| G554000 | Read | congestive cardiomyopathy |
| G554011 | Read | congestive obstructive cardiomyopathy |
| G557100 | Read | beriberi heart disease |
| G58..00 | Read | heart failure |
| G580.00 | Read | congestive heart failure |
| G580000 | Read | acute congestive heart failure |
| G580100 | Read | chronic congestive heart failure |
| G580.11 | Read | congestive cardiac failure |
| G580.12 | Read | right heart failure |
| G580.13 | Read | right ventricular failure |
| G580.14 | Read | biventricular failure |
| G580200 | Read | decompensated cardiac failure |

| | | |
|---|---|---|
| G580300 | Read | compensated cardiac failure |
| G580400 | Read | congestive heart failure due to valvular disease |
| G581.00 | Read | left ventricular failure |
| G581000 | Read | acute left ventricular failure |
| G58..11 | Read | cardiac failure |
| G581.11 | Read | asthma - cardiac |
| G581.13 | Read | impaired left ventricular function |
| G582.00 | Read | acute heart failure |
| G583.00 | Read | heart failure with normal ejection fraction |
| G583.11 | Read | hfnef - heart failure with normal ejection fraction |
| G583.12 | Read | heart failure with preserved ejection fraction |
| G584.00 | Read | right ventricular failure |
| G58z.00 | Read | heart failure nos |
| G58z.11 | Read | weak heart |
| G58z.12 | Read | cardiac failure nos |
| G5y4z00 | Read | post cardiac operation heart failure nos |
| G5yy900 | Read | left ventricular systolic dysfunction |
| G5yyA00 | Read | left ventricular diastolic dysfunction |
| G5yyB00 | Read | right ventricular diastolic dysfunction |
| Q48y100 | Read | congenital cardiac failure |
| R2y1000 | Read | [d]cardiorespiratory failure |
| SP11111 | Read | heart failure as a complication of care |
| ZRad.00 | Read | new york heart assoc classification heart failure symptoms |
| I11.0 | ICD-10 | hypertensive heart disease with (congestive) heart failure |
| I13.0 | ICD-10 | hypertensive heart and renal disease with (congestive) heart failure |
| I13.2 | ICD-10 | hypertensive heart and renal disease with both (congestive) heart failure and renal failure |
| I26.0 | ICD-10 | pulmonary embolism with mention of acute cor pulmonale |
| I50 | ICD-10 | heart failure |
| I50.0 | ICD-10 | congestive heart failure |
| I50.1 | ICD-10 | left ventricular failure |
| I50.9 | ICD-10 | heart failure |

## Hypertension

| Code | Classification | Description |
|---|---|---|
| 14A2.00 | Read | h/o: hypertension |
| 1JD..00 | Read | suspected hypertension |
| 2126100 | Read | hypertension resolved |
| 212K.00 | Read | hypertension resolved |
| 246M.00 | Read | white coat hypertension |
| 662..12 | Read | hypertension monitoring |
| 6624 | Read | borderline hyperten:yearly obs |
| 6627 | Read | good hypertension control |
| 6628 | Read | poor hypertension control |
| 6629 | Read | hypertension:follow-up default |

| | | |
|---|---|---|
| 662b.00 | Read | moderate hypertension control |
| 662c.00 | Read | hypertension six month review |
| 662d.00 | Read | hypertension annual review |
| 662F.00 | Read | hypertension treatm. started |
| 662G.00 | Read | hypertensive treatm.changed |
| 662H.00 | Read | hypertension treatm.stopped |
| 662O.00 | Read | on treatment for hypertension |
| 662P.00 | Read | hypertension monitoring |
| 662P000 | Read | hypertension 9 month review |
| 662q.00 | Read | trial reduction of antihypertensive therapy |
| 662r.00 | Read | trial withdrawal of antihypertensive therapy |
| 67H8.00 | Read | lifestyle advice regarding hypertension |
| 7Q01.00 | Read | high cost hypertension drugs |
| 7Q01y00 | Read | other specified high cost hypertension drugs |
| 8B26.00 | Read | antihypertensive therapy |
| 8BL0.00 | Read | patient on maximal tolerated antihypertensive therapy |
| 8CR4.00 | Read | hypertension clinical management plan |
| 8HT5.00 | Read | referral to hypertension clinic |
| 8I3N.00 | Read | hypertension treatment refused |
| 9h3..00 | Read | exception reporting: hypertension quality indicators |
| 9h31.00 | Read | excepted from hypertension qual indicators: patient unsuit |
| 9h32.00 | Read | excepted from hypertension qual indicators: informed dissent |
| 9N03.00 | Read | seen in hypertension clinic |
| 9N1y200 | Read | seen in hypertension clinic |
| 9N4L.00 | Read | dna - did not attend hypertension clinic |
| 9OI..00 | Read | hypertension monitoring admin. |
| 9OI1.00 | Read | attends hypertension monitor. |
| 9OI..11 | Read | hypertension clinic admin. |
| 9OI2.00 | Read | refuses hypertension monitor. |
| 9OI3.00 | Read | hyperten.monitor offer default |
| 9OI4.00 | Read | hypertens.monitor.1st letter |
| 9OI5.00 | Read | hypertens.monitor 2nd letter |
| 9OI6.00 | Read | hypertens.monitor 3rd letter |
| 9OI7.00 | Read | hypertens.monitor verbal inv. |
| 9OI8.00 | Read | hypertens.monitor phone invite |
| 9OI9.00 | Read | hypertens.monitor deleted |
| 9OIA.00 | Read | hypertension monitor.chck done |
| 9OIA.11 | Read | hypertension monitored |
| 9OIZ.00 | Read | hypertens.monitoring admin.nos |
| F404200 | Read | blind hypertensive eye |
| F421300 | Read | hypertensive retinopathy |
| G2...00 | Read | hypertensive disease |
| G20..00 | Read | essential hypertension |
| G200.00 | Read | malignant essential hypertension |
| G201.00 | Read | benign essential hypertension |

| | | |
|---|---|---|
| G20..11 | Read | high blood pressure |
| G20..12 | Read | primary hypertension |
| G202.00 | Read | systolic hypertension |
| G203.00 | Read | diastolic hypertension |
| G20z.00 | Read | essential hypertension nos |
| G20z.11 | Read | hypertension nos |
| G21..00 | Read | hypertensive heart disease |
| G210.00 | Read | malignant hypertensive heart disease |
| G210000 | Read | malignant hypertensive heart disease without ccf |
| G210100 | Read | malignant hypertensive heart disease with ccf |
| G210z00 | Read | malignant hypertensive heart disease nos |
| G2...11 | Read | bp - hypertensive disease |
| G211.00 | Read | benign hypertensive heart disease |
| G211000 | Read | benign hypertensive heart disease without ccf |
| G211100 | Read | benign hypertensive heart disease with ccf |
| G211z00 | Read | benign hypertensive heart disease nos |
| G21z.00 | Read | hypertensive heart disease nos |
| G21z000 | Read | hypertensive heart disease nos without ccf |
| G21z011 | Read | cardiomegaly - hypertensive |
| G21z100 | Read | hypertensive heart disease nos with ccf |
| G21zz00 | Read | hypertensive heart disease nos |
| G22..00 | Read | hypertensive renal disease |
| G220.00 | Read | malignant hypertensive renal disease |
| G221.00 | Read | benign hypertensive renal disease |
| G22..11 | Read | nephrosclerosis |
| G222.00 | Read | hypertensive renal disease with renal failure |
| G22z.00 | Read | hypertensive renal disease nos |
| G22z.11 | Read | renal hypertension |
| G23..00 | Read | hypertensive heart and renal disease |
| G230.00 | Read | malignant hypertensive heart and renal disease |
| G231.00 | Read | benign hypertensive heart and renal disease |
| G232.00 | Read | hypertensive heart&renal dis wth (congestive) heart failure |
| G233.00 | Read | hypertensive heart and renal disease with renal failure |
| G234.00 | Read | hyperten heart&renal dis+both(congestv)heart and renal fail |
| G23z.00 | Read | hypertensive heart and renal disease nos |
| G24..00 | Read | secondary hypertension |
| G240.00 | Read | secondary malignant hypertension |
| G240000 | Read | secondary malignant renovascular hypertension |
| G240z00 | Read | secondary malignant hypertension nos |
| G241.00 | Read | secondary benign hypertension |
| G241000 | Read | secondary benign renovascular hypertension |
| G241z00 | Read | secondary benign hypertension nos |
| G244.00 | Read | hypertension secondary to endocrine disorders |
| G24z.00 | Read | secondary hypertension nos |
| G24z000 | Read | secondary renovascular hypertension nos |

