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# BMJ Open

## Patterns of routine primary care for osteoarthritis: a cross-sectional electronic health records study

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Manuscripts

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3 1 **Patterns of routine primary care for osteoarthritis: a cross-sectional electronic health records**  
4  
5 2 **study**

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48 21 Running title: Patterns of primary care for osteoarthritis

## 22 **Abstract**

### 23 **Objective**

24 To determine common patterns of recorded primary care for osteoarthritis (OA), and  
25 characteristics associated with the quality of recorded care.

### 26 **Design**

27 An observational study nested within a cluster-randomised controlled trial.

### 28 **Setting**

29 Eight UK general practices who were part of the Management of OsteoArthritis In ConsultationS  
30 (MOSAICS) study.

### 31 **Participants**

32 Patients recorded as consulting within the eight general practices for clinical OA.

### 33 **Primary outcomes**

34 Achievement of seven quality indicators of care, recorded through an electronic template or  
35 routinely recorded in the electronic healthcare records, were identified for patients aged  $\geq 45$  years  
36 consulting over a six-month period with clinical OA. Latent class analysis was used to cluster  
37 patients based on care received. Clusters were compared on patient and clinician-level  
38 characteristics.

### 39 **Results**

40 1724 patients consulted with clinical OA. Common patterns of recorded quality care were: Cluster 1  
41 (38%, *High*) received most quality indicators of care; Cluster 2 (11%, *Moderate*) had pain and  
42 function assessment, and received or were considered for other indicators; Cluster 3 (17%, *Low*)  
43 had pain and function assessment, and received or were considered for paracetamol or topical  
44 NSAIDs; Cluster 4 (35%, *None*) had no recorded quality indicators. Patients with higher levels of  
45 recorded care consulted a clinician who saw more OA patients, consulted multiple times, and had

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2  
3 46 less morbidity. Those in the *High* cluster were more likely to have recorded diagnosed OA and have  
4  
5 47 knee or hip OA.  
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## 7 48 **Conclusions**

9  
10 49 Appropriate delivery of core interventions and relatively safe pharmacological options for OA are  
11  
12 50 still not consistently recorded as provided in primary care. Further research to understand clinical  
13  
14 51 recording behaviours and determine potential barriers to quality care alongside effective training  
15  
16 52 for clinicians is needed.  
17

18  
19 53 **Trial registration** number ISRCTN06984617  
20

## 21 54 **Keywords**

22  
23 55 Osteoarthritis, primary care, quality indicators, latent class analysis  
24

## 25 56 **Article summary**

- 26  
27  
28 57 • This paper describes a novel use of latent class analysis to identify patterns of primary care  
29  
30 58 for osteoarthritis (OA)  
31  
32  
33 59 • The population studied was large and diverse, increasing generalisability, and based on a  
34  
35 60 broad definition of clinical OA to reduce selection bias  
36  
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38  
39 61 • The analysis used some quality indicators of care newly-implemented in practices through  
40  
41 62 an electronic template, which may have increased the recorded quality of care compared to  
42  
43 63 routine practice  
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46  
47 64 • Some care processes may have occurred but not been recorded  
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52 66 **Word count** 3424  
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## 67 Introduction

68 Osteoarthritis (OA) is a common reason for adults aged  $\geq 45$  years to consult primary care. Annually,  
69 in the UK, 4% of such adults are recorded as consulting in general practice for diagnosed OA, with  
70 an additional 8% recorded with joint pain likely to be attributable to OA [1]. Osteoarthritis is a  
71 common reason for disability, and was ranked the 11<sup>th</sup> biggest cause of disability by the 2010  
72 Global Burden of Disease (GBD) [2].

73 The UK National Institute for Health and Care Excellence (NICE) OA management guidelines  
74 recommend core strategies of information provision, physical activity and exercise, and weight  
75 management, supplemented with use of relatively safe pharmacological management strategies  
76 (for example, topical non-steroidal anti-inflammatory drugs [NSAIDs]), as necessary [3].  
77 Intensification of management should depend on response to these initial approaches. However,  
78 there is evidence that patients diagnosed with OA do not receive care that is well aligned to  
79 evidence-based recommendations and which may be overly dependent on pharmacological  
80 methods [4].

81 We have previously identified variation between clinicians in recorded quality of individual  
82 indicators of OA care [5]. However, patterns of OA care and factors linked with increased  
83 probability of adherence to OA quality standards are less well-studied. Using electronic general  
84 practice records data, the objectives of this study were to determine patterns of recorded primary  
85 care for OA based on quality indicators, and to determine associations between higher-quality  
86 recorded care and patient and clinician characteristics.

## 87 Methods

88 This analysis used data from the Management of OsteoArthritis In ConsultationS (MOSAICS) study  
89 (Trial registration number ISRCTN06984617), approved by the North West Research Ethics

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3 90 Committee, Cheshire (reference: 10/H1017/76) [6]. MOSAICS was a mixed-methods study, which  
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5 91 investigated the effect of a model consultation for clinical OA. It was set within eight general  
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7 92 practices in Cheshire, Shropshire and Staffordshire, UK and is reported in line with STROBE  
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10 93 guidelines. The current analysis used anonymised information from the electronic health records  
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12 94 (EHR) of these practices for the six-month baseline period before randomisation of practices to  
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14 95 intervention or control arms [6]. At the beginning of the baseline period, a computerised template  
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16 96 (“e-template”, described below) was installed within the EHR and all practices continued with  
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19 97 otherwise usual care until the end of the baseline period.

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22 98 The study population was all patients aged  $\geq 45$  years registered with the eight general practices  
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24 99 who consulted with clinical OA in the baseline six-month period. UK general practice utilises Read  
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26 100 codes to record morbidities; within MOSAICS, clinical OA was defined as either a recorded OA Read  
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28 101 code or a peripheral joint pain Read code for the hand, hip, knee, or foot, to reduce the potential  
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30  
31 102 for selection bias in clinician coding. Patients were allocated to an index clinician, being the clinician  
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33 103 recording the first formally diagnosed (i.e. OA Read-coded) OA consultation in the baseline period  
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35 104 or, if none, the first peripheral joint pain coded consultation in the same period.

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39 105 Outcome measures were the seven indicators of quality of care for OA in general practice recorded  
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41 106 in the EHR. These could be entered into the EHR as routinely-recorded data or captured through  
42  
43 107 the e-template. The identification and synthesis of appropriate quality indicators using a systematic  
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45 108 review and NICE 2008 guidelines has previously been reported [5,7,8]. The indicators are shown in  
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48 109 Table 1.

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51 110 Achievement of prescribing and referral indicators (recorded prescription of topical NSAIDs or  
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53 111 paracetamol, and onward physiotherapy referral) were determined from data in the routinely-

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3 112 recorded component of the EHR and were determined to have been achieved if they were recorded  
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5 113 within 14 days of any clinical OA consultation in the six-month period.  
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8 114 The e-template facilitated recording of achievement of indicators that are known to be poorly  
9  
10 115 captured in routinely-recorded data [5]: (i) assessment of pain and function, (ii) provision or  
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12 116 consideration of OA information, exercise advice, and weight loss advice, (iii) consideration of  
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14 117 paracetamol or topical NSAID and (iv) consideration of physiotherapy referral. The entry of a code  
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16 118 for clinical OA for a patient aged  $\geq 45$  years triggered the e-template [5]. The clinicians could  
17  
18 119 complete the e-template at any point throughout the consultation and could choose to complete  
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20 120 all, some, or none of the e-template. The e-template has been endorsed by NICE to facilitate  
21  
22 121 enhanced uptake of quality standards [9].  
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27 122 Data from the EHR (derived from both routinely-recorded data and the e-template) were  
28  
29 123 amalgamated within the relevant quality indicator. For example, consideration of paracetamol and  
30  
31 124 topical NSAIDs (entered using e-template) was combined with actual prescription of these agents  
32  
33 125 (routinely-recorded data). Outcomes (Table 1) were dichotomous for pain and function  
34  
35 126 assessments. For all other indicators, the possibilities were for the indicator to be *achieved*,  
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37 127 *considered* (without record of having been delivered), or *not considered*. There is evidence that  
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39 128 weight recording is more common in people who are overweight compared to those who are not  
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41 129 [10]. To minimise the effect of missing data and to preserve the ability of the model to identify  
42  
43 130 people who needed weight loss advice but were not recorded as receiving it, any patient recorded  
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45 131 as being of normal weight or who did not have a weight recorded was allocated to *considered* for  
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47 132 weight loss advice.  
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3 133 We investigated how patterns of care based on the quality indicators were associated with other  
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5 134 OA care processes, recorded in the routine EHR within 14 days of any clinical OA consultation:  
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7 135 prescriptions for oral NSAIDs and opioids, and relevant X-rays (hand, hip knee, or foot).  
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10 136 Factors potentially associated with patterns of quality of care that were considered were: patient  
11  
12 137 age, gender, body mass index (BMI), the site of clinical OA, whether patients had multiple or a  
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14 138 single consultation for clinical OA within the six-month time period, whether the patient was a new  
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16 139 consulter (no clinical OA consultations within the previous 12 months) and total morbidity. Total  
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18 140 morbidity was measured by a count of British National Formulary (BNF) subchapters from which  
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20 141 prescriptions had been issued in the previous 12 months [11]. A proxy measure of OA workload for  
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22 142 the patients' index clinician was determined by dichotomising the number of index clinical OA  
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24 143 consultations at the median value (14) across clinicians.  
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#### 30 Statistical analysis

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32 145 Latent class analysis (LCA) was used to cluster patients into groups based on recorded achievement  
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34 146 of the seven quality indicators. All patients within a cluster should have similar recorded care for  
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36 147 their OA or joint pain, but care should differ between patients belonging to different clusters [12].  
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40 148 Latent class models were fitted, beginning with a one-cluster model where all the patients were  
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42 149 assumed to have been given the same pattern of treatment of OA, up to a seven-cluster model. To  
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44 150 determine the optimum number of clusters, we considered the Bayesian Information Criterion (BIC,  
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46 151 whereby the lowest BIC indicated the best model) with the size of each cluster, and the  
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48 152 interpretability of the model. Posterior probabilities (PP) for a patient (the probabilities of that  
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50 153 patient belonging to each of the clusters within the model) were identified. The cluster that had the  
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52 154 largest PP for a patient was the cluster that patient was assigned to. We used the mean PP for  
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155 patients allocated to each cluster to measure cluster separation; a mean PP of more than 0.7  
156 indicated that the patients were clearly assigned to that specific cluster [13].

