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Funding and policy incentives to encourage implementation of point-of-care C-reactive protein testing for lower respiratory tract infection in NHS primary care: a mixed-methods evaluation

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Complete List of Authors:	Johnson, Matthew; Faculty of Health Sciences, University of Southampton, NIHR CLAHRC Wessex Data Science Hub Cross, Liz; NIHR CLARHC East of England, Attenborough Surgery, Bushey Medical Centre, Herts Valleys Clinical Commissioning Group Sandison, Nick; Faculty of Health Sciences, University of Southampton, NIHR CLAHRC Wessex Stevenson, Jamie; Faculty of Health Sciences, University of Southampton, NIHR CLAHRC Wessex Monks, T; Faculty of Health Sciences, University of Southampton, NIHR CLAHRC Wessex Data Science Hub Moore, Michael; University of Southampton Medical School, Primary Care and Population Sciences
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Manuscripts

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3 1 **Funding and policy incentives to encourage implementation of point-of-care**
4 2 **C-reactive protein testing for lower respiratory tract infection in NHS primary**
5 3 **care: a mixed-methods evaluation**
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9

10 5 **Matthew Johnson**

11 6 Matt.Johnson@soton.ac.uk

12 7 NIHR CLAHRC Wessex Data Science Hub, Faculty of Health Sciences, University of Southampton, UK
13
14
15

16 8
17 9 **Liz Cross**

18 10 liz.cross@nhs.net

19 11 NIHR CLARHC East of England, Attenborough Surgery, Bushey Medical Centre, Herts Valleys Clinical
20 12 Commissioning Group, UK
21
22
23

24 13
25 14 **Nick Sandison**

26 15 N.J.Sandison@soton.ac.uk

27 16 NIHR CLAHRC Wessex, Faculty of Health Sciences, University of Southampton, UK
28
29
30

31 17
32 18 **Jamie Stevenson**

33 19 jamie.stevenson@soton.ac.uk

34 20 NIHR CLAHRC Wessex, Faculty of Health Sciences, University of Southampton, UK
35
36
37

38 21
39 22 **Thomas Monks**

40 23 thomas.monks@soton.ac.uk

41 24 NIHR CLAHRC Wessex Data Science Hub, Faculty of Health Sciences, University of Southampton, UK
42
43
44

45 25
46 26 **Michael Moore (corresponding author)**

47 27 mvm198@soton.ac.uk

48 28 Head of Academic Unit, Primary Care and Population Sciences, University of Southampton
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33 **Abstract**

34 **Objectives:** Utilisation of point-of-care C-reactive protein testing for lower respiratory tract infection
35 has been limited in UK primary care, with costs and funding suggested as important barriers. We aimed
36 to use existing National Health Service funding and policy mechanisms to alleviate these barriers, and
37 engage with clinicians and healthcare commissioners to encourage implementation.

38 **Design:** A mixed-methods study design was adopted, including a qualitative survey to identify
39 clinicians' and commissioners' perceived benefits, barriers and enablers post-implementation, and
40 quantitative analysis of results from a real-world implementation study.

41 **Interventions:** We developed a funding specification to underpin local reimbursement of general
42 practices for test delivery based on an item of service payment. We also created training and
43 administrative materials to facilitate implementation by reducing organisational burden. The
44 implementation study provided intervention sites with a testing device and supplies, training and
45 practical assistance.

46 **Results:** Despite engagement with several groups, implementation and uptake of our funding
47 specification were limited. Survey respondents confirmed costs and funding as important barriers in
48 addition to physical constraints and operational barriers, and cited training and the value of a local
49 champion as enablers. The implementation study demonstrated reduced rates of antibiotic
50 prescription and follow-up consultation amongst intervention sites.