| | | |
|---|---|---|
| G24z100 | Read | hypertension secondary to drug |
| G24zz00 | Read | secondary hypertension nos |
| G25..00 | Read | stage 1 hypertension (nice - nat ins for hth clin excl 2011) |
| G25..11 | Read | stage 1 hypertension |
| G26..00 | Read | severe hypertension (nat inst for health clinical ex 2011) |
| G26..11 | Read | severe hypertension |
| G27..00 | Read | hypertension resistant to drug therapy |
| G28..00 | Read | stage 2 hypertension (nice - nat ins for hth clin excl 2011) |
| G2y..00 | Read | other specified hypertensive disease |
| G2z..00 | Read | hypertensive disease nos |
| G672.00 | Read | hypertensive encephalopathy |
| G672.11 | Read | hypertensive crisis |
| Gyu2.00 | Read | [x]hypertensive diseases |
| Gyu2000 | Read | [x]other secondary hypertension |
| Gyu2100 | Read | [x]hypertension secondary to other renal disorders |
| L122.00 | Read | other pre-existing hypertension in preg/childbirth/puerp |
| L122000 | Read | other pre-existing hypertension in preg/childb/puerp unspec |
| L122100 | Read | other pre-existing hypertension in preg/childb/puerp - deliv |
| L122300 | Read | other pre-exist hypertension in preg/childb/puerp-not deliv |
| L122z00 | Read | other pre-existing hypertension in preg/childb/puerp nos |
| L127.00 | Read | pre-eclampsia or eclampsia with pre-existing hypertension |
| L127z00 | Read | pre-eclampsia or eclampsia + pre-existing hypertension nos |
| L128.00 | Read | pre-exist hypertension compl preg childbirth and puerperium |
| L128000 | Read | pre-exist hyperten heart dis compl preg childbth+puerperium |
| L128200 | Read | pre-exist 2ndry hypertens comp preg childbth and puerperium |
| TJC7.00 | Read | adverse reaction to other antihypertensives |
| TJC7z00 | Read | adverse reaction to antihypertensives nos |
| U60C500 | Read | [x]oth antihyperten drug caus advers eff in therap use |
| U60C511 | Read | [x] adverse reaction to other antihypertensives |
| U60C51A | Read | [x] adverse reaction to antihypertensives nos |
| I10 | ICD-10 | essential (primary) hypertension |
| I11 | ICD-10 | hypertensive heart disease |
| I11.0 | ICD-10 | hypertensive heart disease with (congestive) heart failure |
| I11.9 | ICD-10 | hypertensive heart disease without (congestive) heart failure |
| I12 | ICD-10 | hypertensive renal disease |
| I12.0 | ICD-10 | hypertensive renal disease with renal failure |
| I12.9 | ICD-10 | hypertensive renal disease without renal failure |
| I13 | ICD-10 | hypertensive heart and renal disease |
| I13.0 | ICD-10 | hypertensive heart and renal disease with (congestive) heart failure |
| I13.1 | ICD-10 | hypertensive heart and renal disease with renal failure |
| I13.2 | ICD-10 | hypertensive heart and renal disease with both (congestive) heart failure and renal failure |
| I13.9 | ICD-10 | hypertensive heart and renal disease |
| I15 | ICD-10 | secondary hypertension |
| I15.0 | ICD-10 | renovascular hypertension |
| I15.1 | ICD-10 | hypertension secondary to other renal disorders |

| | | |
|---|---|---|
| I15.2 | ICD-10 | hypertension secondary to endocrine disorders |
| I15.8 | ICD-10 | other secondary hypertension |
| I15.9 | ICD-10 | secondary hypertension |
| I67.4 | ICD-10 | hypertensive encephalopathy |

## Arrhytmia

| Code | Classification | Description |
|---|---|---|
| 14AN.00 | Read | h/o: atrial fibrillation |
| 14AR.00 | Read | history of atrial flutter |
| 212R.00 | Read | atrial fibrillation resolved |
| 327..00 | Read | ecg: supraventricular arrhythmia |
| 3272 | Read | ecg: atrial fibrillation |
| 3273 | Read | ecg: atrial flutter |
| 328..00 | Read | ecg: ventricular arrhythmia |
| 3282 | Read | ecg: ventricular tachycardia |
| 328Z.00 | Read | ecg: ventricular arrhythmia nos |
| 662S.00 | Read | atrial fibrillation monitoring |
| 6A9..00 | Read | atrial fibrillation annual review |
| 7936A00 | Read | implant intravenous pacemaker for atrial fibrillation |
| 8CMW200 | Read | atrial fibrillation care pathway |
| 8HTy.00 | Read | referral to atrial fibrillation clinic |
| 9hF..00 | Read | exception reporting: atrial fibrillation quality indicators |
| 9hF1.00 | Read | excepted from atrial fibrillation qual indic: inform dissent |
| 9Os..00 | Read | atrial fibrillation monitoring administration |
| 9Os0.00 | Read | atrial fibrillation monitoring first letter |
| 9Os1.00 | Read | atrial fibrillation monitoring second letter |
| 9Os2.00 | Read | atrial fibrillation monitoring third letter |
| 9Os3.00 | Read | atrial fibrillation monitoring verbal invite |
| 9Os4.00 | Read | atrial fibrillation monitoring telephone invite |
| G559.00 | Read | arrhythmogenic right ventricular cardiomyopathy |
| G55A.11 | Read | tachycardia-induced cardiomyopathy |
| G56..00 | Read | conduction disorders |
| G56..11 | Read | conduction disorders of heart |
| G567400 | Read | wolff-parkinson-white syndrome |
| G56y.00 | Read | other conduction disorders |
| G56y000 | Read | lown-ganong-levine syndrome |
| G56zz00 | Read | conduction disorders nos |
| G57..00 | Read | cardiac dysrhythmias |
| G570.00 | Read | paroxysmal supraventricular tachycardia |
| G570000 | Read | paroxysmal atrial tachycardia |
| G570100 | Read | paroxysmal atrioventricular tachycardia |
| G570200 | Read | paroxysmal junctional tachycardia |
| G570300 | Read | paroxysmal nodal tachycardia |
| G570z00 | Read | paroxysmal supraventricular tachycardia nos |
| G571.00 | Read | paroxysmal ventricular tachycardia |

| | | |
|---|---|---|
| G57..11 | Read | cardiac arrhythmias |
| G571.11 | Read | ventricular tachycardia |
| G572.00 | Read | paroxysmal tachycardia unspecified |
| G572000 | Read | essential paroxysmal tachycardia |
| G572z00 | Read | paroxysmal tachycardia nos |
| G573.00 | Read | atrial fibrillation and flutter |
| G573000 | Read | atrial fibrillation |
| G573100 | Read | atrial flutter |
| G573200 | Read | paroxysmal atrial fibrillation |
| G573300 | Read | non-rheumatic atrial fibrillation |
| G573400 | Read | permanent atrial fibrillation |
| G573500 | Read | persistent atrial fibrillation |
| G573600 | Read | paroxysmal atrial flutter |
| G573z00 | Read | atrial fibrillation and flutter nos |
| G574.00 | Read | ventricular fibrillation and flutter |
| G574100 | Read | ventricular flutter |
| G574z00 | Read | ventricular fibrillation and flutter nos |
| G576300 | Read | atrial premature depolarization |
| G576400 | Read | junctional premature depolarization |
| G576500 | Read | ventricular premature depolarization |
| G57y.00 | Read | other cardiac dysrhythmias |
| G57y600 | Read | nodal rhythm disorder |
| G57y900 | Read | supraventricular tachycardia nos |
| G57yA00 | Read | re-entry ventricular arrhythmia |
| G57yz00 | Read | other cardiac dysrhythmia nos |
| G57z.00 | Read | cardiac dysrhythmia nos |
| Gyu5a00 | Read | [x]other specified cardiac arrhythmias |
| I45.6 | ICD-10 | pre-excitation syndrome |
| I47 | ICD-10 | paroxysmal tachycardia |
| I47.0 | ICD-10 | re-entry ventricular arrhythmia |
| I47.1 | ICD-10 | supraventricular tachycardia |
| I47.2 | ICD-10 | ventricular tachycardia |
| I47.9 | ICD-10 | paroxysmal tachycardia |
| I48 | ICD-10 | atrial fibrillation and flutter |
| I49 | ICD-10 | other cardiac arrhythmias |
| I49.0 | ICD-10 | ventricular fibrillation and flutter |
| I49.1 | ICD-10 | atrial premature depolarization |
| I49.2 | ICD-10 | junctional premature depolarization |
| I49.3 | ICD-10 | ventricular premature depolarization |
| I49.4 | ICD-10 | other and unspecified premature depolarization |
| I49.5 | ICD-10 | sick sinus syndrome |
| R00.0 | ICD-10 | tachycardia |

## Peripheral arterial disease

| Code | Classification | Description |
|---|---|---|

| | | |
|---|---|---|
| G73z000 | Read | intermittent claudication |
| G73z011 | Read | claudication |
| G73..12 | Read | ischaemia of legs |
| G73zz00 | Read | peripheral vascular disease nos |
| G73z.00 | Read | peripheral vascular disease nos |
| G73yz00 | Read | other specified peripheral vascular disease nos |
| G73..11 | Read | peripheral ischaemic vascular disease |
| G73..00 | Read | other peripheral vascular disease |
| G73..13 | Read | peripheral ischaemia |
| 2G63.00 | Read | ischaemic toe |
| G702.00 | Read | Extremity artery atheroma |
| G742z00 | Read | peripheral arterial embolism and thrombosis nos |
| G702z00 | Read | Extremity artery atheroma NOS |
| G76A.00 | Read | arterial insufficiency |
| G73y100 | Read | Peripheral angiopathic disease EC NOS |
| R055011 | Read | [d]peripheral circulatory failure |
| G73y.00 | Read | other specified peripheral vascular disease |
| 14NB.00 | Read | h/o: peripheral vascular disease procedure |
| Gyu7400 | Read | [x]other specified peripheral vascular diseases |
| 7A56600 | Read | percutaneous transluminal placement peripheral stent artery |
| G733.00 | Read | ischaemic foot |
| G73z012 | Read | vascular claudication |
| G734.00 | Read | peripheral arterial disease |
| 16I..00 | Read | claudication distance |
| I70.2 | ICD-10 | atherosclerosis of arteries of extremities |
| I70.20 | ICD-10 | atherosclerosis of arteries of extremities |
| I70.21 | ICD-10 | atherosclerosis of arteries of extremities |
| I73 | ICD-10 | other peripheral vascular diseases |
| I73.8 | ICD-10 | other specified peripheral vascular diseases |
| I73.9 | ICD-10 | peripheral vascular disease, unspecified |
| I79.2 | ICD-10 | peripheral angiopathy in diseases classified elsewhere |

