Evaluating quality and its determinants in lipid control for secondary prevention of heart disease and stroke in primary care: a study in an inner London Borough

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ABSTRACT

Objectives: To assess quality of management and determinants in lipid control for secondary prevention of cardiovascular disease (CVD) using multilevel regression models.

Design: Cross-sectional study.

Setting: Inner London borough, with a primary care registered population of 378 000 (2013).

Participants: 48/49 participating general practices with 7699 patients on heart disease/stroke registers were included.

Outcome measures: (1) Recording of current total cholesterol levels and lipid control according to national evidence-based standards. (2) Assessed quality by age, sex, ethnicity, deprivation, presence of other risks or comorbidity in meeting both lipid measurement and control standards.

Results: Some process standards were not met. Patients with current cholesterol measurement >5 mmol/L were less likely to have a current statin prescription (adjusted OR=3.10; 95% CI 2.70 to 3.56). They were more likely to have clustering of other CVD risk factors. Women were significantly more likely to have raised cholesterol after adjustment for other factors (adjusted OR=1.74; 95% CI 1.53 to 1.98).

Conclusions: In this study, the key factor that explained poor lipid control in people with CVD was having no current prescription record of a statin. Women were more likely to have poorly controlled cholesterol (independent of comorbid risk factors and after adjusting for age, ethnicity, deprivation index and practice-level variation). Women with CVD should be offered statin prescription and may require higher statin dosage for improved control.

INTRODUCTION

Hyperlipidaemia contributes a significant proportion of modifiable cardiovascular disease (CVD) risk.1 Most of the CVD risk attributable to lipids is due to lipoprotein particles associated with cholesterol deposition in the vascular wall including total cholesterol, non-high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C).2 Interventions that reduce LDL-C reduce CVD risk with a relationship from clinical trials that show a 21% relative risk reduction in major vascular events per 1 mmol/L reduction in LDL-C in all groups.3

The National Institute for Health and Care Excellence (NICE) lipid modification guidelines (CG67 2008 and updated CG181, 2014) advise clinicians to offer statins to all individuals with increased risk of CVD as determined by a QRISK2 or Framingham (1991)-based CVD risk score of 20% over the next decade.4–6 These risk calculation tools give similar results but Framingham overpredictions CVD in UK populations.7 Statin treatment is to be prescribed to all patients with established CVD using simvastatin 40 mg in most patients and atorvastatin 80 mg in acute coronary syndromes. NICE guideline advises...
that cholesterol is checked within 3 months of starting a statin with the aim that patients with established CVD should ideally reach total cholesterol <4 mmol/L; LDL-C <2 mmol/L with an audit standards of total cholesterol <5 mmol/L and LDL-C <3 mmol/L. In primary prevention, no target is specified but all should be treated with simvastatin 40 mg or another off-patent agent of similar efficacy.

General practitioners (GPs) are currently incentivised to manage CVD by the Quality and Outcomes Framework (QOF) which is a ‘Pay for Performance’ (P4P) system. The QOF control target in 2012–2013 was total cholesterol <5 mmol/L. There is some evidence that P4P can improve quality of care, but this evidence is not strong and other factors are also likely to play a role. In addition, the EUROASPIRE III survey has shown that evidence-based guideline targets for lifestyle, risk factors and drug treatments are not being achieved and there remains considerable potential to raise standards to prevent further events and that statins are sub-optimally used.

Inequalities in the management of CVD in primary care have been reported previously with key sex inequalities between men and women and ethnic inequalities.

The Health and Social Care Act 2012 in the UK places a duty on Clinical Commissioning Groups to improve quality and reduce inequalities in access and outcomes of care. Our aim was to evaluate the quality in the management of cholesterol for the secondary prevention of CVD in Lambeth patients on the coronary heart disease (CHD) and/or stroke registers. We compared lipid measurement and control to predefined standards based on QOF and NICE guidelines. We also evaluated the determinants in the management of lipid control and hypothesised that there should be no group differences in the management and control of cholesterol in this cohort of patients on the above registers, according to the predefined standards.

METHODS

This evaluation was carried out in an inner city London borough, with a registered population of 378 000 (2013). We used a cross-sectional study design and identified those patients who were on the CHD and/or stroke registers as of 31 March 2013 and the period 15 months prior to this date.

We used patient-level data from the Lambeth DataNet. This is a pseudo-anonymised database of patients registered with practices in primary care that supports local commissioning, healthcare/service evaluation and monitoring health inequalities. We identified people registered on the CHD and/or stroke registers from 48 of 49 practices that contribute data to the Lambeth DataNet. A key purpose of this database is also to collect and analyse markers of health inequalities such as ethnicity, index of multiple deprivation (IMD), as well as age and sex. The IMD includes income deprivation; employment deprivation; health deprivation and disability; education deprivation; and other markers of deprivations such as crime, barriers to housing and services, and the living environment.