51 **Conclusions:** Although survey respondents highlighted the clinical benefits, funding remains a
52 barrier to implementation in UK primary care, and appears not to be alleviated by the existing financial
53 incentives available to commissioners. The potential to meet incentive targets using lower cost
54 methods, a lack of policy consistency, or competing financial pressures and commissioning programmes
55 may be important determinants of local priorities. An implementation champion could help to catalyse
56 support and overcome operational barriers at the local level, but widespread implementation is likely

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3 57 to require national policy change. Successful implementation may reproduce antibiotic prescribing
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5 58 reductions observed in research studies.
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60 **Strengths and limitations of this study**

- 61 • Use of a mixed-methods study design to assess the benefits, barriers and enablers of
62 implementation from multiple perspectives.
- 63 • The study did not involve research funding for participating sites to enable evaluation of the
64 impact of real-world financial structures associated with NHS commissioning.
- 65 • Development of a pack of resources that could contribute to future implementation projects.
- 66 • The study was undertaken against a background of general financial constraint within the NHS,
67 which may have adversely impacted upon outcomes.

69 **Background**

70 Acute uncomplicated lower respiratory tract infection (LRTI) is the one of the commonest acute illnesses
71 managed in primary care, and even in low antibiotic prescribing countries most patients receive
72 antibiotics^{1 2}. There is a clear national and international agenda to reduce unnecessary antibiotic
73 prescribing³. The recently updated Cochrane review⁴ of antibiotics for acute bronchitis demonstrated
74 modest benefits, with a reduction of cough duration of around half a day. These findings were not
75 replicated in a recently published large trial of antibiotics against placebo⁵. Limited benefit was
76 demonstrated from antibiotics likely to be balanced by harms, and no subgroup was identified in whom
77 there was a clinically relevant benefit^{5 6}.

78 In the absence of clear benefit then what are the drivers of continued prescribing? Patients are
79 concerned about their symptoms⁷, and clinicians are worried about missing severe infection and to
80 avoid medico-legal consequences⁷⁻⁹. However, continued prescribing of antibiotics carries direct
81 prescribing costs, increased re-consultations¹⁰ and the major threat of antibiotic resistance¹¹. Moreover,

1
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3 82 a large cohort study has shown that adverse events following primary care consultation with LRTI
4
5 83 patients are rare, and may not be directly influenced by prescribing strategy¹².

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8 84 There is evidence that antibiotic prescribing in LRTI may be limited by appropriate use of near patient
9
10 85 tests (NPT)¹³⁻¹⁵. Two candidates are available: C-reactive protein (CRP) and procalcitonin (PCT)¹⁶⁻¹⁸. An
11
12 86 individual patient data review and meta-analysis supported the use of PCT to guide antibiotic use in
13
14 87 acute settings including primary care, emergency units and intensive care, and demonstrated equivalent
15
16 88 clinical outcomes with reduced antibiotic uptake¹⁹. Similarly, a recent Cochrane review examining the
17
18 89 role of CRP in acute respiratory illness in primary care²⁰ included six trials with 3,284 participants and
19
20 90 demonstrated a reduction in antibiotic use, although the results were interpreted with caution due to a
21
22 91 high degree of heterogeneity. The recently published National Institute for Clinical Excellence (NICE)
23
24 92 pneumonia guidelines²¹ have also endorsed the use of CRP to aid decision making in primary care,
25
26 93 selecting this ahead of PCT given the current non-availability of an NPT for PCT.

27
28
29 94 Several trials have explored the use of CRP in the primary care setting for management of LRTI, either
30
31 95 alone or in combination with a communications skills training package, and have demonstrated a
32
33 96 substantial reduction in antibiotic prescribing¹³⁻¹⁵. Although CRP is widely used in Scandinavian countries
34
35 97 uptake has been limited in the UK, despite evidence of effectiveness in trial contexts to direct rational
36
37 98 prescribing for LRTI. There is some question, however, of the effectiveness of CRP once adopted in
38
39 99 clinical practice; results of tests performed on those with upper respiratory tract infection were found to
40
41 100 have been misinterpreted, and modest effects on prescribing described²². Some have questioned
42
43 101 whether reduced antibiotic prescribing will be seen following implementation in low prescribing
44
45 102 settings²³, while others have reported CRP being the main determinant of antibiotic prescription in
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47 103 observational cohorts²⁴.