## Mycardial infarction

| Code | Classification | Description |
|---|---|---|
| 14A3.00 | Read | H/O: myocardial infarct <60 |
| 14A4.00 | Read | H/O: myocardial infarct >60 |
| 14AH.00 | Read | H/O: Myocardial infarction in last year |
| 323..00 | Read | ECG: myocardial infarction |
| 3232.00.00 | Read | ECG: old myocardial infarction |
| 3233.00.00 | Read | ECG: antero-septal infarct. |
| 3234.00.00 | Read | ECG:posterior/inferior infarct |
| 3235.00.00 | Read | ECG: subendocardial infarct |
| 3236.00.00 | Read | ECG: lateral infarction |
| 323Z.00 | Read | ECG: myocardial infarct NOS |
| 32B2.00 | Read | ECG: Q wave abnormal |

| | | |
|---|---|---|
| 32B3.00 | Read | ECG: Q wave pathological |
| 32E3.00 | Read | ECG: S-T elevation |
| 44H3.00 | Read | Cardiac enzymes abnormal |
| 44H3000 | Read | Cardiac enzymes abnormal - first set |
| 44p2.00 | Read | Cardiac troponin positive |
| 7929100 | Read | Percut transluminal coronary thrombolysis with streptokinase |
| 7929111 | Read | Percut translum coronary thrombolytic therapy- streptokinase |
| 889A.00 | Read | Diab mellit insulin-glucose infus acute myocardial infarct |
| 8B3a.00 | Read | Door to needle time |
| 8B3g.00 | Read | Pain to thrombolysis time |
| G30..00 | Read | Acute myocardial infarction |
| G30..11 | Read | Attack - heart |
| G30..12 | Read | Coronary thrombosis |
| G30..13 | Read | Cardiac rupture following myocardial infarction (MI) |
| G30..14 | Read | Heart attack |
| G30..15 | Read | MI - acute myocardial infarction |
| G30..16 | Read | Thrombosis - coronary |
| G30..17 | Read | Silent myocardial infarction |
| G300.00 | Read | Acute anterolateral infarction |
| G301.00 | Read | Other specified anterior myocardial infarction |
| G301000 | Read | Acute anteroapical infarction |
| G301100 | Read | Acute anteroseptal infarction |
| G301z00 | Read | Anterior myocardial infarction NOS |
| G302.00 | Read | Acute inferolateral infarction |
| G303.00 | Read | Acute inferoposterior infarction |
| G304.00 | Read | Posterior myocardial infarction NOS |
| G305.00 | Read | Lateral myocardial infarction NOS |
| G306.00 | Read | True posterior myocardial infarction |
| G307.00 | Read | Acute subendocardial infarction |
| G307000 | Read | Acute non-Q wave infarction |
| G307100 | Read | Acute non-ST segment elevation myocardial infarction |
| G308.00 | Read | Inferior myocardial infarction NOS |
| G309.00 | Read | Acute Q-wave infarct |
| G30A.00 | Read | Mural thrombosis |
| G30B.00 | Read | Acute posterolateral myocardial infarction |
| G30X.00 | Read | Acute transmural myocardial infarction of unspecif site |
| G30X000 | Read | Acute ST segment elevation myocardial infarction |
| G30y.00 | Read | Other acute myocardial infarction |
| G30y000 | Read | Acute atrial infarction |
| G30y100 | Read | Acute papillary muscle infarction |
| G30y200 | Read | Acute septal infarction |
| G30yz00 | Read | Other acute myocardial infarction NOS |
| G30z.00 | Read | Acute myocardial infarction NOS |
| G310.00 | Read | Postmyocardial infarction syndrome |
| G310.11 | Read | Dressler's syndrome |

| | | |
|---|---|---|
| G31y100 | Read | Microinfarction of heart |
| G32..00 | Read | Old myocardial infarction |
| G32..11 | Read | Healed myocardial infarction |
| G32..12 | Read | Personal history of myocardial infarction |
| G33z500 | Read | Post infarct angina |
| G35..00 | Read | Subsequent myocardial infarction |
| G350.00 | Read | Subsequent myocardial infarction of anterior wall |
| G351.00 | Read | Subsequent myocardial infarction of inferior wall |
| G353.00 | Read | Subsequent myocardial infarction of other sites |
| G35X.00 | Read | Subsequent myocardial infarction of unspecified site |
| G36..00 | Read | Certain current complication follow acute myocardial infarct |
| G360.00 | Read | Haemopericardium/current comp folow acut myocard infarct |
| G361.00 | Read | Atrial septal defect/curr comp folow acut myocardal infarct |
| G362.00 | Read | Ventric septal defect/curr comp fol acut myocardal infarctn |
| G363.00 | Read | Ruptur cardiac wall w'out haemopericard/cur comp fol ac MI |
| G364.00 | Read | Ruptur chordae tendinae/curr comp fol acute myocard infarct |
| G365.00 | Read | Rupture papillary muscle/curr comp fol acute myocard infarct |
| G366.00 | Read | Thrombosis atrium,auric append&vent/curr comp foll acute MI |
| G38..00 | Read | Postoperative myocardial infarction |
| G380.00 | Read | Postoperative transmural myocardial infarction anterior wall |
| G381.00 | Read | Postoperative transmural myocardial infarction inferior wall |
| G384.00 | Read | Postoperative subendocardial myocardial infarction |
| G38z.00 | Read | Postoperative myocardial infarction, unspecified |
| G501.00 | Read | Post infarction pericarditis |
| Gyu3400 | Read | [X]Acute transmural myocardial infarction of unspecif site |
| I21 | ICD-10 | Acute myocardial infarction |
| I22 | ICD-10 | Subsequent myocardial infarction |
| I23 | ICD-10 | Certain current complications following acute myocardial infarction |

**Diabetes mellitus**

| Code | Classification | Description |
|---|---|---|
| 13AB.00 | Read | diabetic lipid lowering diet |
| 13AC.00 | Read | diabetic weight reducing diet |
| 13B1.00 | Read | diabetic diet |
| 13L4.11 | Read | diabetic child |
| 1434 | Read | h/o: diabetes mellitus |
| 14F4.00 | Read | h/o: admission in last year for diabetes foot problem |
| 14P3.00 | Read | h/o: insulin therapy |
| 2BBF.00 | Read | retinal abnormality - diabetes related |
| 2BBJ.00 | Read | o/e - no right diabetic retinopathy |
| 2BBk.00 | Read | o/e - right eye stable treated prolif diabetic retinopathy |
| 2BBK.00 | Read | o/e - no left diabetic retinopathy |
| 2BBl.00 | Read | o/e - left eye stable treated prolif diabetic retinopathy |
| 2BBL.00 | Read | o/e - diabetic maculopathy present both eyes |
| 2BBM.00 | Read | o/e - diabetic maculopathy absent both eyes |

| | | |
|---|---|---|
| 2BBo.00 | Read | o/e - sight threatening diabetic retinopathy |
| 2BBP.00 | Read | o/e - right eye background diabetic retinopathy |
| 2BBQ.00 | Read | o/e - left eye background diabetic retinopathy |
| 2BBr.00 | Read | impaired vision due to diabetic retinopathy |
| 2BBR.00 | Read | o/e - right eye preproliferative diabetic retinopathy |
| 2BBS.00 | Read | o/e - left eye preproliferative diabetic retinopathy |
| 2BBT.00 | Read | o/e - right eye proliferative diabetic retinopathy |
| 2BBV.00 | Read | o/e - left eye proliferative diabetic retinopathy |
| 2BBW.00 | Read | o/e - right eye diabetic maculopathy |
| 2BBX.00 | Read | o/e - left eye diabetic maculopathy |
| 2G51000 | Read | foot abnormality - diabetes related |
| 2G5A.00 | Read | o/e - right diabetic foot at risk |
| 2G5B.00 | Read | o/e - left diabetic foot at risk |
| 2G5C.00 | Read | foot abnormality - diabetes related |
| 2G5d.00 | Read | o/e - left diabetic foot at increased risk |
| 2G5e.00 | Read | o/e - right diabetic foot at increased risk |
| 2G5E.00 | Read | o/e - right diabetic foot at low risk |
| 2G5F.00 | Read | o/e - right diabetic foot at moderate risk |
| 2G5G.00 | Read | o/e - right diabetic foot at high risk |
| 2G5H.00 | Read | o/e - right diabetic foot - ulcerated |
| 2G5I.00 | Read | o/e - left diabetic foot at low risk |
| 2G5J.00 | Read | o/e - left diabetic foot at moderate risk |
| 2G5K.00 | Read | o/e - left diabetic foot at high risk |
| 2G5L.00 | Read | o/e - left diabetic foot - ulcerated |
| 2G5V.00 | Read | o/e - right chronic diabetic foot ulcer |
| 2G5W.00 | Read | o/e - left chronic diabetic foot ulcer |
| 3881 | Read | education score - diabetes |
| 3882 | Read | diabetes well being questionnaire |
| 3883 | Read | diabetes treatment satisfaction questionnaire |
| 42c..00 | Read | hba1 - diabetic control |
| 42c0.00 | Read | hba1 < 7% - good control |
| 42c1.00 | Read | hba1 7 - 10% - borderline control |
| 42c2.00 | Read | hba1 > 10% - bad control |
| 42W..00 | Read | hb. a1c - diabetic control |
| 42W1.00 | Read | hb. a1c < 7% - good control |
| 42W2.00 | Read | hb. a1c 7-10% - borderline |
| 42W3.00 | Read | hb. a1c > 10% - bad control |
| 42WZ.00 | Read | hb. a1c - diabetic control nos |
| 44T9.00 | Read | glucometer blood sugar |
| 44UZ.00 | Read | blood glucose 14+ mmol/l |
| 44Uz.11 | Read | blood hyperglycaemia nos |
| 44V3.00 | Read | glucose tol. test diabetic |
| 661N400 | Read | diabetes self-management plan review |
| 66A..00 | Read | diabetic monitoring |
| 66A1.00 | Read | initial diabetic assessment |