157 Using a two-level (patient within index clinician) multinomial multilevel logistic regression,  
158 associations between the patient and clinician-level covariates and cluster membership were  
159 estimated and reported as relative risk ratios (RRR) with 95% confidence intervals (CI). We also  
160 used chi-squared tests to compare between clusters on levels of pain and functional limitation  
161 (none, mild, moderate, severe) as recorded in the e-template.

162 Statistical analysis was performed using R studio version 3.3.0, and MLwiN version 2.35 for  
163 Windows.

## 164 Results

165 During the six-month period, 1724 patients consulted with a recorded clinical OA code and  
166 triggered the e-template. All were included in the analysis. 1014 (59%) of these were female, mean  
167 age was 66.1 years (SD: 11.9) and 582 (34%) patients were recorded with a diagnosis of OA rather  
168 than peripheral joint pain.

169 As previously reported [5], pain (63%) and function (62%) assessment were the most commonly  
170 achieved indicators. Recorded provision of OA information (44%), and exercise advice (45%) were  
171 achieved in under half of patients, and weight loss advice in less than a third of patients (31%). 609  
172 (35%) patients were prescribed paracetamol or topical NSAIDs. A referral for physiotherapy was  
173 made in 7% of patients.

174 Table 2 shows the goodness-of-fit statistics for the LCA models with one to seven clusters. The four-  
175 cluster model gave the lowest BIC, and each of the clusters in the three-, four-, and five-cluster  
176 models had a mean PP for patients belonging to that cluster above 0.83. In the three-cluster model

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3 177 the smallest cluster size was 430 (25%), in the four-cluster model it was 184 (11%) and the five-  
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5 178 cluster model had a smallest cluster size of 142 (8%). Based on the cluster sizes, goodness-of-fit  
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7 179 statistics, and interpretability, the four-cluster model was chosen as the optimal model.

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11 180 Table 3 shows the probability of recorded receipt of each of the seven quality indicators for  
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13 181 patients allocated to each cluster. Patients in cluster 1 ( $n=659$ , 38%) had a high probability of having  
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15 182 pain and function assessment recorded (probabilities over 0.97) and of being given OA information  
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17 183 and exercise advice (probabilities over 0.93). Patients' care within this cluster was recorded as  
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19 184 having achieved a median of five indicators and considered for, but not achieved, a median of one  
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21 185 further indicator. Cluster 1 was therefore labelled as having a *High* level of recorded quality of care.  
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23 186 Cluster 2 ( $n=184$ , 11%; *Moderate*) had a high probability of pain and function assessment  
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25 187 (probabilities over 0.95) and of consideration for (but not receipt of) physiotherapy and topical  
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27 188 NSAID or paracetamol. They also had a high probability of being given or considered for OA  
28  
29 189 information and exercise advice. Their recorded care achieved a median of three indicators and  
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31 190 they were considered for care relating to a median of three further indicators. Cluster 3 ( $n=286$ ,  
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33 191 17%; *Low*) had a high probability of pain and function assessment (probabilities over 0.87), and  
34  
35 192 were likely to be prescribed or considered for paracetamol or topical NSAIDs but generally were not  
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37 193 recorded as receiving or being considered for other indicators (received a median of three  
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39 194 processes and considered for a median of one further). Cluster 4 ( $n=595$ , 35%; *None*) had low  
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41 195 probabilities of a record of receiving or being considered for any indicator (received and considered  
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43 196 median zero indicators).

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51 197 Supplementary Table 1 compares the number of people in each cluster who were expected, based  
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53 198 on the model, to receive each care process (identified by the indicators) and the number actually

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3 199 recorded as receiving them. Differences between observed and expected values were small and  
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5 200 generally related to distinguishing between care received compared to care considered.  
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8 201 Patient and clinician characteristics for each cluster are shown in Table 4 with results from the  
9  
10 202 multinomial model comparing clusters in Table 5. Compared to the *None* cluster, patients in the  
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12 203 *High* and *Moderate* clusters tended to consult with a clinician with a higher OA workload, consult  
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14 204 multiple times, and have less total morbidity (Table 5). The patients with *High* level of recorded  
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16 205 care were more likely to have diagnosed OA (adjusted RRR 1.81, 95% CI 1.41, 2.32) and less likely to  
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18 206 have hand or foot clinical OA than patients in the *None* cluster, whilst patients in the *Moderate*  
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20 207 cluster were less likely to have diagnosed OA (RRR 0.55, 95% CI 0.35, 0.85) or be overweight (RRR  
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22 208 0.57, 95% CI 0.39, 0.85), but more likely to have clinical OA in multiple sites (RRR 1.89, 95% CI 0.99,  
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24 209 3.59) than patients in the *None* cluster. Patients in the *Low* cluster were less likely than patients in  
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26 210 the *None* cluster to have a single consultation (RRR 0.45, 95% CI 0.34, 0.60), have clinical OA in the  
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28 211 foot (RRR 0.25, 95% CI 0.13, 0.51), or have multimorbidity.  
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34 212 Those in the *High* cluster had slightly higher levels of opioid prescription (36%; chi-squared test,  
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36 213  $p=0.06$ ), oral NSAID prescription (20%;  $p=0.01$ ), and recorded X-rays (22%;  $p<0.01$ ) than patients in  
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38 214 the other clusters, although differences between the *High* and *Low* clusters, in particular, were  
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40 215 small (Table 6).  
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44 216 In those with a record of a pain assessment, patients in the *High* cluster were more likely to have  
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46 217 recorded moderate or severe pain (70% vs 57% in the *Moderate* cluster and 64% in the *Low*  
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48 218 cluster). The same pattern was seen for functional limitation although differences between clusters  
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50 219 were smaller (Table 6).  
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## 220 Discussion

221 This study has identified four patterns of recorded primary care management of OA based on  
222 previously identified quality indicators of care. Just over a third of patients consulting for clinical OA  
223 had recorded care meeting the majority of quality indicators. Another third were not recorded as  
224 having received or been considered for any of these quality indicators. Factors associated with  
225 higher recorded quality of care included receiving an OA diagnosis, OA in the knee or hip rather  
226 than foot or hand, lower total morbidity burden, multiple consultations for clinical OA, and initial  
227 consultation with a clinician who was recorded as seeing more than the median number of OA  
228 patients. Previous evidence has demonstrated that guidelines for treatment of OA within primary  
229 care are not consistently adhered to [14-16]. The way in which receipt of different recommended  
230 care processes for OA are grouped within patients has not previously been investigated. In our  
231 study, 38% of the patients were recorded as having received a relatively large number of quality  
232 indicators and could be regarded as a group achieving the closest to optimal care based on these  
233 indicators (the *High* group). Care for members of two clusters (*Moderate* and *Low*) achieved some  
234 quality indicators overall but can be distinguished by the fact that information, advice (exercise,  
235 weight loss) and physiotherapy were more likely to be considered in the *Moderate* cluster than the  
236 *Low*. A third of patients were in the *None* cluster which demonstrated the weakest recorded quality  
237 of care with the majority of this group lacking recorded achievement or consideration of any  
238 indicator. The patients in the cluster with the best recorded care (*High*) were also more likely to  
239 receive other elements of care such as oral NSAIDs and referral for X-ray. NICE does not  
240 recommend routine use of X-ray for OA diagnosis and suggests that opioids and oral NSAIDs should  
241 be used only if topical NSAIDs and paracetamol do not relieve pain [3]. The greater use of these  
242 approaches in the *High* cluster may reflect worse severity of OA and this cluster did have slightly  
243 higher levels of clinician-recorded pain and functional limitation than those in the *Moderate* and

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3 244 *Low* clusters. While one hypothesis may be that patients in the *High* cluster are given all possible  
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5 245 care elements, this is unlikely to be the case as differences between clusters on the non-quality  
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7 246 indicator elements of care were generally small, and most patients in the *High* cluster were not in  
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9 247 receipt of these non-recommended approaches.

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13 248 It is possible that the clinicians treating those in the *High* cluster were more engaged with, or more  
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15 249 confident in managing OA. Confidence in OA management could be associated with confidence in  
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17 250 OA diagnosis, which may explain the increased use of OA Read codes in these patients. Conversely,  
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19 251 where OA Read codes were not given there may have been uncertainty about both diagnosis and  
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21 252 management. Previous qualitative observational research of primary care consultations has  
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23 253 identified confusion about the construct of OA, with family doctors tending not to use the term  
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25 254 'osteoarthritis' with patients but instead, normalising symptoms [17]. A formal diagnosis of OA,  
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27 255 delivered explicitly, may be needed for holistic components of care such as patient education and  
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29 256 self-management support to be offered [5,17]. Patients with greater morbidity received a lower  
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31 257 recorded quality of care and this may be because they were (perhaps erroneously) considered less  
32  
33 258 suitable for non-pharmacological and relatively safe pharmacological options. It is also possible that  
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35 259 OA was given lower priority compared to their other problems [17,18]. Patients with foot (and to  
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37 260 some extent hand) OA may also have been particularly susceptible to lower levels of recorded  
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39 261 quality of care and this site has been less well-investigated with regard to effective interventions  
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41 262 [19,20].

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43 263 This is the first study known to the authors which examines patterns of quality of care of chronic  
44  
45 264 conditions such as OA. Other analyses of recorded quality of care for OA have reported some  
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47 265 influences on individual process measures. Broadbent et al. identified older age as being associated  
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49 266 with reduced information provision but increased initial use of paracetamol and, where an oral  
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3 267 NSAID was prescribed, greater first-use of ibuprofen or a COX-2 selective NSAID; female sex was  
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5 268 associated with increased information provision; severe OA was associated with increased pain and  
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7 269 function assessment in the previous year [21]. Unlike in this analysis, Min et al. identified an  
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10 270 association between multimorbidity (using a count of conditions) and better quality of care  
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12 271 amongst vulnerable elders, some of whom had OA [22].