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51 104 The reasons for the delayed uptake of NPT in the UK are not clear. Tests to reduce diagnostic
52
53 105 uncertainty were supported by primary care physicians in a multi-country study including the UK²⁵.
54
55 106 Although studies suggest that CRP is a cost-effective means of addressing LRTI in primary care, there is

1
2
3 107 evidence that concerns around costs and funding remain a barrier to widespread implementation²⁶. As
4
5 108 the UK National Health Service (NHS) model of primary care does not include item of service payments,
6
7 109 implementation of Point of Care testing (PoC) outside of a research setting would generate additional
8
9 110 work and costs for initial purchase, maintenance and consumables, whereas antibiotic prescriptions
10
11 111 have no direct cost at practice level. One plausible way to increase utilisation of CRP PoC would be the
12
13 112 introduction of an item of service payment for use of the test in management of LRTI. The NHS England
14
15 113 General Medical Services contract, in addition to defining the scope of standard primary care services to
16
17 114 be delivered by general practices, also includes provision for opt-in to the delivery of additional, 'locally
18
19 115 enhanced' services (LES)²⁷. This study was based on the hypothesis that the LES scheme may provide a
20
21 116 mechanism to introduce a financial incentive to uptake of CRP PoC for the management of LRTI in an
22
23 117 NHS primary care setting.

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25
26 118 We aimed to evaluate the efficacy of an item of service payment framework introduced at the local
27
28 119 level by way of the LES scheme as a means of encouraging implementation amongst clinicians and
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30 120 healthcare commissioners. We also aimed to work with other groups and localities to explore
31
32 121 alternative approaches to implementation, and to identify the perceived benefits, barriers and
33
34 122 enablers using a post-implementation survey.
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38 123

39 124 **Methods**

40 125 **Leveraging funding and policy incentives**

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44 126 Our work has concentrated on making use of the opportunities afforded by existing NHS funding and
45
46 127 policy mechanisms to encourage implementation of CRP PoC in primary care. We did not provide any
47
48 128 research funding to participating organisations to ensure that successful implementation was not
49
50 129 artificial, and could potentially be reproduced by others in the context of the real-world financial
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52 130 structures and constraints associated with healthcare commissioning in the NHS. All work in this
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54 131 area was undertaken during 2015 and 2016.
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3 132 We developed a standard LES specification to underpin local implementation, establishing a funding
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5 133 framework of reimbursement of general practices by Clinical Commissioning Groups (CCGs) for CRP PoC
6
7 134 on a unit basis. In view of the importance given to budgetary concerns by commissioners considering
8
9 135 CRP implementation²⁶, CCGs may be motivated by its potential to open access to national funding
10
11 136 associated with achieving the NHS England 'Quality Premium' (QP) target for reduced antibiotic
12
13 137 prescribing in primary care²⁸.

16 138 Our research group, NIHR CLAHRC Wessex, is funded by both the National Institute for Health
17
18 139 Research (NIHR) and partner organisations (including CCGs) within the local health system. Partner
19
20 140 funding contributions may be monetary, or comprised of research study involvement. Our locality
21
22 141 covers nine CCGs, each of whom had the opportunity to fulfil this funding obligation by participating
23
24 142 in a CRP implementation study, or similar research. As well as this benefit, there was further
25
26 143 opportunity for any participation costs to be partially or fully offset if the QP was achieved as a
27
28 144 result.

31 145 **Engaging with the NHS**

34 146 Using materials from the GRACE Intro study¹⁵ we developed resources including an online training
35
36 147 course for general practitioners on the use of CRP, a clinical audit form and patient information
37
38 148 leaflet²⁹. All resources were made available to interested organisations as a means of facilitating
39
40 149 implementation by reducing the associated administrative burden.