| | | |
|---|---|---|
| 66A2.00 | Read | follow-up diabetic assessment |
| 66A3.00 | Read | diabetic on diet only |
| 66A4.00 | Read | diabetic on oral treatment |
| 66A5.00 | Read | diabetic on insulin |
| 66A8.00 | Read | has seen dietician - diabetes |
| 66A9.00 | Read | understands diet - diabetes |
| 66Aa.00 | Read | diabetic diet - poor compliance |
| 66AA.11 | Read | injection sites - diabetic |
| 66Ab.00 | Read | diabetic foot examination |
| 66Ac.00 | Read | diabetic peripheral neuropathy screening |
| 66AC.00 | Read | blood sugar charts |
| 66AD.00 | Read | fundoscopy - diabetic check |
| 66Ae.00 | Read | hba1c target |
| 66AE.00 | Read | feet examination |
| 66Af.00 | Read | patient diabetes education review |
| 66Ag.00 | Read | insulin needles changed daily |
| 66AG.00 | Read | diabetic drug side effects |
| 66Ah.00 | Read | insulin needles changed for each injection |
| 66AH.00 | Read | diabetic treatment changed |
| 66AH000 | Read | conversion to insulin |
| 66AH100 | Read | conversion to insulin in secondary care |
| 66AH200 | Read | conversion to insulin by diabetes specialist nurse |
| 66Ai.00 | Read | diabetic 6 month review |
| 66AI.00 | Read | diabetic - good control |
| 66Aj.00 | Read | insulin needles changed less than once a day |
| 66AJ.00 | Read | diabetic - poor control |
| 66AJ000 | Read | chronic hyperglycaemia |
| 66AJ100 | Read | brittle diabetes |
| 66AJ.11 | Read | unstable diabetes |
| 66AJ200 | Read | loss of hypoglycaemic warning |
| 66AJz00 | Read | diabetic - poor control nos |
| 66Ak.00 | Read | diabetic monitoring - lower risk albumin excretion |
| 66AK.00 | Read | diabetic - cooperative patient |
| 66Al.00 | Read | diabetic monitoring - higher risk albumin excretion |
| 66AL.00 | Read | diabetic-uncooperative patient |
| 66Am.00 | Read | insulin dose changed |
| 66AM.00 | Read | diabetic - follow-up default |
| 66An.00 | Read | diabetes type 1 review |
| 66AN.00 | Read | date diabetic treatment start |
| 66Ao.00 | Read | diabetes type 2 review |
| 66Ap.00 | Read | insulin treatment initiated |
| 66AP.00 | Read | diabetes: practice programme |
| 66Aq.00 | Read | diabetic foot screen |
| 66AQ.00 | Read | diabetes: shared care programme |
| 66AQ000 | Read | unsuitable for diabetes year of care programme |

| | | |
|---|---|---|
| 66AQ100 | Read | declined consent for diabetes year of care programme |
| 66AR.00 | Read | diabetes management plan given |
| 66As.00 | Read | diabetic on subcutaneous treatment |
| 66AS.00 | Read | diabetic annual review |
| 66AS000 | Read | diabetes year of care annual review |
| 66At.00 | Read | diabetic dietary review |
| 66AT.00 | Read | annual diabetic blood test |
| 66At000 | Read | type i diabetic dietary review |
| 66At011 | Read | type 1 diabetic dietary review |
| 66At100 | Read | type ii diabetic dietary review |
| 66At111 | Read | type 2 diabetic dietary review |
| 66Au.00 | Read | diabetic erectile dysfunction review |
| 66AU.00 | Read | diabetes care by hospital only |
| 66Av.00 | Read | diabetic assessment of erectile dysfunction |
| 66AV.00 | Read | diabetic on insulin and oral treatment |
| 66Aw.00 | Read | insulin dose |
| 66AW.00 | Read | diabetic foot risk assessment |
| 66AY.00 | Read | diabetic diet - good compliance |
| 66AZ.00 | Read | diabetic monitoring nos |
| 66b1.00 | Read | diabetic monitoring not required |
| 66o..00 | Read | further diabetic monitoring |
| 6761 | Read | diabetic pre-pregnancy counselling |
| 679c.00 | Read | insulin administration education |
| 679L.00 | Read | health education - diabetes |
| 679L000 | Read | education in self management of diabetes |
| 679L200 | Read | education about diabetes and driving |
| 679L211 | Read | advice about diabetes and driving |
| 679R.00 | Read | patient offered diabetes structured education programme |
| 67D8.00 | Read | provision of diabetes clinical summary |
| 68A7.00 | Read | diabetic retinopathy screening |
| 68A9.00 | Read | diabetic retinopathy screening offered |
| 68AB.00 | Read | diabetic digital retinopathy screening offered |
| 7276 | Read | pan retinal photocoagulation for diabetes |
| 7L10000 | Read | continuous subcutaneous infusion of insulin |
| 7L10011 | Read | subcutaneous infusion with insulin pump |
| 7L19800 | Read | subcutaneous injection of insulin |
| 7L19J00 | Read | subcutaneous injection of exenatide |
| 889A.00 | Read | diab mellit insulin-glucose infus acute myocardial infarct |
| 8A12.00 | Read | diabetic crisis monitoring |
| 8A13.00 | Read | diabetic stabilisation |
| 8A17.00 | Read | self monitoring of blood glucose |
| 8B3l.00 | Read | diabetes medication review |
| 8BAi.00 | Read | insulin passport completed |
| 8BAj.00 | Read | informed dissent not to carry insulin passport |
| 8BAm.00 | Read | insulin passport checked |

| | | |
|---|---|---|
| 8BL2.00 | Read | patient on maximal tolerated therapy for diabetes |
| 8CA4100 | Read | pt advised re diabetic diet |
| 8CAQ.00 | Read | advice about blood glucose control |
| 8CE0100 | Read | insulin alert patient information booklet given |
| 8CE0200 | Read | insulin passport given |
| 8CMW700 | Read | diabetes clinical pathway |
| 8CP2.00 | Read | transition of diabetes care options discussed |
| 8CR2.00 | Read | diabetes clinical management plan |
| 8CS0.00 | Read | diabetes care plan agreed |
| 8H2J.00 | Read | admit diabetic emergency |
| 8H3O.00 | Read | non-urgent diabetic admission |
| 8H4e.00 | Read | referral to diabetes special interest general practitioner |
| 8H4F.00 | Read | referral to diabetologist |
| 8H7C.00 | Read | refer |
| 8H7f.00 | Read | referral to diabetes nurse |
| 8H7r.00 | Read | refer to diabetic foot screener |
| 8HBG.00 | Read | diabetic retinopathy 12 month review |
| 8HBH.00 | Read | diabetic retinopathy 6 month review |
| 8Hg4.00 | Read | discharged from care of diabetes specialist nurse |
| 8HgC.00 | Read | discharged from diabetes shared care programme |
| 8HHy.00 | Read | referral to diabetic register |
| 8Hj0.00 | Read | referral to diabetes structured education programme |
| 8Hj3.00 | Read | referral to dafne diabetes structured education programme |
| 8Hj4.00 | Read | referral to desmond diabetes structured education programme |
| 8Hj5.00 | Read | referral to xpert diabetes structured education programme |
| 8HKE.00 | Read | diabetology d.v. requested |
| 8Hl1.00 | Read | referral for diabetic retinopathy screening |
| 8Hl4.00 | Read | referral to community diabetes specialist nurse |
| 8Hlc.00 | Read | referral to community diabetes service |
| 8HLE.00 | Read | diabetology d.v. done |
| 8HME.00 | Read | listed for diabetology admissn |
| 8HTe.00 | Read | referral to diabetes preconception counselling clinic |
| 8HTE100 | Read | referral to community diabetes clinic |
| 8HTi.00 | Read | referral to multidisciplinary diabetic clinic |
| 8HTk.00 | Read | referral to diabetic eye clinic |
| 8HVU.00 | Read | private referral to diabetologist |
| 8I2P.00 | Read | sulphonylureas contraindicated |
| 8I2S.00 | Read | glitazones contraindicated |
| 8I3k.00 | Read | insulin therapy declined |
| 8I3W.00 | Read | diabetic foot examination declined |
| 8I3X.00 | Read | diabetic retinopathy screening refused |
| 8I57.00 | Read | patient held diabetic record declined |
| 8I6F.00 | Read | diabetic retinopathy screening not indicated |
| 8I6G.00 | Read | diabetic foot examination not indicated |
| 8I7B.00 | Read | metformin not tolerated |