Predefined standards

The standards that were used to assess the quality of care were a combination of the upper range of the QOF 12-13 and NICE guidelines.

Coronary heart disease

- Cholesterol level is measured in the past 15 months (at or prior to 31 March 2013) in 90% (range 50–90%) of all patients on the CHD register;
- Cholesterol control ≤5 mmol/L in 70% (range 45–70%) of all patients on CHD register.

Stroke

- Cholesterol level measured in the past 15 months (at or prior to 31 March 2013) in 90% (range 50–90%) of all patients on the stroke register;
- Cholesterol ≤5 mmol/L in 65% (range 40–65%) of all patients on stroke register.

We also analysed data on the current prescription of statins for this cohort of patients within the past 3 months from their last review date. NICE guidelines recommend that all patients with heart disease or stroke should be prescribed a statin or have reasons recorded if not prescribed.

Hypothesis tested

The hypotheses we were testing were as follows:

1. Patients in Lambeth with one or more diagnoses of CHD and stroke are managed according to the predefined quality standards for cholesterol for people on these two registers as of 2012/2013.
2. In Lambeth patients with one or more diagnoses of CHD and stroke—there are no significant group differences as assessed by age, sex, ethnicity, deprivation, presence of other risks or comorbidity in meeting these predefined quality standards.

Analysis

We used STATA V.13.1 to test the hypotheses. Descriptive analyses were done to test the first hypothesis. The outcome (dependent) variables for the regression models were dichotomous and were defined above in the ‘predefined standards’ section. They include (1) measurement of cholesterol (DO1—yes/no) and (2) total cholesterol ≤5 mmol/L (DO2—as controlled and >5 mmol/L as uncontrolled).

The presence of group differences (independent variables) in these were reviewed by: age group (16–44, 45–54, 55–64, 65–74 and ≥75), sex (male, female), ethnic groups (white group, black African/black Caribbean, black British group, missing/unknown, Asian/Asian-British group, mixed group, other ethnic group), IMD quintiles (grouped as follows: least deprived two quintiles 0–40%, 40–60%, 60–80%; most deprived...
80–100%), as well as risk factors for smoking (current smokers, ex-smokers, non-smokers and unknown) and blood pressure or BP (controlled defined as BP \( \leq 150/90 \); uncontrolled defined as BP \( >150/90 \)), type 2 diabetes status (yes or no) and statin prescription status within time frame described above (yes or no).

A number of univariate multilevel logistic regression models taking into account the variation among different general practices were fitted to explore the associations between the outcome variable and different independent variables tested in the second hypothesis. Then a series of multivariate multilevel logistic regression models were fitted to investigate the associations between the predefined standards and all potential independent variables, using random-effect equation for the practice-level variation. Best and final models chosen by series of Wald goodness-of-fit tests were reported in the Results section.20

RESULTS

The total number of primary care practices that participated was 48/49 (98%). The number of people on the CHD and stroke registers was 7869 (CHD only: 4464; stroke only: 2739; combined CHD/stroke=667). The diagnosed crude prevalence of CHD and stroke were 1.3% and 0.9%, respectively, in Lambeth in 2012–2013.\(^8\) The mean age was 69.8 years (95% confidence limits 69.5 to 70.1). There were significantly more males on the registers: male 57.8% (56.7% to 58.9%) compared with female 42.2% (41.1% to 43.3%). Other demographic characteristics are shown in table 1.

Table 2 shows the risk factor characteristics. In this population, about 19% of people with CHD or stroke remained current smokers, just over one in four were not controlled for their blood pressure to a level of 150/90 mm Hg and 70% were overweight or obese. Just over one in four had type 2 diabetes.

**Hypothesis 1**: Patients with one or more of CHD and stroke are managed according to predefined standards and all potential independent variables, using random-effect equation for the practice-level variation. Best and final models chosen by series of Wald goodness-of-fit tests were reported in the Results section.20

Table 3 shows the evaluation of patients having a current record for cholesterol measurement and control for people on these two registers as of 2012/2013 and 2013/2014.