43 150 We visited clinicians and healthcare commissioners in our locality to generate interest, and made
44
45 151 presentations at locality events to promote the LES framework. We also attended an NIHR CLARHC
46
47 152 Wessex showcase event to which local CCGs were invited. We followed up additional enquiries from
48
49 153 other groups outside of our locality who were interested in CRP implementation by offering visits
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51 154 and presentations, and sharing the resources developed for our local study. Resources were shared
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53 155 with ten groups across the country.

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3 156 **Post-implementation survey**
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6 157 In August 2017, following our period of NHS engagement, we issued an electronic survey to a
7
8 158 convenience sample of clinicians and commissioners who had expressed an interest in, or were known
9
10 159 to have contributed to, CRP implementation projects. Overall, nineteen individuals were invited to
11
12 160 participate, including healthcare commissioners, pharmacists, primary and secondary care clinicians,
13
14 161 and public health professionals.
15

16
17 162 We adopted a qualitative approach to explore in more depth the factors motivating respondents' initial
18
19 163 interest, their experience of the implementation process and perceived barriers and enablers. Survey
20
21 164 questions were written in line with these underlying objectives as deductively generated main themes³⁰
22
23 165 **(box 1)**.
24
25

26 We asked participants:

- 27 • What were your/your organisation's reasons for implementing CRP testing?
- 28 • What was your experience of implementing and using CRP testing, and what is happening now?
- 29 • Which aspects of the implementation worked well?
- 30 • What were the barriers to implementation and/or continued use?
- 31 • How did you overcome these barriers?
- 32 • What would have helped, or would help in the future to encourage continued use?
- 33 • What would facilitate the implementation process?
- 34 • What would be your recommendations for those looking to implement CRP testing in the future?

35 **Box 1: Post-implementation survey questions**
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37 166
38 167 Following the method of thematic analysis described by Nowell and colleagues³¹, three members of the
39
40 168 research team (MJ, NS, TM) individually reviewed all survey responses to inductively identify more
41
42 169 specific subthemes. Reviewers took a systematic and iterative approach to analysis, later using
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44 170 researcher triangulation to reach consensus.
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Funded by an NHS England Innovation Challenge Prize, an implementation study was undertaken in Herts Valleys CCG to evaluate CRP utilisation over three winter months (November 2016 – January 2017) and in five general practices, purposively sampled using standardised practice-level prescribing data to target high and medium antibiotic prescribers. The study aimed to evaluate whether, compared to standard care, the availability of CRP PoC for LRTI in primary care was associated with reduced acute and follow-up antibiotic prescribing, and unscheduled primary care reattendances and healthcare contacts in the 28 days following presentation.

Participating practices received an intervention consisting of one testing device and supplies to perform 100 tests, training on the NICE guidelines and equipment use, a review visit and practical assistance from the study team where appropriate; all other costs were borne by the practice. Each practice was free to select an appropriate device location and means of operationalising patient flow based on the physical layout of the practice, available resources and staff skill mix.

In line with the NICE guidelines, patients aged 18-65 presenting to intervention practices with suspected LRTI of less than three weeks' duration where there was diagnostic uncertainty were eligible to receive a test. Eligibility was assessed by the clinician during patient consultation. Patients with acute pneumonia, pregnant, immunocompromised, terminally ill or under follow up for Chronic Obstructive Pulmonary Disease were excluded²¹. As the offer was made on clinician discretion, and the patient entitled to refuse, some eligible patients did not receive a test. However, all eligible patients presenting to intervention practices were included in the evaluation, irrespective of whether they received a test.