| | | |
|---|---|---|
| 8I7C.00 | Read | sulphonylureas not tolerated |
| 8I81.00 | Read | did not complete diabetes structured education programme |
| 8I82.00 | Read | did not complete dafne diabetes structured education program |
| 8I83.00 | Read | did not complete desmond diabetes structured educat program |
| 8I84.00 | Read | did not complete xpert diabetes structured education program |
| 8IAs.00 | Read | diabetic dietary review declined |
| 8IE2.00 | Read | diabetes care plan declined |
| 8IEa.00 | Read | referral to dafne diabetes structured educn prog declined |
| 8IEQ.00 | Read | referral to community diabetes specialist nurse declined |
| 8OA3.00 | Read | provision of written information about diabetes and driving |
| 9360 | Read | patient held diabetic record issued |
| 93C4.00 | Read | patient consent given for addition to diabetic register |
| 9b92000 | Read | diabetic medicine |
| 9h4..00 | Read | exception reporting: diabetes quality indicators |
| 9h41.00 | Read | excepted from diabetes qual indicators: patient unsuitable |
| 9h42.00 | Read | excepted from diabetes quality indicators: informed dissent |
| 9kL..00 | Read | insulin initiation - enhanced services administration |
| 9m00.00 | Read | eligible for diabetic retinopathy screening |
| 9M00.00 | Read | informed consent for diabetes national audit |
| 9m0A.00 | Read | declined diabetic retinopathy screening |
| 9M10.00 | Read | informed dissent for diabetes national audit |
| 9N0m.00 | Read | seen in diabetic nurse consultant clinic |
| 9N0n.00 | Read | seen in community diabetes specialist clinic |
| 9N0o.00 | Read | seen in community diabetic specialist nurse clinic |
| 9N1i.00 | Read | seen in diabetic foot clinic |
| 9N1o.00 | Read | seen in multidisciplinary diabetic clinic |
| 9N1Q.00 | Read | seen in diabetic clinic |
| 9N1v.00 | Read | seen in diabetic eye clinic |
| 9N2d.00 | Read | seen by diabetologist |
| 9N2i.00 | Read | seen by diabetic liaison nurse |
| 9N4I.00 | Read | dna - did not attend diabetic clinic |
| 9N4p.00 | Read | did not attend diabetic retinopathy clinic |
| 9NiA.00 | Read | did not attend diabetes structured education programme |
| 9NiC.00 | Read | did not attend dafne diabetes structured education programme |
| 9NiD.00 | Read | did not attend desmond diabetes structured education program |
| 9NiE.00 | Read | did not attend xpert diabetes structured education programme |
| 9NiZ.00 | Read | did not attend diabetes foot screening |
| 9Nl4.00 | Read | seen by general practitioner special interest in diabetes |
| 9NM0.00 | Read | attending diabetes clinic |
| 9NN8.00 | Read | under care of diabetologist |
| 9NN9.00 | Read | under care of diabetes specialist nurse |
| 9NND.00 | Read | under care of diabetic foot screener |
| 9OL..00 | Read | diabetes monitoring admin. |
| 9OL1.00 | Read | attends diabetes monitoring |
| 9OL..11 | Read | diabetes clinic administration |

| | | |
|---|---|---|
| 9OL2.00 | Read | refuses diabetes monitoring |
| 9OL3.00 | Read | diabetes monitoring default |
| 9OL4.00 | Read | diabetes monitoring 1st letter |
| 9OL5.00 | Read | diabetes monitoring 2nd letter |
| 9OL6.00 | Read | diabetes monitoring 3rd letter |
| 9OL7.00 | Read | diabetes monitor.verbal invite |
| 9OL8.00 | Read | diabetes monitor.phone invite |
| 9OL9.00 | Read | diabetes monitoring deleted |
| 9OLA.00 | Read | diabetes monitor. check done |
| 9OLA.11 | Read | diabetes monitored |
| 9OLB.00 | Read | attended diabetes structured education programme |
| 9OLD.00 | Read | diabetic patient unsuitable for digital retinal photography |
| 9OLE.00 | Read | attended desmond structured programme |
| 9OLF.00 | Read | diabetes structured education programme completed |
| 9OLG.00 | Read | attended xpert diabetes structured education programme |
| 9OLH.00 | Read | attended dafne diabetes structured education programme |
| 9OLJ.00 | Read | dafne diabetes structured education programme completed |
| 9OLK.00 | Read | desmond diabetes structured education programme completed |
| 9OLL.00 | Read | xpert diabetes structured education programme completed |
| 9OLM.00 | Read | diabetes structured education programme declined |
| 9OLN.00 | Read | diabetes monitor invitation by sms (short message service) |
| 9OLZ.00 | Read | diabetes monitoring admin.nos |
| 9Oy..00 | Read | diabetes screening administration |
| 9Oy0000 | Read | diabetic foot screening invitation |
| 9Oy0200 | Read | diabetic foot screening invitation first letter |
| 9Oy0300 | Read | diabetic foot screening invitation second letter |
| 9Oy0400 | Read | diabetic foot screening invitation third letter |
| C10..00 | Read | diabetes mellitus |
| C100.00 | Read | diabetes mellitus with no mention of complication |
| C100000 | Read | diabetes mellitus |
| C100011 | Read | insulin dependent diabetes mellitus |
| C100100 | Read | diabetes mellitus |
| C100111 | Read | maturity onset diabetes |
| C100112 | Read | non-insulin dependent diabetes mellitus |
| C100z00 | Read | diabetes mellitus nos with no mention of complication |
| C101.00 | Read | diabetes mellitus with ketoacidosis |
| C101000 | Read | diabetes mellitus |
| C101100 | Read | diabetes mellitus |
| C101y00 | Read | other specified diabetes mellitus with ketoacidosis |
| C101z00 | Read | diabetes mellitus nos with ketoacidosis |
| C102.00 | Read | diabetes mellitus with hyperosmolar coma |
| C102000 | Read | diabetes mellitus |
| C102100 | Read | diabetes mellitus |
| C102z00 | Read | diabetes mellitus nos with hyperosmolar coma |
| C103.00 | Read | diabetes mellitus with ketoacidotic coma |

| | | |
|---|---|---|
| C103000 | Read | diabetes mellitus |
| C103100 | Read | diabetes mellitus |
| C103y00 | Read | other specified diabetes mellitus with coma |
| C103z00 | Read | diabetes mellitus nos with ketoacidotic coma |
| C104.00 | Read | diabetes mellitus with renal manifestation |
| C104000 | Read | diabetes mellitus |
| C104100 | Read | diabetes mellitus |
| C104.11 | Read | diabetic nephropathy |
| C104y00 | Read | other specified diabetes mellitus with renal complications |
| C104z00 | Read | diabetes mellitus with nephropathy nos |
| C105.00 | Read | diabetes mellitus with ophthalmic manifestation |
| C105000 | Read | diabetes mellitus |
| C105100 | Read | diabetes mellitus |
| C105y00 | Read | other specified diabetes mellitus with ophthalmic complicatn |
| C105z00 | Read | diabetes mellitus nos with ophthalmic manifestation |
| C106.00 | Read | diabetes mellitus with neurological manifestation |
| C106000 | Read | diabetes mellitus |
| C106100 | Read | diabetes mellitus |
| C106.11 | Read | diabetic amyotrophy |
| C106.12 | Read | diabetes mellitus with neuropathy |
| C106.13 | Read | diabetes mellitus with polyneuropathy |
| C106y00 | Read | other specified diabetes mellitus with neurological comps |
| C106z00 | Read | diabetes mellitus nos with neurological manifestation |
| C107.00 | Read | diabetes mellitus with peripheral circulatory disorder |
| C107000 | Read | diabetes mellitus |
| C107100 | Read | diabetes mellitus |
| C107.11 | Read | diabetes mellitus with gangrene |
| C107.12 | Read | diabetes with gangrene |
| C107200 | Read | diabetes mellitus |
| C107300 | Read | iddm with peripheral circulatory disorder |
| C107400 | Read | niddm with peripheral circulatory disorder |
| C107z00 | Read | diabetes mellitus nos with peripheral circulatory disorder |
| C108.00 | Read | insulin dependent diabetes mellitus |
| C108000 | Read | insulin-dependent diabetes mellitus with renal complications |
| C108011 | Read | type i diabetes mellitus with renal complications |
| C108012 | Read | type 1 diabetes mellitus with renal complications |
| C108100 | Read | insulin-dependent diabetes mellitus with ophthalmic comps |
| C108.11 | Read | iddm-insulin dependent diabetes mellitus |
| C108112 | Read | type 1 diabetes mellitus with ophthalmic complications |
| C108.12 | Read | type 1 diabetes mellitus |
| C108.13 | Read | type i diabetes mellitus |
| C108200 | Read | insulin-dependent diabetes mellitus with neurological comps |
| C108211 | Read | type i diabetes mellitus with neurological complications |
| C108212 | Read | type 1 diabetes mellitus with neurological complications |
| C108300 | Read | insulin dependent diabetes mellitus with multiple complicatn |

| | | |
|---|---|---|
| C108311 | Read | type i diabetes mellitus with multiple complications |
| C108400 | Read | unstable insulin dependent diabetes mellitus |
| C108411 | Read | unstable type i diabetes mellitus |
| C108412 | Read | unstable type 1 diabetes mellitus |
| C108500 | Read | insulin dependent diabetes mellitus with ulcer |
| C108511 | Read | type i diabetes mellitus with ulcer |
| C108512 | Read | type 1 diabetes mellitus with ulcer |
| C108600 | Read | insulin dependent diabetes mellitus with gangrene |
| C108700 | Read | insulin dependent diabetes mellitus with retinopathy |
| C108711 | Read | type i diabetes mellitus with retinopathy |
| C108712 | Read | type 1 diabetes mellitus with retinopathy |
| C108800 | Read | insulin dependent diabetes mellitus - poor control |
| C108811 | Read | type i diabetes mellitus - poor control |
| C108812 | Read | type 1 diabetes mellitus - poor control |
| C108900 | Read | insulin dependent diabetes maturity onset |
| C108911 | Read | type i diabetes mellitus maturity onset |
| C108912 | Read | type 1 diabetes mellitus maturity onset |
| C108A00 | Read | insulin-dependent diabetes without complication |
| C108A11 | Read | type i diabetes mellitus without complication |
| C108B00 | Read | insulin dependent diabetes mellitus with mononeuropathy |
| C108B11 | Read | type i diabetes mellitus with mononeuropathy |
| C108C00 | Read | insulin dependent diabetes mellitus with polyneuropathy |
| C108D00 | Read | insulin dependent diabetes mellitus with nephropathy |
| C108D11 | Read | type i diabetes mellitus with nephropathy |
| C108E00 | Read | insulin dependent diabetes mellitus with hypoglycaemic coma |
| C108E11 | Read | type i diabetes mellitus with hypoglycaemic coma |
| C108E12 | Read | type 1 diabetes mellitus with hypoglycaemic coma |
| C108F00 | Read | insulin dependent diabetes mellitus with diabetic cataract |
| C108F11 | Read | type i diabetes mellitus with diabetic cataract |
| C108G00 | Read | insulin dependent diab mell with peripheral angiopathy |
| C108H00 | Read | insulin dependent diabetes mellitus with arthropathy |
| C108H11 | Read | type i diabetes mellitus with arthropathy |
| C108J00 | Read | insulin dependent diab mell with neuropathic arthropathy |
| C108J11 | Read | type i diabetes mellitus with neuropathic arthropathy |
| C108J12 | Read | type 1 diabetes mellitus with neuropathic arthropathy |
| C108y00 | Read | other specified diabetes mellitus with multiple comps |
| C108z00 | Read | unspecified diabetes mellitus with multiple complications |
| C109.00 | Read | non-insulin dependent diabetes mellitus |
| C109000 | Read | non-insulin-dependent diabetes mellitus with renal comps |
| C109011 | Read | type ii diabetes mellitus with renal complications |
| C109012 | Read | type 2 diabetes mellitus with renal complications |
| C109100 | Read | non-insulin-dependent diabetes mellitus with ophthalm comps |
| C109.11 | Read | niddm - non-insulin dependent diabetes mellitus |
| C109111 | Read | type ii diabetes mellitus with ophthalmic complications |
| C109112 | Read | type 2 diabetes mellitus with ophthalmic complications |