Table 4 shows the findings for patients who did not have a current record of cholesterol measurement in the past 15 months. The random effect at the general practice level is reported at the

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**Table 1** Demographic baseline characteristics

| Demographic characteristics | Sublevel | Number (n=7869) | Per cent |
|----------------------------|----------|----------------|----------|
| Age                       |          |                |          |
| 16–44                     | 333      | 4.2            |
| 45–54                     | 840      | 10.7           |
| 55–64                     | 1340     | 17.0           |
| 65–74                     | 2035     | 25.9           |
| \( \geq 75 \)              | 3293     | 41.9           |
| Sex                       |          |                |          |
| Male                      | 4547     | 57.8           |
| Female                    | 3322     | 42.2           |
| Ethnicity                 |          |                |          |
| White group               | 4361     | 55.4           |
| Black/black group         | 1616     | 20.5           |
| British group             | 694      | 8.8            |
| Asian group               | 793      | 10.1           |
| Asian-British group       |          |                |          |
| Mixed group               | 212      | 2.7            |
| Other ethnic group        | 193      | 2.5            |
| Asian/unknown group       |          |                |          |
| Missing/unknown group     | 793      | 10.1           |
| Index of deprivation      | 195      | 2.5            |
| Least deprived            | 793      | 10.1           |
| 40–60%                    | 976      | 12.4           |
| 60–80%                    | 3816     | 48.5           |
| Most deprived             | 2837     | 36.1           |
| 80–100%                   | 45       | 0.6            |

**Table 2** Risk factor characteristics

| Risk factor | Sublevel  | Number | Per cent |
|-------------|-----------|--------|----------|
| Smoking*    | Non-smoker| 4146   | 52.7     |
|             | Current smoker | 1456  | 18.5     |
|             | Ex-smoker    | 2191   | 27.8     |
|             | Unknown      | 76     | 1.0      |
| BP*         | BP \( \leq 150/90 \) | 5604  | 71.2     |
|             | BP \( >150/90 \) | 2182   | 27.7     |
|             | Missing      | 83     | 1.1      |
| Body mass index† | \( <18.5 \) | 138    | 1.9      |
|             | 18.5–24.9    | 1999   | 27.8     |
|             | 25–29.9      | 2613   | 36.4     |
|             | 30–39.9      | 2164   | 30.1     |
|             | \( \geq 40 \) | 267    | 3.7      |
| Type 2 diabetes* | Yes | 2104  | 26.3     |
|              | No          | 5765   | 73.3     |

**Table 3** Risk factor characteristics

| Risk factor | Sublevel  | Number | Per cent |
|-------------|-----------|--------|----------|
| Smoking*    | Non-smoker| 4146   | 52.7     |
|             | Current smoker | 1456  | 18.5     |
|             | Ex-smoker    | 2191   | 27.8     |
|             | Unknown      | 76     | 1.0      |
| Body mass index† | \( <18.5 \) | 138    | 1.9      |
|             | 18.5–24.9    | 1999   | 27.8     |
|             | 25–29.9      | 2613   | 36.4     |
|             | 30–39.9      | 2164   | 30.1     |
|             | \( \geq 40 \) | 267    | 3.7      |

(n=7869).

†(n=7181).

BP, blood pressure.

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Table 3: Evaluation against standards

| Register                      | Number | Per cent | 95% confidence limits | Standard (%) |
|-------------------------------|--------|----------|-----------------------|--------------|
|                               |        |          | Lower limit | Upper limit     |
| Current record in the past 15 months |        |          |             |               |
| Stroke only                    | 2284   | 83.4     | 82.0        | 84.8          | 90            |
| CHD only                       | 3831   | 85.8     | 84.8        | 86.8          | 90            |
| CHD and stroke                 | 597    | 89.5     | 86.9        | 91.7          | 90            |
| Cholesterol ≤5 mmol/L with current record in the past 15 months |        |          |             |               |
| Stroke only                    | 1716   | 75.1     | 73.3        | 76.9          | 65            |
| CHD only                       | 3114   | 81.3     | 80.0        | 82.5          | 70            |
| Stroke and CHD                 | 505    | 84.6     | 81.4        | 87.4          | 70            |
| Statin prescription recorded in the past 6 months and current record in the past 15 months |        |          |             |               |
| Stroke only                    | 1630   | 71.4     | 69.5        | 73.2          | 100           |
| CHD only                       | 3203   | 83.6     | 82.4        | 84.8          | 100           |
| Stroke and CHD                 | 511    | 85.6     | 82.5        | 88.3          | 100           |

CHD, coronary heart disease.

The variance component was estimated to be 0.12. Patients categorised as African-American/black British group (compared with the white group) were significantly more likely to have a current record, as were patients with type 2 diabetes (compared with people without type 2 diabetes). Patients aged between 16 and 64 years or over 75 years were significantly less likely to have a current record for cholesterol levels. Patients aged 16–44 were 68% more likely to not have a current record compared with those aged 65–74. After taking into account other factors, deprivation did not appear to have an effect on current cholesterol recording. Those who were current smokers and had previously raised cholesterol level were also less likely to have a current record of cholesterol level.

Patients with no current record for cholesterol in the past 15 months were nearly three times less likely (adjusted odds=2.97; 95% CI 2.51 to 3.52) to have a record of a current statin prescription.