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15 272 This study has important strengths. The study population was large and the practices were diverse  
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17 273 with respect to urbanisation, staffing, deprivation, and size of registered population, implying good  
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20 274 generalisability. Prescription recording is likely to be near-complete since most prescribing is  
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22 275 electronic and use of the e-template mitigates against missing data from patients using over-the-  
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24 276 counter pharmacological approaches. The e-template also facilitates enhanced data collection in  
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27 277 general practice without incurring biases such as social desirability. LCA uses probabilistic modelling  
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29 278 and finite mixture distributions to collect participants into clusters, which is a different method to  
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31 279 traditional clustering techniques (e.g. cluster analysis). Given this, LCA should produce a lower  
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34 280 misclassification rate and better statistical criteria for investigating model fit [23]. Whilst there was  
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36 281 variation in quality of care between clinicians and practices [5], clustering effects of patients within  
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38 282 clinicians was adjusted for through the multilevel model. There are some limitations in this analysis.  
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41 283 Due to the inherent nature of EHR studies, the data extracted is a function of both the individual  
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43 284 clinician's clinical and recording behaviours. It is therefore possible that some patients were  
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45 285 misclassified as the lack of a record of a care process does not conclusively demonstrate that it did  
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47 286 not occur. Compared to prescription recording, it is less certain how well-recorded referrals are.  
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49  
50 287 However, despite the limitations of EHR data, the differences in levels of prescribed analgesia  
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52 288 between the clusters suggests there were real differences in care between the four clusters  
53  
54 289 identified. Conversely, patients may have been coded as receiving some elements of care without



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3 290 this necessarily having been conducted in a comprehensive or meaningful way. Triangulation of  
4  
5 291 medical record indicators with patient-reported indicators would be needed to evaluate this  
6  
7 292 further. Our assumption that those without a weight recorded were considered for weight loss  
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9 293 advice was based on the increased likelihood of a weight recording if a patients appears overweight  
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11 294 [10] but will have over-estimated the proportion of patients considered for weight loss advice.  
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13  
14 295 However, over 80% of patients did have a weight record. The association between multiple  
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16 296 consultations for OA and clusters with higher recorded quality of care may reflect greater  
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18 297 opportunity to provide and record care but may also have reflected a greater disease severity and  
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20 298 healthcare need. Although we considered comorbidities, previous research has identified that OA  
21  
22 299 may be discussed in complex consultations about multiple problems [17] and the length of time  
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24 300 discussing OA in a consultation would likely be an important influence on the level of recorded care.  
25  
26 301 It is also possible that those with recorded peripheral joint pain rather than recorded OA may not  
27  
28 302 have OA, particularly in the foot [24]. The e-template itself was previously found to be associated  
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30 303 with increased prescription of paracetamol and topical NSAIDs and so the patterns of care recorded  
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32 304 may not be generalisable to practices not using the e-template [5].  
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38 305 Promotion of core interventions (information, exercise, and weight loss advice), alongside  
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40 306 appropriate use of the relatively safe pharmacological options, remains an important strategy in the  
41  
42 307 primary care management of OA but many patients receive few or none of these. This is particularly  
43  
44 308 true for patients with higher levels of morbidity, or hand or foot OA. Whilst there is substantial  
45  
46 309 variation in recorded care of OA, high quality care appears feasible given we found that over a third  
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48 310 of patients with OA were recorded as receiving most core recommendations. A structured annual  
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50 311 review for people with OA [25] as recommended by NICE [9] may help, possibly nurse-led,  
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52 312 integrated, where appropriate, into a multimorbidity review. However, barriers to providing and  
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3 313 recording high quality care still need to be identified and mechanisms need to be explored to  
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5 314 ensure appropriate delivery of care to all patients.  
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31 324 analysis plan, cleaned the data, and drafted and revised the paper; KSD is PI for the study, led the  
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33 325 design of the MOSAICS study, and revised the paper; EC, ZP and AF were involved in the  
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35 326 interpretation of the findings and revised the paper. All authors have approved the final version.  
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### 38 348 **Data access statement**

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41 349 The Centre has established data sharing arrangements to support joint publications and other  
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43 350 research collaborations. Applications for access to anonymised data from our research databases  
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45 351 are reviewed by the Centre's Data Custodian and Academic Proposal (DCAP) Committee and a  
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47 352 decision regarding access to the data is made subject to the NRES ethical approval first provided for  
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49 353 the study and to new analysis being proposed. Further information on our data sharing procedures  
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51 354 can be found on the Centre's website  
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355 (<http://www.keele.ac.uk/pchs/publications/datasharingresources/>) or by emailing the Centre's  
356 data manager ([primarycare.datasharing@keele.ac.uk](mailto:primarycare.datasharing@keele.ac.uk)).

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**Table 1:** Quality Indicators and categories used for latent class analysis

Quality Indicator	Categories	Definition
Pain Assessed	Assessed	Recorded level of pain <sup>a</sup>
	Not Assessed	No entry recorded <sup>a</sup>
Function Assessed	Assessed	Recorded level of function <sup>a</sup>
	Not Assessed	No entry recorded <sup>a</sup>
OA Information	Given	Recorded written or verbal <sup>a</sup>
	Considered, but Not Given	Recorded not appropriate <sup>a</sup>
Exercise Advice	Not Considered	No entry recorded <sup>a</sup>
	Given	Recorded written or verbal <sup>a</sup>
Weight loss Advice <sup>c</sup>	Considered, but Not Given	Recorded not appropriate <sup>a</sup>
	Not Considered	No entry recorded <sup>a</sup>
Paracetamol or Topical NSAID	Prescribed	Either drug prescribed <sup>b</sup>
	Considered, but Not Prescribed	Neither drug prescribed but recorded tried, offered, patient declined, or not appropriate <sup>a</sup>
Physiotherapy	Not Considered	Neither drug prescribed, recorded unknown or no entry recorded for both drugs <sup>a</sup>
	Referred	Recorded referral <sup>b</sup>
Physiotherapy	Considered, but Not Referred	No referral but recorded as offered, or not necessary or not appropriate <sup>a</sup>
	Not Considered	No referral, recorded not this time or no entry recorded <sup>a</sup>

<sup>a</sup> from e-template; <sup>b</sup> from routine records; <sup>c</sup> patients without a recorded BMI of  $\geq 25$  within the last 3 years were allocated to “Considered, but not given” category

**Table 2:** Latent class analysis goodness of fit statistics

Number of clusters	BIC	$\chi^2$ goodness of fit	Population (%) of smallest cluster	Range of mean PP across clusters	<i>n</i> (%) with PP<0.7
1	20994.14	32978.08	1724 (100)	1.000	0 (0)
2	15160.57	3332.77	1071 (62)	0.992, 0.987	3 (<1)
3	14715.82	1727.74	430 (25)	0.906, 0.991	138 (8)
4	14627.48	1522.28	184 (11)	0.848, 0.994	157 (9)
5	14661.55	809.88	142 (8)	0.830, 0.993	207 (12)
6	14699.79	733.23	112 (6)	0.754, 0.996	257 (15)
7	14771.09	818.78	22 (1)	0.701, 0.996	267 (15)

BIC: Bayesian Information Criterion; PP: posterior probability

**Table 3:** Conditional item response probabilities for the quality indicators for each cluster

		Overall <i>n</i> (%)	Cluster			
Quality Indicators			<i>High</i> ( <i>n</i> =659, 38%)	<i>Moderate</i> ( <i>n</i> =184, 11%)	<i>Low</i> ( <i>n</i> =286, 17%)	<i>None</i> ( <i>n</i> =595, 35%)
Pain Assessment	Assessed	1092 (63)	0.978	0.961	0.922	0.014
	Not Assessed	632 (37)	0.022	0.039	0.078	0.987
Function Assessment	Assessed	1070 (62)	0.981	0.955	0.873	0.000
	Not Assessed	654 (38)	0.019	0.045	0.127	1.000
OA Information	Given	764 (44)	0.930	0.463	0.319	0.001
	Considered, Not Given	85 (5)	0.009	0.330	0.011	0.000
	Not Considered	875 (51)	0.062	0.207	0.670	1.000
Exercise Advice	Given	768 (45)	0.994	0.417	0.237	0.000
	Considered, Not Given	96 (6)	0.007	0.313	0.067	0.000
	Not Considered	860 (50)	0.000	0.270	0.696	1.000
Weight Advice	Given	536 (31)	0.593	0.115	0.089	0.000
	Considered, Not Given	153 (9)	0.298	0.733	0.347	0.441
	Not Considered	1035 (60)	0.109	0.152	0.564	0.559
Topical NSAID/paracetamol	Prescribed	609 (35)	0.476	0.273	0.394	0.239
	Considered, Not Prescribed	570 (33)	0.496	0.641	0.406	0.004
	Not Considered	545 (32)	0.028	0.086	0.200	0.757
Physiotherapy	Referred	124 (7)	0.111	0.037	0.101	0.032
	Considered, Not Referred	532 (31)	0.559	0.732	0.080	0.000
	Not Considered	1068 (62)	0.330	0.230	0.819	0.968
Median count (IQR) Assessed/prescribed/given/referred			5 (4, 6)	3 (2, 3)	3 (2, 3)	0 (0, 1)
Median count (IQR) Considered			1 (1, 2)	3 (2, 4)	1 (0, 1)	0 (0, 1)