| | | |
|---|---|---|
| C109.12 | Read | type 2 diabetes mellitus |
| C109.13 | Read | type ii diabetes mellitus |
| C109200 | Read | non-insulin-dependent diabetes mellitus with neuro comps |
| C109211 | Read | type ii diabetes mellitus with neurological complications |
| C109212 | Read | type 2 diabetes mellitus with neurological complications |
| C109300 | Read | non-insulin-dependent diabetes mellitus with multiple comps |
| C109312 | Read | type 2 diabetes mellitus with multiple complications |
| C109400 | Read | non-insulin dependent diabetes mellitus with ulcer |
| C109411 | Read | type ii diabetes mellitus with ulcer |
| C109412 | Read | type 2 diabetes mellitus with ulcer |
| C109500 | Read | non-insulin dependent diabetes mellitus with gangrene |
| C109511 | Read | type ii diabetes mellitus with gangrene |
| C109512 | Read | type 2 diabetes mellitus with gangrene |
| C109600 | Read | non-insulin-dependent diabetes mellitus with retinopathy |
| C109611 | Read | type ii diabetes mellitus with retinopathy |
| C109612 | Read | type 2 diabetes mellitus with retinopathy |
| C109700 | Read | non-insulin dependent diabetes mellitus - poor control |
| C109711 | Read | type ii diabetes mellitus - poor control |
| C109712 | Read | type 2 diabetes mellitus - poor control |
| C109900 | Read | non-insulin-dependent diabetes mellitus without complication |
| C109912 | Read | type 2 diabetes mellitus without complication |
| C109A00 | Read | non-insulin dependent diabetes mellitus with mononeuropathy |
| C109A11 | Read | type ii diabetes mellitus with mononeuropathy |
| C109B00 | Read | non-insulin dependent diabetes mellitus with polyneuropathy |
| C109B11 | Read | type ii diabetes mellitus with polyneuropathy |
| C109C00 | Read | non-insulin dependent diabetes mellitus with nephropathy |
| C109C11 | Read | type ii diabetes mellitus with nephropathy |
| C109C12 | Read | type 2 diabetes mellitus with nephropathy |
| C109D00 | Read | non-insulin dependent diabetes mellitus with hypoglyca coma |
| C109D11 | Read | type ii diabetes mellitus with hypoglycaemic coma |
| C109D12 | Read | type 2 diabetes mellitus with hypoglycaemic coma |
| C109E00 | Read | non-insulin depend diabetes mellitus with diabetic cataract |
| C109E11 | Read | type ii diabetes mellitus with diabetic cataract |
| C109E12 | Read | type 2 diabetes mellitus with diabetic cataract |
| C109F00 | Read | non-insulin-dependent d m with peripheral angiopath |
| C109F11 | Read | type ii diabetes mellitus with peripheral angiopathy |
| C109F12 | Read | type 2 diabetes mellitus with peripheral angiopathy |
| C109G00 | Read | non-insulin dependent diabetes mellitus with arthropathy |
| C109G11 | Read | type ii diabetes mellitus with arthropathy |
| C109G12 | Read | type 2 diabetes mellitus with arthropathy |
| C109H00 | Read | non-insulin dependent d m with neuropathic arthropathy |
| C109H11 | Read | type ii diabetes mellitus with neuropathic arthropathy |
| C109H12 | Read | type 2 diabetes mellitus with neuropathic arthropathy |
| C109J00 | Read | insulin treated type 2 diabetes mellitus |
| C109J11 | Read | insulin treated non-insulin dependent diabetes mellitus |

| | | |
|---|---|---|
| C109J12 | Read | insulin treated type ii diabetes mellitus |
| C109K00 | Read | hyperosmolar non-ketotic state in type 2 diabetes mellitus |
| C10B.00 | Read | diabetes mellitus induced by steroids |
| C10B000 | Read | steroid induced diabetes mellitus without complication |
| C10C.00 | Read | diabetes mellitus autosomal dominant |
| C10C.11 | Read | maturity onset diabetes in youth |
| C10C.12 | Read | maturity onset diabetes in youth type 1 |
| C10D.00 | Read | diabetes mellitus autosomal dominant type 2 |
| C10D.11 | Read | maturity onset diabetes in youth type 2 |
| C10E.00 | Read | type 1 diabetes mellitus |
| C10E000 | Read | type 1 diabetes mellitus with renal complications |
| C10E012 | Read | insulin-dependent diabetes mellitus with renal complications |
| C10E100 | Read | type 1 diabetes mellitus with ophthalmic complications |
| C10E.11 | Read | type i diabetes mellitus |
| C10E111 | Read | type i diabetes mellitus with ophthalmic complications |
| C10E112 | Read | insulin-dependent diabetes mellitus with ophthalmic comps |
| C10E.12 | Read | insulin dependent diabetes mellitus |
| C10E200 | Read | type 1 diabetes mellitus with neurological complications |
| C10E212 | Read | insulin-dependent diabetes mellitus with neurological comps |
| C10E300 | Read | type 1 diabetes mellitus with multiple complications |
| C10E311 | Read | type i diabetes mellitus with multiple complications |
| C10E312 | Read | insulin dependent diabetes mellitus with multiple complicat |
| C10E400 | Read | unstable type 1 diabetes mellitus |
| C10E411 | Read | unstable type i diabetes mellitus |
| C10E412 | Read | unstable insulin dependent diabetes mellitus |
| C10E500 | Read | type 1 diabetes mellitus with ulcer |
| C10E511 | Read | type i diabetes mellitus with ulcer |
| C10E512 | Read | insulin dependent diabetes mellitus with ulcer |
| C10E600 | Read | type 1 diabetes mellitus with gangrene |
| C10E611 | Read | type i diabetes mellitus with gangrene |
| C10E700 | Read | type 1 diabetes mellitus with retinopathy |
| C10E711 | Read | type i diabetes mellitus with retinopathy |
| C10E712 | Read | insulin dependent diabetes mellitus with retinopathy |
| C10E800 | Read | type 1 diabetes mellitus - poor control |
| C10E811 | Read | type i diabetes mellitus - poor control |
| C10E812 | Read | insulin dependent diabetes mellitus - poor control |
| C10E900 | Read | type 1 diabetes mellitus maturity onset |
| C10E911 | Read | type i diabetes mellitus maturity onset |
| C10E912 | Read | insulin dependent diabetes maturity onset |
| C10EA00 | Read | type 1 diabetes mellitus without complication |
| C10EA11 | Read | type i diabetes mellitus without complication |
| C10EA12 | Read | insulin-dependent diabetes without complication |
| C10EB00 | Read | type 1 diabetes mellitus with mononeuropathy |
| C10EC00 | Read | type 1 diabetes mellitus with polyneuropathy |
| C10EC11 | Read | type i diabetes mellitus with polyneuropathy |

| | | |
|---|---|---|
| C10EC12 | Read | insulin dependent diabetes mellitus with polyneuropathy |
| C10ED00 | Read | type 1 diabetes mellitus with nephropathy |
| C10ED12 | Read | insulin dependent diabetes mellitus with nephropathy |
| C10EE00 | Read | type 1 diabetes mellitus with hypoglycaemic coma |
| C10EE12 | Read | insulin dependent diabetes mellitus with hypoglycaemic coma |
| C10EF00 | Read | type 1 diabetes mellitus with diabetic cataract |
| C10EF12 | Read | insulin dependent diabetes mellitus with diabetic cataract |
| C10EG00 | Read | type 1 diabetes mellitus with peripheral angiopathy |
| C10EH00 | Read | type 1 diabetes mellitus with arthropathy |
| C10EJ00 | Read | type 1 diabetes mellitus with neuropathic arthropathy |
| C10EK00 | Read | type 1 diabetes mellitus with persistent proteinuria |
| C10EL00 | Read | type 1 diabetes mellitus with persistent microalbuminuria |
| C10EL11 | Read | type i diabetes mellitus with persistent microalbuminuria |
| C10EM00 | Read | type 1 diabetes mellitus with ketoacidosis |
| C10EM11 | Read | type i diabetes mellitus with ketoacidosis |
| C10EN00 | Read | type 1 diabetes mellitus with ketoacidotic coma |
| C10EN11 | Read | type i diabetes mellitus with ketoacidotic coma |
| C10EP00 | Read | type 1 diabetes mellitus with exudative maculopathy |
| C10EP11 | Read | type i diabetes mellitus with exudative maculopathy |
| C10EQ00 | Read | type 1 diabetes mellitus with gastroparesis |
| C10ER00 | Read | latent autoimmune diabetes mellitus in adult |
| C10F.00 | Read | type 2 diabetes mellitus |
| C10F000 | Read | type 2 diabetes mellitus with renal complications |
| C10F011 | Read | type ii diabetes mellitus with renal complications |
| C10F100 | Read | type 2 diabetes mellitus with ophthalmic complications |
| C10F.11 | Read | type ii diabetes mellitus |
| C10F111 | Read | type ii diabetes mellitus with ophthalmic complications |
| C10F200 | Read | type 2 diabetes mellitus with neurological complications |
| C10F211 | Read | type ii diabetes mellitus with neurological complications |
| C10F300 | Read | type 2 diabetes mellitus with multiple complications |
| C10F311 | Read | type ii diabetes mellitus with multiple complications |
| C10F400 | Read | type 2 diabetes mellitus with ulcer |
| C10F411 | Read | type ii diabetes mellitus with ulcer |
| C10F500 | Read | type 2 diabetes mellitus with gangrene |
| C10F511 | Read | type ii diabetes mellitus with gangrene |
| C10F600 | Read | type 2 diabetes mellitus with retinopathy |
| C10F611 | Read | type ii diabetes mellitus with retinopathy |
| C10F700 | Read | type 2 diabetes mellitus - poor control |
| C10F711 | Read | type ii diabetes mellitus - poor control |
| C10F900 | Read | type 2 diabetes mellitus without complication |
| C10F911 | Read | type ii diabetes mellitus without complication |
| C10FA00 | Read | type 2 diabetes mellitus with mononeuropathy |
| C10FA11 | Read | type ii diabetes mellitus with mononeuropathy |
| C10FB00 | Read | type 2 diabetes mellitus with polyneuropathy |
| C10FB11 | Read | type ii diabetes mellitus with polyneuropathy |