Table 5 shows the finding for the subgroup of patients who had a current record of cholesterol but were not achieving a lipid control standards (cholesterol level <5 mmol/L) within the past 15 months of the study date. The random effect at the general practice level is estimated to be 0.022. These patients were significantly more (OR 3.10; 95% CI 2.70 to 3.56) likely not to have a current record for a statin prescription. After adjustment for other factors, they were also more likely to be current smokers and to have raised blood pressure. Women were also significantly more likely than men to have raised cholesterol after adjustment for other factors. Women were significantly less likely to have a current record for a statin prescription (75%; 74% to 77%) compared with men (83%; 82% to 84%). There were significant differences in current recorded prescribing with age (those aged 16–44 and 45–54 were less likely to have a current record of statins prescribed: 44% and 71%, respectively) and ethnicity (African-American/black British groups were less likely to have statins prescribed and Asian groups more likely: 74% and 88%, respectively). However, there was no significant difference in the adjusted OR with age (apart from the 75+ age group who were significantly better controlled) and ethnicity for poor lipid control. Patients with additional comorbidities with type 2 diabetes were significantly more likely to achieve cholesterol control ≤5 mmol/L.

DISCUSSION

Key findings

In this study of patients attending primary care practices in an inner London borough in South London, the key factor that explained poor lipid control in people on the CHD and stroke registers was having no record of having been prescribed a statin in the past 3 months from their last review date. Women were less likely to be prescribed a statin compared with men. Among individuals with previous history of CHD or stroke, women are more likely than men to have poorly controlled cholesterol. This finding was independent of smoking status, blood pressure, statin prescription and type 2 diabetes status and also remained unchanged after adjusting for age, ethnicity, deprivation index and practice-level variation. We found no ethnic difference in lipid control after adjustment for other factors. The very elderly (75+) were significantly better controlled.

Patients with a history of both CHD and stroke were those most likely to be managed according to current guidelines. Patients who had only had a stroke were less likely to have had their cholesterol measured, controlled or to be prescribed a statin than patients with CHD.

There was a clustering of risk factors in that patients who had poor lipid control were also more likely to be current smokers, have raised blood pressure and were less likely to have a current statin prescription recorded.

What is already known

Studies looking at the efficacy of lipid-lowering treatments in patients with established CVD have found no
significant differences between sexes but found that women were more likely than men to have higher LDL-C levels both before and after treatment suggesting that women may need more aggressive lipid-lowering treatment than men to achieve targets.14 21–25

Women are less likely to be prescribed medication including statins as secondary prevention following stroke26 27 and acute coronary syndrome.28 These findings are true internationally with similar results being found in Ireland,29 Italy30 and Sweden.31 Large studies suggest that the effect is mainly seen in younger women.32 33 Similar results have previously been found in East London.34 Women were also less likely to be prescribed aggressive lipid-lowering treatment or any treatment at all. A Canadian study also found discrepancies between the three groups: stroke, CHD and both, as well as sex discrepancies similar to the results found in Lambeth.35 Some studies have failed to find a significant difference in lipid treatment between the sexes.36 37 Others suggest that sex differences disappear once the data have been adjusted for age and severity of disease.38 39 Millett et al in their study identified improvements in lipid control and blood pressure targets in ethnic groups, although black groups were less likely to be prescribed statins. They suggested that the introduction of QOF led to marked improvements in both the process of care and management of CHD. They did not report on sex or age differences in lipid control.15 A systematic review of 27 studies looking at equity dimensions in the evaluation of QOF, across a

Table 4  Multilevel logistic regression model—current record for measurement of cholesterol (DO1) in the past 15 months and demographic, risk factor and treatment with statin characteristics