The five intervention practices were compared to three Herts Valleys CCG control practices of similar size and prescribing level, all of which continued to provide standard care. Control practices did not receive training. One member of the study team (LC) conducted a retrospective electronic search at control practices to identify new clinical consultations (during the same study period) with patients who met the CRP eligibility criteria. Presentations were identified using a set of Read codes³² commonly used to record clinical activity related to LRTI in NHS primary care, and relevant information collected for analytical purposes.

Results from the implementation study are given in **Appendix A**.

Box 2: Herts Valleys CCG implementation study

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Results

Adoption of the LES framework and implementation of CRP

175 Whilst there was initial interest in CRP PoC facilitated by use of the LES framework, ultimately no
176 CCGs within the NIHR CLAHRC Wessex locality participated in implementation projects. CRP was
177 under consideration by one local CCG as part of a range of measures that might contribute to
178 achieving a 'Quality, Innovation, Productivity and Prevention' programme target around improving
179 detection of pneumonia in primary care, with the aim of enabling earlier intervention and reducing

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3 180 hospital admissions. The CCG had planned to implement CRP across all of its general practices, but
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5 181 concluded that the associated upfront capital cost was too substantial and did not proceed.

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8 182 Another CCG outside of our locality was interested in more widespread CRP implementation based
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10 183 on antibiotic prescribing reductions observed during a pilot undertaken in a single general practice.
11
12 184 Although ten testing devices were procured and were initially regularly used, declining utilisation in
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14 185 the face of operational barriers prompted the CCG to cease procurement of PoC consumables.
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16 186 Financial incentivisation by way of the LES framework was considered as a means of encouraging
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18 187 utilisation, but ultimately failed to reengage interest.

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20
21 188 We are not aware of any other CCGs having adopted the LES framework, or having engaged in
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23 189 implementation projects.

24 25 26 190 **Post-implementation survey**

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28 191 Of the nineteen individuals invited to participate, seven (37%) submitted full responses. Several
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30 192 subthemes emerged from inductive analysis, with a high level of consistency amongst respondents
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32 193 **(table 1)**.

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35 194 All respondents reported being organisationally motivated by the potential for CRP PoC to help
36
37 195 reduce antibiotic prescribing, while some further specified a desire to reduce variation in prescribing
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39 196 rates amongst practices in their locality. However, respondents also described mixed clinician
40
41 197 utilisation: while some regularly incorporated PoC into consultations for suspected LRTI, others did
42
43 198 not use it at all. Furthermore, one respondent noted that while utilisation had initially been high, it
44
45 199 had declined over time.

Benefits:
<ul style="list-style-type: none">• A clinical aid to appropriate antibiotic prescribing• An objective measure to improve patient confidence in the prescribing action
Barriers:

<ul style="list-style-type: none"> • Limited time available during consultation • Layout of facility and placement of testing device • Cost of implementation and continued use • Source of funding • Resistance to change • Maintaining engagement
Enablers:
<ul style="list-style-type: none"> • Early adopters to share experience and provide mentorship • Training and education • Champions within practice/locality • Collaboration at local and national level • Better utilisation of IT to facilitate testing process
Table 1: Benefits, barriers and enablers of implementation

200

201 **Benefits**

202 Most respondents agreed that CRP is a valuable clinical aid to appropriate antibiotic prescribing for
 203 patients with symptoms of LRTI. Furthermore, some highlighted its value as an objective measure to
 204 improve patient confidence in the chosen prescribing action, particularly in consultation with those
 205 who are “very keen” to receive antibiotics. Two respondents noted that, in their experience, patients
 206 had responded positively to the test and were satisfied with the outcome.

207 **Barriers**

208 In general, respondents reported that interest amongst clinicians was sometimes poor, and
 209 suggested a need for financial incentives and support to encourage widespread uptake. Most
 210 mentioned cost pressures, while some questioned who should be responsible for funding: general
 211 practices or the CCG. Despite the evidence base for the clinical benefits, one respondent suggested
 212 that there remains a need to “clearly demonstrate short term benefits in costs, workload and safety”
 213 to develop and maintain engagement.