| | | |
|---|---|---|
| C10FC00 | Read | type 2 diabetes mellitus with nephropathy |
| C10FC11 | Read | type ii diabetes mellitus with nephropathy |
| C10FD00 | Read | type 2 diabetes mellitus with hypoglycaemic coma |
| C10FD11 | Read | type ii diabetes mellitus with hypoglycaemic coma |
| C10FE00 | Read | type 2 diabetes mellitus with diabetic cataract |
| C10FE11 | Read | type ii diabetes mellitus with diabetic cataract |
| C10FF00 | Read | type 2 diabetes mellitus with peripheral angiopathy |
| C10FF11 | Read | type ii diabetes mellitus with peripheral angiopathy |
| C10FG00 | Read | type 2 diabetes mellitus with arthropathy |
| C10FG11 | Read | type ii diabetes mellitus with arthropathy |
| C10FH00 | Read | type 2 diabetes mellitus with neuropathic arthropathy |
| C10FJ00 | Read | insulin treated type 2 diabetes mellitus |
| C10FJ11 | Read | insulin treated type ii diabetes mellitus |
| C10FK00 | Read | hyperosmolar non-ketotic state in type 2 diabetes mellitus |
| C10FK11 | Read | hyperosmolar non-ketotic state in type ii diabetes mellitus |
| C10FL00 | Read | type 2 diabetes mellitus with persistent proteinuria |
| C10FL11 | Read | type ii diabetes mellitus with persistent proteinuria |
| C10FM00 | Read | type 2 diabetes mellitus with persistent microalbuminuria |
| C10FM11 | Read | type ii diabetes mellitus with persistent microalbuminuria |
| C10FN00 | Read | type 2 diabetes mellitus with ketoacidosis |
| C10FN11 | Read | type ii diabetes mellitus with ketoacidosis |
| C10FP00 | Read | type 2 diabetes mellitus with ketoacidotic coma |
| C10FP11 | Read | type ii diabetes mellitus with ketoacidotic coma |
| C10FQ00 | Read | type 2 diabetes mellitus with exudative maculopathy |
| C10FR00 | Read | type 2 diabetes mellitus with gastroparesis |
| C10FS00 | Read | maternally inherited diabetes mellitus |
| C10G.00 | Read | secondary pancreatic diabetes mellitus |
| C10G000 | Read | secondary pancreatic diabetes mellitus without complication |
| C10M.00 | Read | lipoatrophic diabetes mellitus |
| C10N.00 | Read | secondary diabetes mellitus |
| C10N000 | Read | secondary diabetes mellitus without complication |
| C10N100 | Read | cystic fibrosis related diabetes mellitus |
| C10y.00 | Read | diabetes mellitus with other specified manifestation |
| C10y100 | Read | diabetes mellitus |
| C10yy00 | Read | other specified diabetes mellitus with other spec comps |
| C10yz00 | Read | diabetes mellitus nos with other specified manifestation |
| C10z.00 | Read | diabetes mellitus with unspecified complication |
| C10z000 | Read | diabetes mellitus |
| C10z100 | Read | diabetes mellitus |
| C10zy00 | Read | other specified diabetes mellitus with unspecified comps |
| C10zz00 | Read | diabetes mellitus nos with unspecified complication |
| C110000 | Read | iatrogenic hyperinsulinism |
| C110.11 | Read | insulin coma |
| C11y000 | Read | steroid induced diabetes |
| C314.11 | Read | renal diabetes |

| | | |
|---|---|---|
| C350011 | Read | bronzed diabetes |
| Cyu2.00 | Read | [x]diabetes mellitus |
| Cyu2000 | Read | [x]other specified diabetes mellitus |
| Cyu2300 | Read | [x]unspecified diabetes mellitus with renal complications |
| F171100 | Read | autonomic neuropathy due to diabetes |
| F345000 | Read | diabetic mononeuritis multiplex |
| F35z000 | Read | diabetic mononeuritis nos |
| F372.00 | Read | polyneuropathy in diabetes |
| F372000 | Read | acute painful diabetic neuropathy |
| F372100 | Read | chronic painful diabetic neuropathy |
| F372.11 | Read | diabetic polyneuropathy |
| F372.12 | Read | diabetic neuropathy |
| F372200 | Read | asymptomatic diabetic neuropathy |
| F381300 | Read | myasthenic syndrome due to diabetic amyotrophy |
| F381311 | Read | diabetic amyotrophy |
| F3y0.00 | Read | diabetic mononeuropathy |
| F420.00 | Read | diabetic retinopathy |
| F420000 | Read | background diabetic retinopathy |
| F420100 | Read | proliferative diabetic retinopathy |
| F420200 | Read | preproliferative diabetic retinopathy |
| F420300 | Read | advanced diabetic maculopathy |
| F420400 | Read | diabetic maculopathy |
| F420500 | Read | advanced diabetic retinal disease |
| F420600 | Read | non proliferative diabetic retinopathy |
| F420700 | Read | high risk proliferative diabetic retinopathy |
| F420800 | Read | high risk non proliferative diabetic retinopathy |
| F420z00 | Read | diabetic retinopathy nos |
| F440700 | Read | diabetic iritis |
| F464000 | Read | diabetic cataract |
| G73y000 | Read | diabetic peripheral angiopathy |
| K01x100 | Read | nephrotic syndrome in diabetes mellitus |
| K01x111 | Read | kimmelstiel - wilson disease |
| K08yA00 | Read | proteinuric diabetic nephropathy |
| K08yA11 | Read | clinical diabetic nephropathy |
| K27y700 | Read | erectile dysfunction due to diabetes mellitus |
| Kyu0300 | Read | [x]glomerular disorders in diabetes mellitus |
| L180500 | Read | pre-existing diabetes mellitus |
| L180600 | Read | pre-existing diabetes mellitus |
| L180X00 | Read | pre-existing diabetes mellitus |
| M037200 | Read | cellulitis in diabetic foot |
| M21yC00 | Read | insulin lipohypertrophy |
| M21yC11 | Read | insulin site lipohypertrophy |
| M271000 | Read | ischaemic ulcer diabetic foot |
| M271100 | Read | neuropathic diabetic ulcer - foot |
| M271200 | Read | mixed diabetic ulcer - foot |

| | | |
|---|---|---|
| N030000 | Read | diabetic cheiroarthropathy |
| N030011 | Read | diabetic cheiropathy |
| N030100 | Read | diabetic charcot arthropathy |
| R054200 | Read | [d]gangrene of toe in diabetic |
| R054300 | Read | [d]widespread diabetic foot gangrene |
| R105712 | Read | [d]hyperglycaemia |
| Ryu8A00 | Read | [x]hyperglycaemia |
| TJ23.00 | Read | adverse reaction to insulins and antidiabetic agents |
| TJ23000 | Read | adverse reaction to insulins |
| TJ23200 | Read | adverse reaction to chlorpropamide |
| TJ23300 | Read | adverse reaction to glibenclamide |
| TJ23400 | Read | adverse reaction to gliclazide |
| TJ23500 | Read | adverse reaction to glipizide |
| TJ23800 | Read | adverse reaction to tolazamide |
| TJ23900 | Read | adverse reaction to tolbutamide |
| TJ23A00 | Read | adverse reaction to metformin hydrochloride |
| TJ23B00 | Read | adverse reaction to glucagon |
| TJ23z00 | Read | adverse reaction to insulins and antidiabetic agents nos |
| U602300 | Read | [x]insul/oral hypoglyc drugs caus adverse eff therapeut use |
| U602311 | Read | [x] adverse reaction to insulins and antidiabetic agents |
| U602312 | Read | [x] adverse reaction to insulins |
| U602315 | Read | [x] adverse reaction to glibenclamide |
| U602316 | Read | [x] adverse reaction to gliclazide |
| U602317 | Read | [x] adverse reaction to glipzide |
| U602318 | Read | [x] adverse reaction to gliquidone |
| U60231A | Read | [x] adverse reaction to tolazamide |
| U60231B | Read | [x] adverse reaction to tolbutamide |
| U60231C | Read | [x] adverse reaction to metformin hydrochloride |
| U60231E | Read | [x] adverse reaction to insulins and antidiabetic agents nos |
| ZC2C800 | Read | dietary advice for diabetes mellitus |
| ZC2C900 | Read | dietary advice for type i diabetes |
| ZC2CA00 | Read | dietary advice for type ii diabetes |
| ZL22500 | Read | under care of diabetic liaison nurse |
| ZL62500 | Read | referral to diabetes nurse |
| ZL62600 | Read | referral to diabetic liaison nurse |
| ZLA2500 | Read | seen by diabetic liaison nurse |
| ZLD7500 | Read | discharge by diabetic liaison nurse |
| ZRB4.00 | Read | diabetes clinic satisfaction questionnaire |
| ZRB4.11 | Read | csq - diabetes clinic satisfaction questionnaire |
| ZRB5.00 | Read | diabetes treatment satisfaction questionnaire |
| ZRB5.11 | Read | dtsq - diabetes treatment satisfaction questionnaire |
| ZRB6.00 | Read | diabetes wellbeing questionnaire |
| ZRB6.11 | Read | dwbq - diabetes wellbeing questionnaire |
| ZRBa.00 | Read | education score - diabetes |
| ZRbH.00 | Read | perceived control of insulin-dependent diabetes |