**Table 4:** Patient and clinician characteristics for each cluster

		Total <i>n</i> (%)	Cluster			
			<i>High</i> ( <i>n</i> =659)	<i>Moderate</i> ( <i>n</i> =184)	<i>Low</i> ( <i>n</i> =286)	<i>None</i> ( <i>n</i> =595)
Age:	45-64	817	277 (34)	109 (13)	293 (43)	138 (17)
	65-74	442	213 (48)	20 (5)	144 (33)	65 (15)
	75-84	349	133 (38)	35 (10)	116 (33)	65 (19)
	85+	116	36 (31)	20 (17)	42 (36)	18 (6)
Gender:	Male	710	286 (40)	68 (10)	113 (16)	243 (34)
	Female	1014	373 (37)	116 (11)	173 (17)	352 (35)
BMI category:						
	Normal	315	111 (35)	54 (17)	48 (15)	102 (32)
	Overweight	1080	471 (44)	83 (8)	193 (18)	333 (31)
	Not recorded	329	77 (23)	47 (14)	45 (14)	160 (49)
Recorded joint pain only		1142	366 (32)	148 (13)	207 (18)	421 (37)
OA diagnosis		582	293 (50)	36 (6)	79 (14)	174 (30)
Site of OA:						
	Knee	855	359 (42)	80 (9)	149 (17)	267 (31)
	Hip	363	135 (37)	41 (11)	68 (19)	119 (33)
	Foot	125	30 (24)	15 (12)	10 (8)	70 (56)
	Hand	152	33 (22)	25 (16)	31 (20)	63 (41)
	Unspecified	99	30 (30)	8 (8)	16 (16)	45 (46)
	Multiple	130	72 (55)	15 (12)	12 (9)	31 (24)
Morbidity load <sup>a</sup> :						
BNF count	0-4	485	156 (32)	68 (14)	89 (18)	172 (36)
	5-9	578	240 (42)	56 (10)	99 (17)	183 (32)
	10+	661	263 (40)	60 (9)	98 (15)	240 (36)
Clinician OA workload <sup>b</sup> :						
	Below the median	197	41 (21)	16 (8)	36 (18)	104 (53)
	Above the median	1527	618 (41)	168 (11)	250 (16)	491 (32)
Median (IQR) no. of OA consultations <sup>b</sup>		1 (0, 1)	1 (1, 2)	1 (1, 2)	1 (1, 2)	1 (1, 1)
OA consultations <sup>b</sup> :						
	Multiple	532	250 (47)	63 (12)	99 (19)	120 (23)
	Single	1192	409 (34)	121 (10)	187 (16)	475 (40)
Consulter status:						
	Repeat	566	232 (41)	53 (9)	84 (15)	197 (35)
	New <sup>c</sup>	1158	427 (37)	131 (11)	202 (17)	398 (34)

<sup>a</sup> Number of BNF sections from which prescription was made in previous 12 months; <sup>b</sup> during six month period; <sup>c</sup> no clinical OA consultations within the previous 12 months

**Table 5:** Associations of patient and clinician characteristics with cluster membership

<i>n</i> = 1724		<i>High vs None</i> RRR <sup>a</sup> (95% CI)	<i>Moderate vs None</i> RRR <sup>a</sup> (95% CI)	<i>Low vs None</i> RRR <sup>a</sup> (95% CI)	
Age:	45-64	1	1	1	
	65-74	1.41 (1.07, 1.84)	0.45 (0.27, 0.74)	0.97 (0.69, 1.37)	
	75-84	1.13 (0.83, 1.52)	1.02 (0.65, 1.60)	1.42 (0.99, 2.05)	
	85+	0.91 (0.56, 1.47)	1.56 (0.85, 2.89)	1.24 (0.69, 2.23)	
Gender:	Male	1	1	1	
	Female	0.86 (0.69, 1.07)	1.03 (0.75, 1.43)	1.04 (0.80, 1.36)	
BMI category:	Normal	1	1	1	
	Overweight	1.20 (0.91, 1.60)	0.57 (0.39, 0.85)	1.33 (0.93, 1.90)	
	Not recorded	0.39 (0.27, 0.56)	0.52 (0.33, 0.81)	0.52 (0.33, 0.82)	
Recorded joint pain only		1	1	1	
	OA diagnosis	1.81 (1.41, 2.32)	0.55 (0.35, 0.85)	0.93 (0.68, 1.29)	
Site of OA:	Knee	1	1	1	
	Hip	0.86 (0.66, 1.14)	1.14 (0.76, 1.71)	1.04 (0.75, 1.44)	
	Foot	0.38 (0.24, 0.60)	0.73 (0.39, 1.36)	0.25 (0.13, 0.51)	
	Hand	0.45 (0.30, 0.70)	1.18 (0.70, 1.98)	0.88 (0.56, 1.39)	
	Unspecified	0.48 (0.30, 0.80)	0.85 (0.38, 1.90)	0.74 (0.41, 1.34)	
Morbidity load <sup>b</sup> :	BNF count	Multiple	1.13 (0.75, 1.74)	1.89 (0.99, 3.59)	0.65 (0.34, 1.24)
		0-4	1	1	1
		5-9	0.95 (0.71, 1.26)	0.74 (0.50, 1.11)	0.75 (0.54, 1.06)
		10+	0.64 (0.47, 0.87)	0.55 (0.35, 0.86)	0.50 (0.35, 0.73)
Clinician OA workload <sup>c</sup> :	Below the median	1	1	1	
	Above the median	2.90 (1.98, 4.25)	2.32 (1.33, 4.03)	1.46 (0.98, 2.18)	
OA consultations <sup>c</sup> :	Multiple	1	1	1	
	Single	0.43 (0.34, 0.54)	0.47 (0.33, 0.66)	0.45 (0.34, 0.60)	
Consulter status:	Repeat	1	1	1	
	New <sup>d</sup>	1.12 (0.89, 1.41)	1.09 (0.76, 1.55)	1.18 (0.88, 1.59)	

<sup>a</sup> Relative risk ratio from multilevel multinomial regression (patients within initial clinician seen) adjusted for all presented covariates, *None* cluster is reference; <sup>b</sup> Number of BNF sections from which prescription was made in previous 12 months; <sup>c</sup> during six month period;

<sup>d</sup> no clinical OA consultations within the previous 12 month

**Table 6:** Use of management processes other than those used as quality indicators, and recorded severity of pain and functional limitation, by cluster

<i>n</i> (column %)	Cluster					<i>p</i> -value <sup>a</sup>
	Total <i>n</i> (%)	High ( <i>n</i> =659)	Moderate ( <i>n</i> =184)	Low ( <i>n</i> =286)	None ( <i>n</i> =595)	
Opioid Prescribed	557 (33)	236 (36)	54 (29)	94 (33)	173 (29)	0.06
Oral NSAID Prescribed	284 (17)	130 (20)	21 (11)	49 (17)	84 (14)	0.01
X-ray Requested	263 (15)	142 (22)	30 (16)	52 (18)	39 (7)	<0.01
<i>n</i> with pain record	1092	645	177	263	7	0.001 <sup>b</sup>
No pain	16 (1)	4 (<1)	7 (4)	4 (2)	1	
Mild pain	348 (32)	187 (29)	69 (39)	91 (35)	1	
Moderate pain	582 (53)	357 (55)	84 (47)	136 (52)	5	
Severe pain	146 (13)	97 (15)	17 (10)	32 (12)	0	
<i>n</i> with function record	1070	646	174	250	0	0.004 <sup>b</sup>
No limitation	101 (9)	46 (7)	29 (16)	26 (10)	0	
Mild limitation	456 (43)	276 (43)	73 (42)	107 (43)	0	
Moderate limitation	427 (40)	277 (43)	57 (33)	93 (37)	0	
Severe limitation	86 (8)	47 (7)	15 (9)	24 (10)	0	

<sup>a</sup> $\chi^2$  test, <sup>b</sup> excluding *None* cluster

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Title upload
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract upload
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	2
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	2-3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	3
		<i>Case-control study</i> —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	
Variables	7	<i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	3-5
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed	
		<i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	N/A
Data sources/ measurement	8*	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3-5
		For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	3-5
Bias	9	Describe any efforts to address potential sources of bias	3
Study size	10	Explain how the study size was arrived at	N/A (sample size calculation was for the clinical outcomes reported elsewhere)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(a) Describe all statistical methods, including those used	5-6

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2 to control for confounding

3 (b) Describe any methods used to examine subgroups N/A  
4 and interactions

5 (c) Explain how missing data were addressed 4

6 (d) *Cohort study*—If applicable, explain how loss to N/A  
7 follow-up was addressed

8 *Case-control study*—If applicable, explain how  
9 matching of cases and controls was addressed

10 *Cross-sectional study*—If applicable, describe analytical  
11 methods taking account of sampling strategy

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14 (e) Describe any sensitivity analyses N/A

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<b>Results</b>		<b>Page</b>	
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 4
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	N/A
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	N/A
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	Table 3
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 5
		(b) Report category boundaries when continuous variables were categorized	Table 4, 5
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	8-9
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	11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
<b>Other information</b>			
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	13

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Patterns of routine primary care for osteoarthritis in the UK: a cross-sectional electronic health records study

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Keywords:	Osteoarthritis, PRIMARY CARE, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Latent class analysis

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Manuscripts

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3 **1 Patterns of routine primary care for osteoarthritis: a cross-sectional electronic health records**  
4  
5 **2 study**

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7 3 H Jackson<sup>1,2</sup>, LA Barnett<sup>1</sup>, KP Jordan<sup>1,3</sup>, KS Dziedzic<sup>1</sup>, E Cottrell<sup>1</sup>, AG Finney<sup>1</sup>, Z Paskins<sup>1</sup>, JJ Edwards<sup>1</sup>

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48 21 Running title: Patterns of primary care for osteoarthritis



## 22 Abstract

### 23 Objective

24 To determine common patterns of recorded primary care for osteoarthritis (OA), and patient and  
25 provider characteristics associated with the quality of recorded care.

### 26 Design

27 An observational study nested within a cluster-randomised controlled trial.

### 28 Setting

29 Eight UK general practices who were part of the Management of OsteoArthritis In ConsultationS  
30 (MOSAICS) study.

### 31 Participants

32 Patients recorded as consulting within the eight general practices for clinical OA.

### 33 Primary outcomes

34 Achievement of seven quality indicators of care (pain/function assessment, information provision,  
35 exercise/weight advice, analgesics, physiotherapy), recorded through an electronic template or  
36 routinely-recorded in the electronic healthcare records, were identified for patients aged  $\geq 45$  years  
37 consulting over a six-month period with clinical OA. Latent class analysis was used to cluster  
38 patients based on care received. Clusters were compared on patient and clinician-level  
39 characteristics.

### 40 Results

41 1724 patients (median by practice 183) consulted with clinical OA. Common patterns of recorded  
42 quality care were: Cluster 1 (38%, *High*) received most quality indicators of care; Cluster 2 (11%,  
43 *Moderate*) had pain and function assessment, and received or were considered for other indicators;  
44 Cluster 3 (17%, *Low*) had pain and function assessment, and received or were considered for  
45 paracetamol or topical NSAIDs; Cluster 4 (35%, *None*) had no recorded quality indicators. Patients

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3 46 with higher levels of recorded care consulted a clinician who saw more OA patients, consulted  
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5 47 multiple times, and had less morbidity. Those in the *High* cluster were more likely to have recorded  
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7 48 diagnosed OA and have knee/hip OA.