214 Most respondents commented on the impact of operational constraints, such as the physical layout
 215 of the practice, how to accommodate multiple users, and the time required to carry out the test,
 216 particularly in the context of high workload and limited consultation duration. Although some
 217 respondents argued that other benefits justified its use despite these barriers, others specifically

1
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3 218 cited them as disincentives, especially for clinicians who may have a negative attitude to CRP or be
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5 219 resistant to change.

6 7 8 220 **Enablers**

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10 221 Most respondents discussed the importance of collaboration, although interpretations of this
11
12 222 differed. Some suggested that early adopter sites share lessons learned to help others and avoid
13
14 223 duplicated effort. The value of training and education during the implementation process were
15
16 224 consistently emphasised, and development of a standard programme was suggested. Others
17
18 225 mentioned the role of NIHR in fostering collaborative working, and the potential for general practice
19
20 226 or CCG champions to improve engagement and resolve problems. Some respondents also suggested
21
22 227 better use of IT to facilitate testing. Specific examples included the deployment of standard
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24 228 templates to record the test and result in the practice management system, and use of electronic
25
26 229 alerts during consultation to prompt clinicians to PoC if indicated.
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31 32 231 **Discussion**

33 34 232 **Summary of main findings**

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37 233 Despite initial interest, there was no implementation in the NIHR CLAHRC Wessex locality, and no
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39 234 CCGs formally adopted the LES framework. The research team were unable to gain significant
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41 235 traction with CCG management, and when contact was established CCGs were unwilling to prioritise
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43 236 antibiotic stewardship over other local initiatives. The policy levers seemed to have little impact in
44
45 237 this locality, where CCGs were struggling to remain in budget. The financial rewards arising from the
46
47 238 QP only applied to CCGs meeting financial targets. Elsewhere, one CCG implemented CRP and,
48
49 239 following declining utilisation in response to operational barriers, found that the LES framework was
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51 240 insufficient as a mechanism to reengage interest.

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54 241 Although the small sample size limits inference and generalisability, our post-implementation survey
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56 242 identified several financial, operational and physical barriers in common with previous qualitative
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3 243 research²⁶. Respondents confirmed that implementation would be unlikely without financial
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5 244 incentives but also highlighted difficulties integrating PoC into practice workflow, and constraints
6
7 245 arising from a lack of dedicated space, equipment sharing and limited time. Reported enablers
8
9 246 included adequate training and the value of a local champion.

10
11
12 247 Some respondents also emphasised the clinical benefits of CRP, giving anecdotal examples of cases
13
14 248 where testing had prevented antibiotic prescription. The potential for more widespread repetition of
15
16 249 this outcome is suggested by quantitative results from the Herts Valley CCG implementation study,
17
18 250 where a successful, separately funded implementation scheme was run for a three month period,
19
20 251 driven by a local champion. Observation of substantial prescribing reductions amongst intervention
21
22 252 practices suggests that implementation in the NHS might replicate the prescribing reductions
23
24 253 reported in research studies.

254 **Comparison with other literature**

255 We are unaware of any other implementation studies concerning CRP PoC in the UK. In other health
256 settings PoC is widely adopted²², and following government directives has been introduced in the
257 Netherlands³³. The financial barriers to implementation have been identified in a previous study
258 including European and UK participants²³, which noted that countries with high rates of use had
259 alternative reimbursement models, and that widespread implementation in Europe followed health
260 policy change. The same study also highlighted issues around workflow and time as potential
261 barriers to implementation in the UK.

262 **Strengths and weaknesses**

263 Our study describes the results of attempts at CRP implementation without the resources associated
264 with research, and without specific policy directives. It is unclear how generalisable our findings
265 might be; it would appear that CCG partnership with NIHR CLAHRC Wessex and national level
266 incentives via the QP should have maximised the potential for local implementation. The scheme

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3 267 was devised during a time of general financial constraint within the NHS, which may have had
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5 268 particular impact in the Wessex locality.