| | | |
|---|---|---|
| ZV65312 | Read | [v]dietary counselling in diabetes mellitus |
| ZV6DA00 | Read | [v]admitted for commencement of insulin |
| ZV6DB00 | Read | [v]admitted for conversion to insulin |
| E10 | ICD-10 | insulin-dependent diabetes mellitus |
| E10.0 | ICD-10 | insulin-dependent diabetes mellitus |
| E10.1 | ICD-10 | insulin-dependent diabetes mellitus |
| E10.2 | ICD-10 | insulin-dependent diabetes mellitus |
| E10.3 | ICD-10 | insulin-dependent diabetes mellitus |
| E10.4 | ICD-10 | insulin-dependent diabetes mellitus |
| E10.5 | ICD-10 | insulin-dependent diabetes mellitus |
| E10.6 | ICD-10 | insulin-dependent diabetes mellitus |
| E10.7 | ICD-10 | insulin-dependent diabetes mellitus |
| E10.8 | ICD-10 | insulin-dependent diabetes mellitus |
| E10.9 | ICD-10 | insulin-dependent diabetes mellitus |
| E11 | ICD-10 | non-insulin-dependent diabetes mellitus |
| E11.0 | ICD-10 | non-insulin-dependent diabetes mellitus |
| E11.1 | ICD-10 | non-insulin-dependent diabetes mellitus |
| E11.2 | ICD-10 | non-insulin-dependent diabetes mellitus |
| E11.3 | ICD-10 | non-insulin-dependent diabetes mellitus |
| E11.4 | ICD-10 | non-insulin-dependent diabetes mellitus |
| E11.5 | ICD-10 | non-insulin-dependent diabetes mellitus |
| E11.6 | ICD-10 | non-insulin-dependent diabetes mellitus |
| E11.7 | ICD-10 | non-insulin-dependent diabetes mellitus |
| E11.8 | ICD-10 | non-insulin-dependent diabetes mellitus |
| E11.9 | ICD-10 | non-insulin-dependent diabetes mellitus |
| E13 | ICD-10 | other specified diabetes mellitus |
| E13.0 | ICD-10 | other specified diabetes mellitus |
| E13.1 | ICD-10 | other specified diabetes mellitus |
| E13.2 | ICD-10 | other specified diabetes mellitus |
| E13.3 | ICD-10 | other specified diabetes mellitus |
| E13.4 | ICD-10 | other specified diabetes mellitus |
| E13.5 | ICD-10 | other specified diabetes mellitus |
| E13.6 | ICD-10 | other specified diabetes mellitus |
| E13.7 | ICD-10 | other specified diabetes mellitus |
| E13.8 | ICD-10 | other specified diabetes mellitus |
| E13.9 | ICD-10 | other specified diabetes mellitus |
| E14 | ICD-10 | unspecified diabetes mellitus |
| E14.0 | ICD-10 | unspecified diabetes mellitus |
| E14.1 | ICD-10 | unspecified diabetes mellitus |
| E14.2 | ICD-10 | unspecified diabetes mellitus |
| E14.3 | ICD-10 | unspecified diabetes mellitus |
| E14.4 | ICD-10 | unspecified diabetes mellitus |
| E14.5 | ICD-10 | unspecified diabetes mellitus |
| E14.6 | ICD-10 | unspecified diabetes mellitus |
| E14.7 | ICD-10 | unspecified diabetes mellitus |

| | | |
|---|---|---|
| E14.8 | ICD-10 | unspecified diabetes mellitus |
| E14.9 | ICD-10 | unspecified diabetes mellitus |
| G59.0 | ICD-10 | diabetic mononeuropathy |
| G63.2 | ICD-10 | diabetic polyneuropathy |
| H28.0 | ICD-10 | diabetic cataract |
| H36.0 | ICD-10 | diabetic retinopathy |
| M14.2 | ICD-10 | diabetic arthropathy |
| N08.3 | ICD-10 | glomerular disorders in diabetes mellitus |
| Y42.3 | ICD-10 | insulin and oral hypoglycaemic [antidiabetic] drugs |

## Death

Date of death registered in CPRD

**The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.**

| | Item No. | STROBE items | Location in manuscript where items are reported | RECORD items | Location in manuscript where items are reported |
|---|---|---|---|---|---|
| **Title and abstract** | | | | | |
| | 1 | (a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found | a) 1, 3<br>b) 3 | RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included.<br><br>RECORD 1.2: If applicable, the geographic region and time period within which the study took place should be reported in the title or abstract.<br><br>RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract. | 1.1) 1, 3<br>1.2) 1, 3<br>1.3) 3 |
| **Introduction** | | | | | |
| Background rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 5 | | |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 5 | | |
| **Methods** | | | | | |
| Study Design | 4 | Present key elements of study design early in the paper | 5-6 | | |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 5-7 | | |

| | | | | | |
|---|---|---|---|---|---|
| Participants | 6 | *(a) Cohort study* - Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study* - Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study* - Give the eligibility criteria, and the sources and methods of selection of participants<br><br>*(b) Cohort study* - For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study* - For matched studies, give matching criteria and the number of controls per case | a) 5-7<br>b) Not applicable | RECORD 6.1: The methods of study population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided.<br><br>RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided.<br><br>RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage. | 6.1) 5-7<br>6.2) 5-6, 15<br>6.3) Not needed |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable. | 5-7 | RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided. | 5-7 |
| Data sources/ measurement | 8 | For each variable of interest, give sources of data and details of methods of assessment (measurement).<br>Describe comparability of assessment methods if there is more than one group | 5-7 | | |

| | | | | | |
|---|---|---|---|---|---|
| Bias | 9 | Describe any efforts to address potential sources of bias | 8-10 | | |
| Study size | 10 | Explain how the study size was arrived at | 6-7 | | |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why | 5-10 | | |
| Statistical methods | 12 | (a) Describe all statistical methods, including those used to control for confounding<br>(b) Describe any methods used to examine subgroups and interactions<br>(c) Explain how missing data were addressed<br>(d) *Cohort study* - If applicable, explain how loss to follow-up was addressed<br>*Case-control study* - If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study* - If applicable, describe analytical methods taking account of sampling strategy<br>(e) Describe any sensitivity analyses | 8-10 | | |
| Data access and cleaning methods | | 5-7 | | RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population. | 12.1) 5-6<br>12.2) 5-7 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | RECORD 12.2: Authors should provide information on the data cleaning methods used in the study. | |
| Linkage | | 5-6 | | RECORD 12.3: State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided. | 12.3) 5-6 |
| **Results** | | | | | |
| Participants | 13 | (a) Report the numbers of individuals at each stage of the study (*e.g.*, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed)<br>(b) Give reasons for non-participation at each stage.<br>(c) Consider use of a flow diagram | 6, 10-13 | RECORD 13.1: Describe in detail the selection of the persons included in the study (*i.e.,* study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram. | 13.1) 6, 10-13 |
| Descriptive data | 14 | (a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential confounders<br>(b) Indicate the number of participants with missing data for each variable of interest<br>(c) *Cohort study* - summarise follow-up time (*e.g.*, average and total amount) | 10-11, Table 1 | | |
| Outcome data | 15 | *Cohort study* - Report numbers of outcome events or summary measures over time<br>*Case-control study* - Report numbers in each exposure | 10-13 | | |

| | | | | | |
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| | | category, or summary measures of exposure<br>*Cross-sectional study* - Report numbers of outcome events or summary measures | | | |
| Main results | 16 | (a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included<br>(b) Report category boundaries when continuous variables were categorized<br>(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | 10-13 | | |
| Other analyses | 17 | Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses | 10-13 | | |
| **Discussion** | | | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 13 | | |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 13-15 | RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported. | 13-15 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, | 18,19 | | |

| | | | | | |
|---|---|---|---|---|---|
| | | limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | | | |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 18 | | |
| **Other Information** | | | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 20 | | |
| Accessibility of protocol, raw data, and programming code | | .. | 20, Appendix, protocol made available for reviewers | RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code. | 20, Appendix, protocol made available for reviewers |

*Reference: Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press.









36/bmjopen-2016-012818 on 9 January 2017. Downloaded from

# *Correction: Adherence to guidelines for creatinine and potassium monitoring and discontinuation following renin–angiotensin system blockade: a UK general practice-based cohort study*

Schmidt M, Mansfield KE, Bhaskaran K, *et al*. Adherence to guidelines for creatinine and potassium monitoring and discontinuation following renin–angiotensin system blockade: a UK general practice-based cohort study. *BMJ Open* 2017;**7**:e012818. doi: 10.1136/bmjopen-2016-012818

In the 3rd column of Table 5 the heading 'Serum potassium increase ≥30%*' should read 'Serum potassium increase >6 mmol/L'.



*BMJ Open* 2017;**7**:e012818corr1. doi:10.1136/bmjopen-2016-012818corr1