| Variable | Category | Total N | DO1: N (%) | Adjusted OR (95% confidence limits) | p Value |
|----------|----------|---------|------------|-----------------------------------|---------|
| Age (years) (n=7841) | 16–44 | 333 | 147 (44) | **1.68** (**1.14 to 2.47**) | 0.008 |
| | 45–54 | 840 | 170 (20) | **1.50** (**1.13 to 1.98**) | 0.005 |
| | 55–64 | 1340 | 190 (14) | **1.45** (**1.13 to 1.87**) | 0.004 |
| | 65–74 | 2035 | 189 (9) | Ref | |
| | 75+ | 3293 | 433 (13) | **1.41** (**1.13 to 1.75**) | 0.002 |
| Sex (n=7869) | Male | 4547 | 663 (15) | Ref | |
| | Female | 3322 | 494 (15) | 0.90 (**0.76 to 1.06**) | 0.220 |
| Ethnicity (n=7869) | White group | 4361 | 643 (15) | Ref | |
| | Black/Black British | 1616 | 197 (12) | **0.78** (**0.62 to 0.97**) | 0.029 |
| | Asian/Asian British | 694 | 82 (12) | 1.07 (**0.78 to 1.47**) | 0.6736 |
| | Mixed groups | 212 | 38 (18) | 1.07 (**0.67 to 1.72**) | 0.769 |
| | Other ethnic groups | 193 | 28 (15) | 1.18 (**0.72 to 1.93**) | 0.5010 |
| | Not known/missing | 793 | 169 (21) | 1.18 (**0.90 to 1.54**) | 0.231 |
| Deprivation—Index of Multiple | Least deprived | 195 | 22 (11) | Ref | |
| | Deprivation national ranking (n=7824) | 40–60% | 976 | 153 (16) | 1.46 (**0.76 to 2.79**) | 0.254 |
| | 60–80% | 3816 | 538 (14) | 1.49 (**0.80 to 2.78**) | 0.210 |
| | Most deprived | 2837 | 438 (15) | 1.59 (**0.85 to 2.99**) | 0.147 |
| Smoking (7869) | Non-smoker | 4146 | 579 (14) | Ref | |
| | Ex-smoker | 2191 | 266 (12) | 1.07 (**0.88 to 1.30**) | 0.514 |
| | Current Smoker | 1456 | 271 (19) | **1.40** (**1.13 to 1.74**) | 0.002 |
| | Unknown | 76 | 41 (54) | 1.54 (**0.51 to 4.63**) | 0.440 |
| Blood pressure (n=7786) | ≤150/90 mm Hg | 5604 | 742 (13) | Ref | |
| | >150/90 mm Hg | 2182 | 343 (16) | 1.15 (**0.96 to 1.36**) | 0.123 |
| Total cholesterol (n=7562) | ≤5 mmol/L | 5897 | 562 (10) | Ref | |
| | >5 mmol/L | 1665 | 289 (17) | **1.33** (**1.12 to 1.59**) | 0.001 |
| Statin prescription (n=7869) | Yes | 5891 | 547 (9) | Ref | |
| | No | 1978 | 610 (31) | 2.97 (**2.51 to 3.52**) | <0.0001 |
| BMI (kg/m²) (n=7181) | <18.5 | 138 | 23 (17) | 1.24 (**0.75 to 2.04**) | 0.403 |
| | 18.5–24.9 | 1999 | 255 (13) | Ref | |
| | 25–29.9 | 2613 | 267 (10) | 0.97 (**0.80 to 1.18**) | 0.742 |
| | 30–39.9 | 2164 | 201 (9) | 0.94 (**0.76 to 1.16**) | 0.576 |
| | ≥40 | 267 | 24 (9) | 0.94 (**0.59 to 1.50**) | 0.801 |
| Type 2 diabetes (n=7869) | Yes | 2104 | 111 (5) | **0.37** (**0.29 to 0.47**) | <0.0001 |
| | No | 5765 | 1046 (18) | Ref | |
| Practice-level variance | | | | **0.12** (**0.06 to 0.25**) | |

Logistic model for current record for cholesterol in the past 15 months, goodness-of-fit test; number of observations=7135; number of groups=10; Hosmer-Lemeshow \( \chi^2 \) (8)=5.74; probability \( > \chi^2=0.676 \); likelihood ratio test for testing multilevel logistic regression model compared with conventional logistic regression model \( p \) value <0.0001.

BMI, body mass index.
range of conditions, did not suggest worsening inequity in treatment or treatment outcomes.40

What this paper adds

The Health and Social Care Act 2012 places a duty on Clinical Commissioning Groups to reduce inequalities in access and outcomes of care.16 This paper shows that routine pseudo-anonymised patient-level data can be used to monitor quality and its determinants in a systematic way. We found important age differences in the processes of care—people aged 16–64 were less likely to meet lipid measurement standards. Lack of cholesterol measurement may be a proxy to access care. Possible explanations for these age differences need further exploration but could be related to higher risk taking behaviour in younger age groups, more reluctance to take time off work and attend routine healthcare leading to lower access to care in this age group. Patients from black ethnic groups and with comorbidity with diabetes were more likely to meet the lipid measurement standard. Possible explanations for this may be better systems in place for people with comorbidities or that they are more likely to attend or be followed up for care processes. For the lipid control standards, the findings of this study in South London are similar to those observed worldwide. In patients with established CVD population, women are more likely than men to have raised cholesterol, and yet they are less likely to be prescribed a statin. Critically patients with poor lipid control were also significantly less likely to have a current statin prescription. Possible explanation for these findings need further exploration but could include (1) the majority of women in this area live in more deprived circumstances which may lead to lower health literacy and lower level of clinical engagement; (2) women may see themselves as lower risk of CVD and can be mistakenly perceived as being at lower risk by clinicians. However, patients with diabetes (as an additional comorbidity) were more likely to meet lipid control standards. Possible explanations for this are that additional comorbidity may lead to better systems of care provided by primary care. We believe that the methodology used in this paper provides an approach for evaluating determinants of quality of care that partly fit into the theory-based framework for conceptualising equity of care developed by Boeckxstaens et al.40 We have outlined some of the limitations to our