## 9 49 **Conclusions**

10 50 Patterns of recorded care for OA fell into four natural clusters. Appropriate delivery of core  
11  
12 51 interventions and relatively safe pharmacological options for OA are still not consistently recorded  
13  
14 52 as provided in primary care. Further research to understand clinical recording behaviours and  
15  
16 53 determine potential barriers to quality care alongside effective training for clinicians is needed.

17  
18  
19 54 **Trial registration number:** ISRCTN06984617

## 20 55 **Keywords**

21 56 Osteoarthritis, primary care, quality indicators, latent class analysis

## 22 57 **Article summary**

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30 58 • This paper describes a novel use of latent class analysis to identify patterns of primary care  
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32 59 for osteoarthritis (OA)
- 33  
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35  
36 60 • The population studied was large and diverse, increasing generalisability, and based on a  
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38 61 broad definition of clinical OA to reduce selection bias
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41 62 • The analysis used some quality indicators of care newly-implemented in practices through  
42  
43 63 an electronic template (pain/function assessment, information provision, exercise/weight  
44  
45 64 advice, analgesics, physiotherapy), which may have increased the recorded quality of care  
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47 65 compared to routine practice
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51 66 • Four clusters of recorded care were identified: approximately one-third of patients had a  
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53 67 high probability of delivery of most care processes whilst another third had a low probability  
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55 68 of any such delivery. The remaining patients had a high probability of pain and function

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69 assessment but were distinguished by the probability of delivery or consideration of other  
70 aspects of care.

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## 72 Introduction

73 Osteoarthritis (OA) is a common reason for adults aged  $\geq 45$  years to consult primary care. Annually,  
74 in the UK, 4% of such adults are recorded as consulting in general practice for diagnosed OA, with  
75 an additional 8% recorded with joint pain likely to be attributable to OA [1]. Osteoarthritis is a  
76 common reason for disability, and was ranked the 11<sup>th</sup> biggest cause of disability by the 2010  
77 Global Burden of Disease (GBD) [2].

78 The UK National Institute for Health and Care Excellence (NICE) OA management guidelines  
79 recommend core strategies of information provision, physical activity and exercise, and weight  
80 management, supplemented with use of relatively safe pharmacological management strategies  
81 (for example, topical non-steroidal anti-inflammatory drugs [NSAIDs]), as necessary [3].  
82 Intensification of management should depend on response to these initial approaches. However,  
83 there is evidence that patients diagnosed with OA do not receive care that is well aligned to  
84 evidence-based recommendations and which may be overly dependent on pharmacological  
85 methods [4].

86 We have previously identified variation between clinicians in recorded quality of individual  
87 indicators of OA care [5]. However, patterns of OA care and factors linked with increased  
88 probability of adherence to OA quality standards are less well-studied. Using electronic general  
89 practice records data, the objectives of this study were to determine patterns of recorded primary  
90 care for OA based on quality indicators, and to determine associations between higher-quality  
91 recorded care and patient and clinician characteristics.

## 92 Methods

93 This analysis used data from the Management of OsteoArthritis In ConsultationS (MOSAICS) study  
94 (Trial registration number ISRCTN06984617), approved by the North West Research Ethics

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3 95 Committee, Cheshire (reference: 10/H1017/76) [6]. MOSAICS was a mixed-methods study, which  
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5 96 investigated the effect of a model consultation for clinical OA. It was set within eight general  
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7 97 practices in Cheshire, Shropshire and Staffordshire, UK. Practice eligibility has been reported  
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9 98 elsewhere [6]. The current analysis, reported in line with STROBE guidelines, used anonymised  
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11 99 information from the electronic health records (EHR) of these practices for the six-month baseline  
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14 100 period before randomisation of practices to intervention or control arms [6]. At the beginning of  
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16 101 the baseline period, a computerised template (“e-template”, described below) was installed within  
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18 102 the EHR and all practices continued with otherwise usual care until the end of the baseline period.

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22 103 The study population was all patients aged  $\geq 45$  years registered with the eight general practices  
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24 104 who consulted with clinical OA in the baseline six-month period. UK general practice utilises a  
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26 105 system of Read codes (similar in principle to the International Classification of Diseases codes) to  
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28 106 record symptoms, morbidities, and care processes [7]; within MOSAICS, clinical OA was defined as  
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30 107 either a recorded OA Read code or a peripheral joint pain Read code for the hand, hip, knee, or  
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32 108 foot, to reduce the potential for selection bias in clinician coding. Patients were allocated to an  
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34 109 index clinician, being the clinician recording the first formally diagnosed (i.e. OA Read-coded) OA  
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36 110 consultation in the baseline period or, if none, the first peripheral joint pain coded consultation in  
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38 111 the same period.

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43 112 Outcome measures were the seven indicators of quality of care for OA in general practice recorded  
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45 113 in the EHR (Table 1). These could be entered into the EHR as routinely-recorded data or captured  
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47 114 through the e-template. The identification and synthesis of appropriate quality indicators using a  
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49 115 systematic review and NICE 2008 guidelines has previously been reported [5,8,9].

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54 116 Achievement of prescribing and referral indicators (recorded prescription of topical NSAIDs or  
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56 117 paracetamol, and onward physiotherapy referral) were determined from data in the routinely-

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3 118 recorded component of the EHR and were determined to have been achieved if they were recorded  
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5 119 within 14 days of any clinical OA consultation in the six-month period.  
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8 120 The e-template facilitated recording of achievement of indicators that are known to be poorly  
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10 121 captured in routinely-recorded data [5]: (i) assessment of pain and function, (ii) provision or  
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12 122 consideration of OA information, exercise advice, and weight loss advice, (iii) consideration of  
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14 123 paracetamol or topical NSAID and (iv) consideration of physiotherapy referral. The entry of a code  
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16 124 for clinical OA for a patient aged  $\geq 45$  years triggered the e-template. The design, interpretation, and  
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18 125 effects of the e-template have previously been reported [5]. The clinicians could complete the e-  
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20 126 template at any point throughout the consultation and could choose to complete all, some, or none  
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22 127 of the e-template. The e-template has been endorsed by NICE to facilitate enhanced uptake of  
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24 128 quality standards [10].  
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30 129 Data from the EHR (derived from both routinely-recorded data and the e-template) were  
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32 130 amalgamated within the relevant quality indicator. For example, consideration of paracetamol and  
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34 131 topical NSAIDs (entered using e-template) was combined with actual prescription of these agents  
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36 132 (routinely-recorded data). Outcomes (Table 1) were dichotomous for pain and function  
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38 133 assessments. For all other indicators, the possibilities were for the indicator to be *achieved*,  
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40 134 *considered* (without record of having been delivered), or *not considered*. There is evidence that  
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42 135 weight recording is more common in people who are overweight compared to those who are not  
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44 136 [11]. To minimise the effect of missing data and to preserve the ability of the model to identify  
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46 137 people who needed weight loss advice but were not recorded as receiving it, any patient recorded  
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48 138 as being of normal weight or who did not have a weight recorded was allocated to *considered* for  
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50 139 weight loss advice.  
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3 140 We investigated how patterns of care based on the quality indicators were associated with other  
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5 141 OA care processes, recorded in the routine EHR within 14 days of any clinical OA consultation:  
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7 142 prescriptions for oral NSAIDs and opioids, and relevant X-rays (hand, hip knee, or foot).  
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10 143 Factors potentially associated with patterns of quality of care that were considered were: patient  
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12 144 age, gender, body mass index (BMI), the site of clinical OA, whether patients had multiple or a  
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14 145 single consultation for clinical OA within the six-month time period, whether the patient was a new  
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16 146 consulter (no clinical OA consultations within the previous 12 months) and total morbidity. Total  
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18 147 morbidity was measured by a count of British National Formulary (BNF) subchapters from which  
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20 148 prescriptions had been issued in the previous 12 months [12]. A proxy measure of OA workload for  
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22 149 the patients' index clinician was determined by dichotomising the number of index clinical OA  
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24 150 consultations at the median value (14) across clinicians.  
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### 30 Statistical analysis

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32 152 Latent class analysis (LCA) was used to cluster patients into groups based on recorded achievement  
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34 153 of the seven quality indicators. All patients within a cluster should have similar recorded care for  
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36 154 their OA or joint pain, but care should differ between patients belonging to different clusters [13].  
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40 155 Latent class models were fitted, beginning with a one-cluster model where all the patients were  
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42 156 assumed to have been given the same pattern of treatment of OA, up to a seven-cluster model. To  
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44 157 determine the optimum number of clusters, we considered the Bayes Information Criterion [14]  
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46 158 (BIC, whereby the lowest BIC indicated the best model) with the size of each cluster, and the  
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48 159 interpretability of the model. Posterior probabilities (PP) for a patient (the probabilities of that  
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50 160 patient belonging to each of the clusters within the model) were identified. The cluster that had the  
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52 161 largest PP for a patient was the cluster that patient was assigned to. We used the mean PP for  
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162 patients allocated to each cluster to measure cluster separation; a mean PP of more than 0.7

163 indicated that the patients were clearly assigned to that specific cluster [15].

164 Using a two-level (patient within index clinician) multinomial multilevel logistic regression,

165 associations between the patient and clinician-level covariates and cluster membership were

166 estimated and reported as relative risk ratios (RRR) with 95% confidence intervals (CI). We also

167 used chi-squared tests to compare between clusters on levels of pain and functional limitation

168 (none, mild, moderate, severe) as recorded in the e-template.

169 Statistical analysis was performed using R studio version 3.3.0, and MLwiN version 2.35 for

170 Windows.

## 171 Results

172 During the six-month period, 1724 patients (median per practice  $n=183$ ) consulted with a recorded

173 clinical OA code and triggered the e-template. All were included in the analysis. 1014 (59%) of these

174 were female, mean age was 66.1 years (SD: 11.9) and 582 (34%) patients were recorded with a

175 diagnosis of OA rather than peripheral joint pain. Among consulters, 50% were recorded as having

176 clinical OA at the knee, 21% at the hip, and the remainder with ankle/foot, wrist/hand, multisite, or

177 unspecified clinical OA.

178 As previously reported [5], pain (63%) and function (62%) assessment were the most commonly

179 achieved indicators. Recorded provision of OA information (44%), and exercise advice (45%) were

180 achieved in under half of patients, and weight loss advice in less than a third of patients (31%). 609

181 (35%) patients were prescribed paracetamol or topical NSAIDs. A referral for physiotherapy was

182 made in 7% of patients.