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8 269 **Limitations around funding mechanisms**

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10 270 The criteria required to achieve the QP, even taking the antibiotic prescribing element alone, has
11
12 271 been inconsistent. Some changes have been significant, such as a move to greater emphasis on
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14 272 antibiotic prescribing for urinary tract infection as of 2018/19²⁸. Furthermore, as the QP is awarded
15
16 273 retrospectively and is contingent upon meeting other financial targets, the funding mechanism is not
17
18 274 guaranteed, making it difficult to engage commissioners and to create a firm financial framework to
19
20 275 underpin CRP implementation.

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22
23 276 A further feature of the QP is that no method of achievement is stipulated; the antibiotic prescribing
24
25 277 element simply requires an absolute prescribing reduction. The NHS has reported a national ~7%
26
27 278 reduction in primary care coinciding with the implementation phase of this study³⁴⁻³⁶, which may
28
29 279 have resulted from a general policy shift and increased focus of clinical training in primary care. This
30
31 280 suggests that overall improvements could be gained and the QP target potentially achieved by way
32
33 281 of alternative, lower cost methods alone, negating commissioners' financial incentive for CRP
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35 282 implementation irrespective of the clinical benefits.

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39 283 The pressures of multiple, competing commissioning programmes may limit engagement with
40
41 284 certain initiatives, while the overall funding structure of the NHS may also influence commissioners'
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43 285 preferences and priorities. One CCG within our locality suggested that, despite evidence of a net cost
44
45 286 saving associated with CRP³⁷, whilst the upfront implementation costs reside with primary care, any
46
47 287 savings would principally be realised by the secondary care sector. In this instance, therefore,
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49 288 concerns that the costs and benefits of the initiative may be distinctly localised within separate areas
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51 289 of the health system acted as a disincentive to its adoption.

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54 290 **Implications**

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3 291 Whilst the use of existing financial structures appeared appealing as a mechanism, it was not
4
5 292 possible to fully test the hypothesis that modest financial incentives to general practices at local
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7 293 level would enable CRP implementation, as financial pressures impeded CCG adoption of the policy.
8
9 294 National incentives for CCGs did not appear to override the financial constraints because a) financial
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11 295 rewards were only available to CCGs meeting financial targets, and b) antibiotic targets were being
12
13 296 achieved through other mechanisms not requiring financial investment.

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16 297 Although a small case study suggests that implementation outside of research studies may result in
17
18 298 similar prescribing reductions, since it was driven by local investment and a local champion it may
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20 299 not fully reflect implementation in routine practice, or be generalisable to other areas. Furthermore,
21
22 300 and recalling questions over the primacy of lower cost measures, the fact that this intervention
23
24 301 provided training and support in addition to testing materials limits the extent to which the
25
26 302 observed prescribing reductions can be confidently attributed to CRP PoC alone.

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28
29 303 The value of an enthusiastic, local champion to catalyse support for implementation emerged from
30
31 304 both the qualitative and quantitative strands of this study. Knowledge mobilisation and
32
33 305 implementation in practice may be assisted by way of a Researcher-In-Residence model³⁸, while
34
35 306 further qualitative and observational research could improve understanding of how champions are
36
37 307 able to persuade and engage clinicians and to encourage commissioners to look beyond the
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39 308 immediate financial disincentives, and whether they may be effective in other areas and settings.
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41 309 Further economic research might also model different modes of implementation to assess the costs
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43 310 and consequences across the system, and to find alternative funding models to overcome the
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45 311 financial barriers. Multi-purpose testing devices, for example, may have the advantage of spreading
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47 312 investment across several funding streams.

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51 313 In conclusion, it seems unlikely that financial schemes falling outside of national policy will gain
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53 314 much traction in a financially constrained NHS. Full-scale implementation of CRP PoC is likely to
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55 315 require central implementation via government policy or contractual changes.