| Table 5 | Multilevel logistic regression model—total cholesterol level >5 mmol/L (DO2) in the past 15 months |
|----------|---------------------------------------------|
| Variable | Category | Total N | DO2: N (%) | Adjusted OR (95% confidence limits) | p Value |
| Age (n=6711) | 16–44 | 186 | 49 (26) | 0.79 (0.54 to 1.14) | 0.208 |
| | 45–54 | 670 | 166 (28) | 1.20 (0.96 to 1.50) | 0.102 |
| | 55–64 | 1149 | 261 (23) | 1.10 (0.91 to 1.33) | 0.330 |
| | 65–74 | 1846 | 380 (21) | Ref |  |
| | 75+ | 2860 | 500 (17) | 0.74 (0.63 to 0.88) | <0.0001 |
| Sex (n=6711) | Male | 3883 | 649 (17) | Ref |  |
| | Female | 2828 | 727 (26) | 1.74 (1.53 to 1.98) | <0.0001 |
| Ethnicity (n=6711) | White group | 3717 | 762 (21) | Ref |  |
| | Black/Black British | 1419 | 310 (22) | 0.99 (0.84 to 1.16) | 0.892 |
| | Asian/Asian British | 612 | 90 (15) | 0.85 (0.66 to 1.09) | 0.198 |
| | Mixed groups | 174 | 41 (24) | 1.04 (0.71 to 1.54) | 0.830 |
| | Other ethnic groups | 165 | 29 (18) | 0.85 (0.56 to 1.31) | 0.470 |
| | Not known/missing | 624 | 144 (23) | 1.13 (0.91 to 1.40) | 0.264 |
| Deprivation (Index of Multiple Deprivation national ranking) (n=6672) | Least deprived | 173 | 37 (21) | Ref |  |
| | 40–60% | 822 | 148 (18) | 0.79 (0.52 to 1.21) | 0.276 |
| | 60–80% | 3278 | 677 (21) | 0.91 (0.61 to 1.35) | 0.634 |
| | Most deprived | 2399 | 508 (21) | 0.91 (0.61 to 1.37) | 0.664 |
| Smoking (n=6711) | Non-smoker | 3566 | 736 (21) | Ref |  |
| | Ex-smoker | 1925 | 346 (18) | 1.00 (0.86 to 1.18) | 0.939 |
| | Current Smoker | 1185 | 286 (24) | 1.28 (1.07 to 1.52) | 0.006 |
| | Unknown | 35 | 8 (23) | 1.33 (0.57 to 3.11) | 0.506 |
| Blood pressure (n=6700) | ≤150/90 mm Hg | 4861 | 898 (18) | Ref |  |
| | >150/90 mm Hg | 1839 | 477 (26) | 1.35 (1.17 to 1.54) | <0.0001 |
| Statin prescription (n=6711) | Yes | 5344 | 845 (16) | Ref |  |
| | No | 1367 | 531 (39) | 3.10 (2.70 to 3.56) | <0.0001 |
| Type 2 diabetes (n= 6711) | Yes | 1993 | 1098 (23) | 0.62 (0.53 to 0.72) | <0.0001 |
| | No | 4718 | 278 (14) | Ref |  |
| Practice-level variance | 0.022 (0.005 to 0.095) |  |

Logistic model for total cholesterol level >5 mmol/L in the past 15 months, goodness-of-fit test number of observations=6370; number of groups=10; Hosmer-Lemeshow $\chi^2$ (8)=16.26; probability $>\chi^2=0.039$; likelihood ratio test for testing multilevel logistic regression model compared with conventional logistic regression model p value=0.045.
approach below. We have also provided online supplementary data tables that show improvements overall in recording of total cholesterol, current statin prescription and change in mean total cholesterol by age, sex, ethnicity and deprivation for the cohort of patients that had records in 2013 and 2011. These online supplementary data suggest that P4P is continuing to have a positive impact locally but also shows differential changes in total cholesterol control by some of the characteristics we have reported.