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3 183 Table 2 shows the goodness-of-fit statistics for the LCA models with one to seven clusters. The four-  
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5 184 cluster model gave the lowest BIC, and each of the clusters in the three-, four-, and five-cluster  
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7 185 models had a mean PP for patients belonging to that cluster above 0.83. In the three-cluster model  
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9 186 the smallest cluster size was 430 (25%), in the four-cluster model it was 184 (11%) and the five-  
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11 187 cluster model had a smallest cluster size of 142 (8%). Based on the cluster sizes, goodness-of-fit  
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13 188 statistics, and clinical interpretability, the four-cluster model was chosen as the optimal model.

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17 189 Table 3 shows the probability of recorded receipt of each of the seven quality indicators for  
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19 190 patients allocated to each cluster. Patients in cluster 1 ( $n=659$ , 38%) had a high probability of having  
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21 191 pain and function assessment recorded (probabilities over 0.97) and of being given OA information  
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23 192 and exercise advice (probabilities over 0.93). Patients' care within this cluster was recorded as  
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25 193 having achieved a median of five indicators and considered for, but not achieved, a median of one  
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27 194 further indicator. Cluster 1 was therefore labelled as having a *High* level of recorded quality of care.  
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29 195 Cluster 2 ( $n=184$ , 11%; *Moderate*) had a high probability of pain and function assessment  
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31 196 (probabilities over 0.95) and of consideration for (but not receipt of) physiotherapy and topical  
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33 197 NSAID or paracetamol. They also had a high probability of being given or considered for OA  
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35 198 information and exercise advice. Their recorded care achieved a median of three indicators and  
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37 199 they were considered for care relating to a median of three further indicators. Cluster 3 ( $n=286$ ,  
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39 200 17%; *Low*) had a high probability of pain and function assessment (probabilities over 0.87), and  
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41 201 were likely to be prescribed or considered for paracetamol or topical NSAIDs but generally were not  
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43 202 recorded as receiving or being considered for other indicators (received a median of three  
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45 203 processes and considered for a median of one further). Cluster 4 ( $n=595$ , 35%; *None*) had low  
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47 204 probabilities of a record of receiving or being considered for any indicator (received and considered  
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49 205 median zero indicators).

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3 206 Table 4 compares the number of people in each cluster who were expected, based on the model, to  
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5 207 receive each care process (identified by the indicators) and the number actually recorded as  
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7 208 receiving them. Differences between observed and expected values were small and generally  
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9 209 related to distinguishing between care received compared to care considered. For example, in the  
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11 210 pain assessment domain, there was no difference between the counts of observed and expected  
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13 211 provision for the *High* and *Moderate* clusters, and a difference of only one patient in the *Low* and  
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15 212 *None* clusters; for OA information provision, this was observed more frequently than expected for  
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17 213 the *High* cluster (observed n=620 compared to 613 expected) but less frequently for the *Moderate*  
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19 214 (59 vs. 85) and *Low* (85 vs. 91) clusters.

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24 215 Patient and clinician characteristics for each cluster are shown in Table 5 with results from the  
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26 216 multinomial model comparing clusters in Table 6. Compared to the *None* cluster, patients in the  
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28 217 *High* and *Moderate* clusters tended to consult with a clinician with a higher OA workload, consult  
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30 218 multiple times, and have less total morbidity (Table 6). The patients with *High* level of recorded  
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32 219 care were more likely to have diagnosed OA (adjusted RRR 1.81, 95% CI 1.41, 2.32) and less likely to  
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34 220 have hand or foot clinical OA than patients in the *None* cluster, whilst patients in the *Moderate*  
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36 221 cluster were less likely to have diagnosed OA (RRR 0.55, 95% CI 0.35, 0.85) or be overweight (RRR  
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38 222 0.57, 95% CI 0.39, 0.85), but more likely to have clinical OA in multiple sites (RRR 1.89, 95% CI 0.99,  
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40 223 3.59) than patients in the *None* cluster. Patients in the *Low* cluster were less likely than patients in  
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42 224 the *None* cluster to have a single consultation (RRR 0.45, 95% CI 0.34, 0.60), have clinical OA in the  
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44 225 foot (RRR 0.25, 95% CI 0.13, 0.51), or have multimorbidity.

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50 226 Those in the *High* cluster had slightly higher levels of opioid prescription (36%; chi-squared test,  
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52 227  $p=0.06$ ), oral NSAID prescription (20%;  $p=0.01$ ), and recorded X-rays (22%;  $p<0.01$ ) than patients in

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3 228 the other clusters, although differences between the *High* and *Low* clusters, in particular, were  
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5 229 small (Table 7).

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7  
8 230 In those with a record of a pain assessment, patients in the *High* cluster were more likely to have  
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10 231 recorded moderate or severe pain (70% vs 57% in the *Moderate* cluster and 64% in the *Low*  
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12 232 cluster). The same pattern was seen for functional limitation although differences between clusters  
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15 233 were smaller (Table 7).

## 18 234 **Discussion**

19  
20 235 This study has identified four patterns of recorded primary care management of OA based on  
21  
22 236 previously identified quality indicators of care. Just over a third of patients consulting for clinical OA  
23  
24 237 had recorded care meeting the majority of quality indicators. Another third were not recorded as  
25  
26 238 having received or been considered for any of these quality indicators. Factors associated with  
27  
28 239 higher recorded quality of care included receiving an OA diagnosis, OA in the knee or hip rather  
29  
30 240 than foot or hand, lower total morbidity burden, multiple consultations for clinical OA, and initial  
31  
32 241 consultation with a clinician who was recorded as seeing more than the median number of OA  
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34 242 patients. Previous evidence has demonstrated that guidelines for treatment of OA within primary  
35  
36 243 care are not consistently adhered to [16-18]. The way in which receipt of different recommended  
37  
38 244 care processes for OA are grouped within patients has not previously been investigated. In our  
39  
40 245 study, 38% of the patients were recorded as having received a relatively large number of quality  
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42 246 indicators and could be regarded as a group achieving the closest to optimal care based on these  
43  
44 247 indicators (the *High* group). Care for members of two clusters (*Moderate* and *Low*) achieved some  
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46 248 quality indicators overall but can be distinguished by the fact that information, advice (exercise,  
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48 249 weight loss) and physiotherapy were more likely to be considered in the *Moderate* cluster than the  
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50 250 *Low*. A third of patients were in the *None* cluster which demonstrated the weakest recorded quality  
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3 251 of care with the majority of this group lacking recorded achievement or consideration of any  
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5 252 indicator. The patients in the cluster with the best recorded care (*High*) were also more likely to  
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7 253 receive other elements of care such as oral NSAIDs and referral for X-ray. NICE does not  
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9  
10 254 recommend routine use of X-ray for OA diagnosis and suggests that opioids and oral NSAIDs should  
11  
12 255 be used only if topical NSAIDs and paracetamol do not relieve pain [3]. The greater use of these  
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14 256 approaches in the *High* cluster may reflect worse severity of OA and this cluster did have slightly  
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16 257 higher levels of clinician-recorded pain and functional limitation than those in the *Moderate* and  
17  
18 258 *Low* clusters. While one hypothesis may be that patients in the *High* cluster are given all possible  
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20 259 care elements, this is unlikely to be the case as differences between clusters on the non-quality  
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22 260 indicator elements of care were generally small, and most patients in the *High* cluster were not in  
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24 261 receipt of these non-recommended approaches.  
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29 262 It is possible that the clinicians treating those in the *High* cluster were more engaged with, or more  
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31 263 confident in managing OA. Confidence in OA management could be associated with confidence in  
32  
33 264 OA diagnosis, which may explain the increased use of OA Read codes in these patients. Conversely,  
34  
35 265 where OA Read codes were not given there may have been uncertainty about both diagnosis and  
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37 266 management. Previous qualitative observational research of primary care consultations has  
38  
39 267 identified confusion about the construct of OA, with family doctors tending not to use the term  
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41 268 'osteoarthritis' with patients but instead, normalising symptoms [19]. A formal diagnosis of OA,  
42  
43 269 delivered explicitly, may be needed for holistic components of care such as patient education and  
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45 270 self-management support to be offered [5,19]. Patients with greater morbidity received a lower  
46  
47 271 recorded quality of care and this may be because they were (perhaps erroneously) considered less  
48  
49 272 suitable for non-pharmacological and relatively safe pharmacological options. It is also possible that  
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51 273 OA was given lower priority compared to their other problems [19,20]. Patients with foot (and to  
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3 274 some extent hand) OA may also have been particularly susceptible to lower levels of recorded  
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5 275 quality of care and this site has been less well-investigated with regard to effective interventions  
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7 276 [21,22].  
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11 277 This is the first study known to the authors which examines patterns of quality of care of chronic  
12  
13 278 conditions such as OA. Other analyses of recorded quality of care for OA have reported some  
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15 279 influences on individual process measures. Broadbent et al. identified older age as being associated  
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17 280 with reduced information provision but increased initial use of paracetamol and, where an oral  
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19 281 NSAID was prescribed, greater first-use of ibuprofen or a COX-2 selective NSAID; female sex was  
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21 282 associated with increased information provision; severe OA was associated with increased pain and  
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23 283 function assessment in the previous year [23]. Unlike in this analysis, Min et al. identified an  
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25 284 association between multimorbidity (using a count of conditions) and better quality of care  
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27 285 amongst vulnerable elders, some of whom had OA [24].  
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32 286 This study has important strengths. The study population was large and the practices were diverse  
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34 287 with respect to urbanisation, staffing, deprivation, and size of registered population, implying good  
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36 288 generalisability. Prescription recording is likely to be near-complete since most prescribing is  
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38 289 electronic and use of the e-template mitigates against missing data from patients using over-the-  
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40 290 counter pharmacological approaches. The e-template also facilitates enhanced data collection in  
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42 291 general practice without incurring biases such as social desirability. LCA uses probabilistic modelling  
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44 292 and finite mixture distributions to collect participants into clusters, which is a different method to  
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46 293 traditional clustering techniques (e.g. cluster analysis). Given this, LCA should produce a lower  
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48 294 misclassification rate and better statistical criteria for investigating model fit [25]. Whilst there was  
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50 295 variation in quality of care between clinicians and practices [5], clustering effects of patients within  
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52 296 clinicians was adjusted for through the multilevel model. There are some limitations in this analysis.  
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3 297 Due to the inherent nature of EHR studies, the data extracted is a function of both the individual  
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5 298 clinician's clinical and recording behaviours. It is therefore possible that some patients were  
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7 299 misclassified as the lack of a record of a care process does not conclusively demonstrate that it did  
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10 300 not occur. Compared to prescription recording, it is less certain how well-recorded referrals are.  
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12 301 However, despite the limitations of EHR data, the differences in levels of prescribed analgesia  
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14 302 between the clusters suggests there were real differences in care between the four clusters  
15  
16 303 identified. Conversely, patients may have been coded as receiving some elements of care without  
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18 304 this necessarily having been conducted in a comprehensive or meaningful way. Triangulation of  
19  
20 305 medical record indicators with patient-reported indicators would be needed to evaluate this  
21  
22 306 further. Our assumption that those without a weight recorded were considered for weight loss  
23  
24 307 advice was based on the increased likelihood of a weight recording if a patients appears overweight  
25  
26 308 [11] but will have over-estimated the proportion of patients considered for weight loss advice.  
27  
28 309 However, over 80% of patients did have a weight record. The association between multiple  
29  
30 310 consultations for OA and clusters with higher recorded quality of care may reflect greater  
31  
32 311 opportunity to provide and record care but may also have reflected a greater disease severity and  
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34 312 healthcare need. Although we considered comorbidities, previous research has identified that OA  
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36 313 may be discussed in complex consultations about multiple problems [19] and the length of time  
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38 314 discussing OA in a consultation would likely be an important influence on the level of recorded care.  
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40 315 It is also possible that those with recorded peripheral joint pain rather than recorded OA may not  
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42 316 have OA, particularly in the foot [26]. The e-template itself was previously found to be associated  
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44 317 with increased prescription of paracetamol and topical NSAIDs and so the patterns of care recorded  
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46 318 may not be generalisable to practices not using the e-template [5].  
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3 319 Promotion of core interventions (information, exercise, and weight loss advice), alongside  
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5 320 appropriate use of the relatively safe pharmacological options, remains an important strategy in the  
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7 321 primary care management of OA but many patients receive few or none of these. This is particularly  
8  
9 322 true for patients with higher levels of morbidity, or hand or foot OA. Whilst there is substantial  
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11 323 variation in recorded care of OA, high quality care appears feasible given we found that over a third  
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13 324 of patients with OA were recorded as receiving most core recommendations. A lack of a systematic  
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15 325 approach to people with OA has previously been reported [27]. A structured annual review for  
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17 326 people with OA [28] as recommended by NICE [10] may help. This may possibly be nurse-led and  
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19 327 integrated, where appropriate, into a multimorbidity long-term condition review. However, causes  
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21 328 of variation in providing and recording of high quality care still need to be identified and  
22  
23 329 mechanisms need to be explored to ensure appropriate delivery of care to all patients.  
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52 339 analysis plan, cleaned the data, and drafted and revised the paper; KSD is PI for the study, led the  
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3 340 design of the MOSAICS study, and revised the paper; EC, ZP and AF were involved in the  
4  
5 341 interpretation of the findings and revised the paper. All authors have approved the final version.  
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7

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34  
35  
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2  
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4  
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8 363 **Data access statement**  
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10  
11 364 The Centre has established data sharing arrangements to support joint publications and other  
12  
13 365 research collaborations. Applications for access to anonymised data from our research databases  
14  
15 366 are reviewed by the Centre's Data Custodian and Academic Proposal (DCAP) Committee and a  
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17 367 decision regarding access to the data is made subject to the NRES ethical approval first provided for  
18  
19 368 the study and to new analysis being proposed. Further information on our data sharing procedures  
20  
21 369 can be found on the Centre's website  
22  
23 370 (<http://www.keele.ac.uk/pchs/publications/datasharingresources/>) or by emailing the Centre's  
24  
25 371 data manager ([primarycare.datasharing@keele.ac.uk](mailto:primarycare.datasharing@keele.ac.uk)).  
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**Table 1:** Seven quality Indicators and categories used for latent class analysis

Quality Indicator	Categories	Definition
1. Pain assessed	Assessed	Recorded level of pain <sup>a</sup>
	Not assessed	No entry recorded <sup>a</sup>
2. Function assessed	Assessed	Recorded level of function <sup>a</sup>
	Not assessed	No entry recorded <sup>a</sup>
3. OA information	Given	Recorded written or verbal <sup>a</sup>
	Considered, but not given	Recorded not appropriate <sup>a</sup>
	Not considered	No entry recorded <sup>a</sup>
4. Exercise advice	Given	Recorded written or verbal <sup>a</sup>
	Considered, but not given	Recorded not appropriate <sup>a</sup>
	Not considered	No entry recorded <sup>a</sup>
5. Weight loss advice <sup>c</sup>	Given	Recorded written or verbal <sup>a</sup>
	Considered, but not given	Recorded not appropriate <sup>a</sup>
	Not considered	No entry recorded <sup>a</sup>
6. Paracetamol or topical NSAID	Prescribed	Either drug prescribed <sup>b</sup>
	Considered, but not prescribed	Neither drug prescribed but recorded tried, offered, patient declined, or not appropriate <sup>a</sup>
	Not considered	Neither drug prescribed, recorded unknown or no entry recorded for both drugs <sup>a</sup>
7. Physiotherapy	Referred	Recorded referral <sup>b</sup>
	Considered, but not referred	No referral but recorded as offered, or not necessary or not appropriate <sup>a</sup>
	Not considered	No referral, recorded not this time or no entry recorded <sup>a</sup>

<sup>a</sup> from e-template; <sup>b</sup> from routine records; <sup>c</sup> patients without a recorded BMI of  $\geq 25$  within the last 3 years were allocated to "Considered, but not given" category

**Table 2:** Latent class analysis goodness of fit statistics

Number of clusters	BIC	$\chi^2$ goodness of fit	Population (%) of smallest cluster	Range of mean PP across clusters	<i>n</i> (%) with PP<0.7
1	20994.14	32978.08	1724 (100)	1.000	0 (0)
2	15160.57	3332.77	1071 (62)	0.992, 0.987	3 (<1)
3	14715.82	1727.74	430 (25)	0.906, 0.991	138 (8)
4	14627.48	1522.28	184 (11)	0.848, 0.994	157 (9)
5	14661.55	809.88	142 (8)	0.830, 0.993	207 (12)
6	14699.79	733.23	112 (6)	0.754, 0.996	257 (15)
7	14771.09	818.78	22 (1)	0.701, 0.996	267 (15)

BIC: Bayes Information Criterion; PP: posterior probability

**Table 3:** Conditional item response probabilities for the quality indicators for each cluster

		Overall <i>n</i> (%)	Cluster			
Quality Indicators			<i>High</i> ( <i>n</i> =659, 38%)	<i>Moderate</i> ( <i>n</i> =184, 11%)	<i>Low</i> ( <i>n</i> =286, 17%)	<i>None</i> ( <i>n</i> =595, 35%)
Pain Assessment	Assessed	1092 (63)	0.978	0.961	0.922	0.014
	Not Assessed	632 (37)	0.022	0.039	0.078	0.987
Function Assessment	Assessed	1070 (62)	0.981	0.955	0.873	0.000
	Not Assessed	654 (38)	0.019	0.045	0.127	1.000
OA Information	Given	764 (44)	0.930	0.463	0.319	0.001
	Considered, Not Given	85 (5)	0.009	0.330	0.011	0.000
	Not Considered	875 (51)	0.062	0.207	0.670	1.000
Exercise Advice	Given	768 (45)	0.994	0.417	0.237	0.000
	Considered, Not Given	96 (6)	0.007	0.313	0.067	0.000
	Not Considered	860 (50)	0.000	0.270	0.696	1.000
Weight Advice	Given	536 (31)	0.593	0.115	0.089	0.000
	Considered, Not Given	153 (9)	0.298	0.733	0.347	0.441
	Not Considered	1035 (60)	0.109	0.152	0.564	0.559
Topical NSAID/ paracetamol	Prescribed	609 (35)	0.476	0.273	0.394	0.239
	Considered, Not Prescribed	570 (33)	0.496	0.641	0.406	0.004
	Not Considered	545 (32)	0.028	0.086	0.200	0.757
Physiotherapy	Referred	124 (7)	0.111	0.037	0.101	0.032
	Considered, Not Referred	532 (31)	0.559	0.732	0.080	0.000
	Not Considered	1068 (62)	0.330	0.230	0.819	0.968
Median count (IQR) Assessed/prescribed/given/referred			5 (4, 6)	3 (2, 3)	3 (2, 3)	0 (0, 1)
Median count (IQR) Considered			1 (1, 2)	3 (2, 4)	1 (0, 1)	0 (0, 1)

**Table 4:** Expected number compared to observed for each category of indicators, by cluster

Quality Indicators		Cluster											
		High (n=659, 38%)			Moderate (n=184, 11%)			Low (n=266, 17%)			None (n=595, 35%)		
		E	O	Δ	E	O	Δ	E	O	Δ	E	O	Δ
Pain Assessment	Assessed (n=1092, 63%)	645	645	0	177	177	0	264	264	1	8	7	1
	Not assessed (n=632, 37%)	14	14	0	7	7	0	22	22	-1	587	588	-1
Function Assessment	Assessed (n=1070, 62%)	646	646	0	176	174	2	250	250	0	0	0	0
	Not assessed (n=655, 38%)	13	13	0	8	10	-2	36	36	0	595	595	0
OA Information	Given (n=764, 44%)	613	620	-7	85	59	26	91	88	6	0	0	0
	Considered, not given (n=85, 5%)	6	3	3	61	81	-20	3	1	2	0	0	0
	Not considered (n=875, 51%)	41	36	5	38	44	-6	192	200	-8	595	595	0
Exercise Advice	Given (n=768, 45%)	655	658	-3	77	53	24	68	55	11	0	0	0
	Considered, not given (n=96, 6%)	4	1	3	58	77	-19	19	1	1	0	0	0
	Not considered (n=860, 50%)	0	0	0	50	54	-4	199	211	-12	595	595	0
Weight Advice	Given (n=536, 31%)	391	370	21	21	20	1	26	27	4	0	0	0
	Considered, not given (n= 153, 9%)	196	213	-17	135	140	-5	99	99	0	262	262	0
	Not considered (n=1035, 60%)	72	76	-4	28	24	4	161	166	-4	333	333	0
Topical NSAID or paracetamol	Prescribed (n=609, 35%)	314	311	3	50	47	3	113	112	2	142	140	2
	Considered, not prescribed (n=570, 33%)	327	330	-3	118	119	-1	116	117	-2	2	3	-1
	Not considered (n=545, 32%)	18	18	0	16	18	-2	57	55	0	450	452	-2
Physiotherapy	Referred (n=124, 7%)	73	69	4	7	6	1	29	36	-1	19	19	0
	Considered, not referred (n=532, 31%)	369	371	-2	135	147	-12	23	17	9	0	0	0
	Not considered (n=1068, 62%)	218	219	-1	42	31	11	234	241	-8	576	576	0