Limitations
In the UK, all diagnosed cases of CHD and stroke are registered by GPs as part of QOF disease registers as this is part of the GP contract. We know from modelled estimates that the registers may underestimate actual number of cases by as much as 50%—however, these estimates are based on a number of assumptions and there is uncertainty in modelled prevalence estimates. It would be important to understand the characteristics of people who may not be registered on the CHD/stroke registers to understand equity of access to care more completely. This study used data from all cases that were diagnosed and on the QOF registers from all but one practice. There was a small proportion of data that was missing in the age, deprivation and some of the risk factors in the disease register. This varied for different indicators—for example, missing age was 28 records or 0.4% of all records; IMD 45 records or 0.6% of all records; cholesterol level recorded—this was 307 records or 4% of all records; body mass index was 688 records or 9% of all records; for the second outcome cholesterol level >5 mmol missing data were: IMD 39 records or 0.6% and 1 record for cholesterol level. However, as this was a large study, we do not think this will have introduced substantial non-response biases. This study used data collected from routine practice consultations, so there could be potential measurement errors or biases introduced as part of this. The data gathered did not include the date of any original CVD event and this factor was not considered in the regression analysis. Registry studies show a decline in adherence with cardiovascular preventive therapies including statins with time postevent. The data gathered in this study do not allow differentiation of haemorrhagic from ischaemic strokes which may explain some of the differences in prescriptions. However, it is likely that most strokes were ischaemic in aetiology in this population. We also did not assess whether there was a record of prescriptions for other lipid-lowering strategies in this cohort, though statins are the most commonly prescribed lipid-lowering drugs there is substantial usage of ezetimibe in some areas in the UK. The data obtained did not include reasons for why women are not being prescribed statins, for example, whether they were declining them when offered, or whether they were experiencing more side effects and asking to stop taking statins or whether they were not being offered statins in the first place. We also were not able to explore whether healthcare professionals have a perception that women are lower risk of further CVD and not treated as aggressively as men. This study was conducted in a single setting and the findings may not be more widely generalisable to the UK population as implementation of NICE guidelines may vary in different areas. However, some of these results on lipid control outcomes are consistent with findings from other studies. These factors need further exploration to inform future strategies.

CONCLUSIONS
This evaluation has identified important quality issues and their determinants. Some of these variations in quality suggest possible health inequities in the secondary prevention of heart disease and stroke. The findings suggest that primary care has an important role in identifying and optimising management in those patients with CVD who do not have current record of cholesterol reading. GPs should also identify people with established CVD who have no current record of statin prescription as these patients had a greater probability of poor lipid control. This evaluation identified these patients were also more likely to have other CVD risks (raised blood pressure and current smokers). Finally, this study suggests that primary care professionals need to identify and optimise lipid management in patients with CVD who have no current statin prescription and also that women with CVD may require higher statin dosage for better lipid control for secondary prevention. Potential policy implications for P4P systems such as QOF are that these need to consider the determinants of quality and the variation in implementation by social characteristics within a broader framework of equity of access, treatment and treatment outcomes based on an assessment of needs.

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Contributors HD and JC designed the study. JC extracted and cleaned the data from Lambeth DataNet and HD and JC performed the primary analyses. KL and HD performed the logistic regression analyses and KL performed the multilevel logistic regression analyses. HLE reviewed the literature. HD and HLE drafted the manuscript and AW, HW, AH and JB critically edited the manuscript and provided final approval. HD is guarantor of this work and had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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(supplementary data tables).

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Supplementary data:

The following tables provide supplementary data referred to in the response to the peer reviewers comments.

Supplementary table 1: Variation in statin prescribing by age, sex, ethnicity and deprivation index.

| Factor         | Detail                          | Current prescription record (%) | 95% confidence interval |
|----------------|---------------------------------|--------------------------------|-------------------------|
| Age (n = 6711) | 16-44                           | 44                             | 37 to 51                |
|                | 45-54                           | 71                             | 68 to 75                |
|                | 55-64                           | 83                             | 81 to 85                |
|                | 65-74                           | 84                             | 82 to 85                |
|                | 75+                             | 80                             | 78 to 81                |
| Sex (n = 6711) | Male                            | 83                             | 82 to 84                |
|                | Female                          | 75                             | 74 to 77                |
| Ethnicity (n = 6711) | White Group                  | 81                             | 79 to 82                |
|                | Black/Black British             | 74                             | 72 to 76                |
|                | Asian/Asian British             | 88                             | 86 to 91                |
|                | Mixed groups                    | 78                             | 72 to 84                |
|                | Other ethnic groups             | 83                             | 77 to 89                |
|                | Not known/missing               | 78                             | 75 to 81                |
| IMD (6672)     | Least deprived 0-40%            | 78                             | 72 to 84                |
|                | 40-60%                          | 80                             | 78 to 83                |
|                | 60-80%                          | 80                             | 79 to 82                |
|                | Most deprived 80-100%           | 79                             | 77 to 80                |
**Supplementary table 2:** Comparison of recording of current (within 15 months) recording of cholesterol status between 2011 & 2013 in cohort of patients with two readings

|                   | Yes      | No       | Total |
|-------------------|----------|----------|-------|
| **Cholesterol record in 2013** |          |          |       |
| Yes               | 5,557    | 645      | 6,202 |
| Row %             | 90       | 10       | 100   |
| Column %          | 83       | 56       | 79    |
| No                | 1,155    | 512      | 1,667 |
| Row %             | 69       | 31       | 100   |
| Column %          | 17       | 44       | 21    |
| **Total**         | 6,712    | 1,157    | 7,869 |
| **Row %**         | 85       | 15       | 100   |
| **Column %**      | 100      | 100      | 100   |