E: expected number; O: observed number; Δ: difference

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**Table 5:** Patient and clinician characteristics for each cluster

	Total <i>n</i> (%)	Cluster				
		High ( <i>n</i> =659)	Moderate ( <i>n</i> =184)	Low ( <i>n</i> =286)	None ( <i>n</i> =595)	
<b>Patient factors</b>						
<b>Age</b>						
45-64	817	277 (34)	109 (13)	293 (43)	138 (17)	
65-74	442	213 (48)	20 (5)	144 (33)	65 (15)	
75-84	349	133 (38)	35 (10)	116 (33)	65 (19)	
85+	116	36 (31)	20 (17)	42 (36)	18 (6)	
<b>Gender</b>						
Male	710	286 (40)	68 (10)	113 (16)	243 (34)	
Female	1014	373 (37)	116 (11)	173 (17)	352 (35)	
<b>BMI category:</b>						
Normal	315	111 (35)	54 (17)	48 (15)	102 (32)	
Overweight	1080	471 (44)	83 (8)	193 (18)	333 (31)	
Not recorded	329	77 (23)	47 (14)	45 (14)	160 (49)	
<b>Diagnosis</b>						
Recorded with joint pain only	1142	366 (32)	148 (13)	207 (18)	421 (37)	
OA diagnosis	582	293 (50)	36 (6)	79 (14)	174 (30)	
<b>Site of OA:</b>						
Knee	855	359 (42)	80 (9)	149 (17)	267 (31)	
Hip	363	135 (37)	41 (11)	68 (19)	119 (33)	
Foot	125	30 (24)	15 (12)	10 (8)	70 (56)	
Hand	152	33 (22)	25 (16)	31 (20)	63 (41)	
Unspecified	99	30 (30)	8 (8)	16 (16)	45 (46)	
Multiple	130	72 (55)	15 (12)	12 (9)	31 (24)	
<b>Morbidity load<sup>a</sup>:</b>						
BNF count 0-4	485	156 (32)	68 (14)	89 (18)	172 (36)	
5-9	578	240 (42)	56 (10)	99 (17)	183 (32)	
10+	661	263 (40)	60 (9)	98 (15)	240 (36)	
<b>Number of OA consultations<sup>b</sup>:</b>						
Multiple	532	250 (47)	63 (12)	99 (19)	120 (23)	
Single	1192	409 (34)	121 (10)	187 (16)	475 (40)	
Median (IQR) no. of OA consultations <sup>b</sup>	1 (0, 1)	1 (1, 2)	1 (1, 2)	1 (1, 2)	1 (1, 1)	
<b>Consulter status:</b>						
Repeat	566	232 (41)	53 (9)	84 (15)	197 (35)	
New <sup>c</sup>	1158	427 (37)	131 (11)	202 (17)	398 (34)	
<b>Clinician factors</b>						
<b>Clinician OA workload<sup>b</sup>:</b>						
Below the median	197	41 (21)	16 (8)	36 (18)	104 (53)	
Above the median	1527	618 (41)	168 (11)	250 (16)	491 (32)	

<sup>a</sup> Number of BNF subchapters from which prescription was made in previous 12 months; <sup>b</sup> during six month period; <sup>c</sup> no clinical OA consultations within the previous 12 months



**Table 6:** Associations of patient and clinician characteristics with cluster membership

<i>n</i> = 1724	<i>High vs None</i> RRR <sup>a</sup> (95% CI)	<i>Moderate vs None</i> RRR <sup>a</sup> (95% CI)	<i>Low vs None</i> RRR <sup>a</sup> (95% CI)
<b>Patient factors</b>			
<b>Age</b>			
45-64	1	1	1
65-74	1.41 (1.07, 1.84)	0.45 (0.27, 0.74)	0.97 (0.69, 1.37)
75-84	1.13 (0.83, 1.52)	1.02 (0.65, 1.60)	1.42 (0.99, 2.05)
85+	0.91 (0.56, 1.47)	1.56 (0.85, 2.89)	1.24 (0.69, 2.23)
<b>Gender</b>			
Male	1	1	1
Female	0.86 (0.69, 1.07)	1.03 (0.75, 1.43)	1.04 (0.80, 1.36)
<b>BMI category</b>			
Normal	1	1	1
Overweight	1.20 (0.91, 1.60)	0.57 (0.39, 0.85)	1.33 (0.93, 1.90)
Not recorded	0.39 (0.27, 0.56)	0.52 (0.33, 0.81)	0.52 (0.33, 0.82)
<b>Diagnosis</b>			
Recorded with joint pain only	1	1	1
OA diagnosis	1.81 (1.41, 2.32)	0.55 (0.35, 0.85)	0.93 (0.68, 1.29)
<b>Site of OA</b>			
Knee	1	1	1
Hip	0.86 (0.66, 1.14)	1.14 (0.76, 1.71)	1.04 (0.75, 1.44)
Foot	0.38 (0.24, 0.60)	0.73 (0.39, 1.36)	0.25 (0.13, 0.51)
Hand	0.45 (0.30, 0.70)	1.18 (0.70, 1.98)	0.88 (0.56, 1.39)
Unspecified	0.48 (0.30, 0.80)	0.85 (0.38, 1.90)	0.74 (0.41, 1.34)
Multiple	1.13 (0.75, 1.74)	1.89 (0.99, 3.59)	0.65 (0.34, 1.24)
<b>Morbidity load<sup>b</sup>:</b>			
BNF count 0-4	1	1	1
5-9	0.95 (0.71, 1.26)	0.74 (0.50, 1.11)	0.75 (0.54, 1.06)
10+	0.64 (0.47, 0.87)	0.55 (0.35, 0.86)	0.50 (0.35, 0.73)
<b>Number of OA consultations<sup>c</sup></b>			
Multiple	1	1	1
Single	0.43 (0.34, 0.54)	0.47 (0.33, 0.66)	0.45 (0.34, 0.60)
<b>Consulter status</b>			
Repeat	1	1	1
New <sup>d</sup>	1.12 (0.89, 1.41)	1.09 (0.76, 1.55)	1.18 (0.88, 1.59)
<b>Clinician factors</b>			
<b>Clinician OA workload<sup>c</sup></b>			
Below the median	1	1	1
Above the median	2.90 (1.98, 4.25)	2.32 (1.33, 4.03)	1.46 (0.98, 2.18)

<sup>a</sup> Relative risk ratio from multilevel multinomial regression (patients within initial clinician seen) adjusted for all presented covariates, *None* cluster is reference; <sup>b</sup> Number of BNF subchapters from which prescription was made in previous 12 months; <sup>c</sup> during six month period; <sup>d</sup> no clinical OA consultations within the previous 12 month

**Table 7:** Use of management processes other than those used as quality indicators, and recorded severity of pain and functional limitation, by cluster

<i>n</i> (column %)	Cluster					<i>p</i> -value <sup>a</sup>
	Total <i>n</i> (%)	High ( <i>n</i> =659)	Moderate ( <i>n</i> =184)	Low ( <i>n</i> =286)	None ( <i>n</i> =595)	
Opioid Prescribed	557 (33)	236 (36)	54 (29)	94 (33)	173 (29)	0.06
Oral NSAID Prescribed	284 (17)	130 (20)	21 (11)	49 (17)	84 (14)	0.01
X-ray Requested	263 (15)	142 (22)	30 (16)	52 (18)	39 (7)	<0.01
<i>n</i> with pain record	1092	645	177	263	7	0.001 <sup>b</sup>
No pain	16 (1)	4 (<1)	7 (4)	4 (2)	1	
Mild pain	348 (32)	187 (29)	69 (39)	91 (35)	1	
Moderate pain	582 (53)	357 (55)	84 (47)	136 (52)	5	
Severe pain	146 (13)	97 (15)	17 (10)	32 (12)	0	
<i>n</i> with function record	1070	646	174	250	0	0.004 <sup>b</sup>
No limitation	101 (9)	46 (7)	29 (16)	26 (10)	0	
Mild limitation	456 (43)	276 (43)	73 (42)	107 (43)	0	
Moderate limitation	427 (40)	277 (43)	57 (33)	93 (37)	0	
Severe limitation	86 (8)	47 (7)	15 (9)	24 (10)	0	

<sup>a</sup> $\chi^2$  test, <sup>b</sup> excluding *None* cluster

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Title upload
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract upload
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	2
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	2-3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	3
		<i>Case-control study</i> —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 <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	
Variables	7	(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed	N/A
		<i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	3-5
Bias	9	Describe any efforts to address potential sources of bias	3
Study size	10	Explain how the study size was arrived at	N/A (sample size calculation was for the clinical outcomes reported elsewhere)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(a) Describe all statistical methods, including those used	5-6

1  
2 to control for confounding

3 (b) Describe any methods used to examine subgroups N/A  
4 and interactions

5 (c) Explain how missing data were addressed 4

6 (d) *Cohort study*—If applicable, explain how loss to N/A  
7 follow-up was addressed

8 *Case-control study*—If applicable, explain how  
9 matching of cases and controls was addressed

10 *Cross-sectional study*—If applicable, describe analytical  
11 methods taking account of sampling strategy

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13  
14 (e) Describe any sensitivity analyses N/A

15 Continued on next page

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<b>Results</b>		<b>Page</b>	
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 4
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	N/A
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	N/A
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	Table 3
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 5
		(b) Report category boundaries when continuous variables were categorized	Table 4, 5
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	8-9
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	11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
<b>Other information</b>			
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	13

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).