**Pearson chi square < 0.0001**

Recording of cholesterol improved from 79% to 85% in the cohort of patients who had records in both time periods.

**Supplementary table 3:** Comparison of current statin prescribing between 2011 & 2013 in cohort of patients with two readings

|                   | Yes      | No       | Total |
|-------------------|----------|----------|-------|
| **Current statin prescription record in 2013** |          |          |       |
| Yes               | 4,120    | 313      | 4,433 |
| Row %             | 93       | 7        | 100   |
| Column %          | 77       | 23       | 66    |
| No                | 1,224    | 1,055    | 2,279 |
| Row %             | 53.71    | 46.29    | 100   |
| Column %          | 23       | 77       | 34    |
| **Total**         | 5,344    | 1,368    | 6,712 |
| **Row %**         | 80       | 20       | 100   |
| **Column %**      | 100      | 100      | 100   |

**Pearson chi square < 0.0001**

Recording of current statin prescribing improved from 66% to 80% in the cohort of patients who had records in both time periods.
Supplementary table 4: Comparison of mean total cholesterol by age, sex, ethnicity and deprivation index between 2011 & 2013 in cohort of patients with two readings

| Profile characteristics | Number | Mean 2011 | Mean 2013 | Difference in mean | 95% confidence limits | p-value (paired t-test) |
|-------------------------|--------|-----------|-----------|--------------------|-----------------------|------------------------|
| Overall                 | 6931   | 4.50      | 4.33      | 0.17               | 0.14 to 0.19          | <0.0001                |
| Age group               |        |           |           |                    |                       |                        |
| 16-44                   | 144    | 4.77      | 4.55      | 0.22               | 0.02 to 0.41          | 0.03                   |
| 45-54                   | 665    | 4.73      | 4.55      | 0.18               | 0.09 to 0.27          | 0.0001                 |
| 55-64                   | 1184   | 4.64      | 4.41      | 0.22               | 0.16 to 0.29          | <0.0001                |
| 65-74                   | 1865   | 4.46      | 4.31      | 0.15               | 0.10 to 0.19          | <0.0001                |
| 75+                     | 3072   | 4.40      | 4.24      | 0.16               | 0.13 to 0.19          | <0.0001                |
| Sex                     |        |           |           |                    |                       |                        |
| Male                    | 3955   | 4.35      | 4.17      | 0.18               | 0.15 to 0.21          | <0.0001                |
| Female                  | 2976   | 4.69      | 4.54      | 0.15               | 0.11 to 0.18          | <0.0001                |
| Ethnic category         |        |           |           |                    |                       |                        |
| White Group             | 3860   | 4.51      | 4.35      | 0.16               | 0.14 to 0.20          | <0.0001                |
| Black/Black British group | 1442 | 4.50      | 4.36      | 0.14               | 0.10 to 0.20          | <0.0001                |
| Asian/Asian British     | 607    | 4.28      | 4.10      | 0.18               | 0.10 to 0.26          | <0.0001                |
| Mixed groups            | 183    | 4.41      | 4.29      | 0.12               | -0.02 to 0.27         | 0.08                   |
| Other ethnic groups     | 166    | 4.35      | 4.23      | 0.12               | -0.02 to 0.26         | 0.09                   |
| Not known/missing       | 673    | 4.65      | 4.43      | 0.22               | 0.15 to 0.30          | <0.0001                |
| IMD                     |        |           |           |                    |                       |                        |
| Least deprived (0-40%)   | 178    | 4.54      | 4.27      | 0.27               | 0.14 to 0.41          | 0.0001                 |
| 40-60%                  | 836    | 4.49      | 4.25      | 0.24               | 0.18 to 0.30          | <0.0001                |
| 60-80%                  | 3376   | 4.51      | 4.34      | 0.17               | 0.14 to 0.20          | <0.0001                |
| Most deprived           | 2500   | 4.48      | 4.35      | 0.13               | 0.10 to 0.17          | <0.0001                |

Note greater improvements in mean total cholesterol seen in younger age groups, men (compared to women), Asian/Asian British and least deprived categories compared to most deprived groups. However none of these differential impacts are significantly different within each category analysed.