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317

318 **Appendix A: Results from Herts Valleys CCG implementation study**

319 Five intervention practices with a total list size of 63,743 patients recorded 682 eligible LRTI
 320 presentations during the study period, of which 176 (26%) involved a CRP test. Three control
 321 practices recorded 258 presentations (based on the same eligibility criteria) from 35,928 patients.

322 Overall, fewer initial presentations to intervention practices resulted in antibiotic prescription over
 323 the following 28 days (59% of initial presentations, as compared to 79%) and follow-up consultations
 324 (30% compared to 38%), although there was little difference to antibiotic prescribing at follow-up
 325 (both arms 68%) (**table 2**). Furthermore, initial presentations with antibiotic prescription then
 326 resulting in follow-up consultation with an additional prescription were more common amongst
 327 control practices (21% compared to 13%). As delayed prescribing was relatively infrequent at both
 328 intervention and control practices all prescriptions were combined into a single outcome,
 329 irrespective of delay.

	Intervention arm (n = 682)		Control arm (n = 258)	
	Outcome events	%	Outcome events	%
CRP test at initial presentation	176	26	-	-
Antibiotic prescription at initial presentation	405	59	204	79
Follow-up consultation after initial presentation	206	30	99	38
Antibiotic prescription at follow-up consultation	140	68 ^a	67	68 ^a
Initial presentation with antibiotic prescription, then follow-up consultation with additional antibiotic prescription	92	13	55	21

Table 2: Primary care healthcare events resulting from initial LRTI presentation

All percentages compared to number of initial presentations, except (^a) compared to number of follow up consultations

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331 Using logistic regression, we found that the odds of antibiotic prescribing at initial presentation
 332 (where acute and delayed prescribing were grouped into a single outcome) were reduced by 62%
 333 amongst intervention practices, and the odds of follow up consultation reduced by 32% (**table 3**). In
 334 each case we adjusted for patient age (modelled as a binary variable with categories '< 44' and '≥
 335 45'), and found that each outcome was more likely amongst presenting patients in the older age
 336 category.

Outcome	Variable	Adjusted OR (95% CI)	p-value
Antibiotic prescription at initial presentation	Study arm		
	Control	<i>Reference</i>	
	Intervention	0.38 (0.27, 0.53)	< 0.001
	Patient age		
	< 44	<i>Reference</i>	
	≥ 45	1.35 (1.02, 1.77)	0.035
Follow-up consultation after initial presentation	Study arm		
	Control	<i>Reference</i>	
	Intervention	0.68 (0.51, 0.92)	0.013
	Patient age		
	< 44	<i>Reference</i>	
	≥ 45	1.40 (1.06, 1.85)	0.019

Table 3: Multivariate logistic regression models for the association of practice-level intervention with antibiotic prescribing at initial presentation and follow-up consultation after initial presentation

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338

339 **List of abbreviations**

340 LRTI: Lower respiratory tract infection; NPT: Near patient test; CRP: C-reactive protein; PCT:

341 Procalcitonin; NICE: National Institute for Clinical Excellence; NHS: National Health Service; PoC:

342 Point of care testing; LES: Locally Enhanced Service; CCG: Clinical Commissioning Group; QP: NHS

343 England Quality Premium; NIHR: National Institute for Health Research

344

345 **Declarations**346 **Ethical approval**

347 The Integrated Research Application System (IRAS) confirmed that formal ethical approval was not

348 required for the Herts Valleys CCG implementation study; a service evaluation project.

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4
5 355 Innovation Challenge Prize, Acorn award.
6

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8 356 **Competing interests**

9 357 MJ, NS, JS, TM and MM have no competing interests to declare. LC has received honoraria from
10
11 358 Abbott Laboratories and Roche Diagnostics Ltd for speaking events.
12

13
14 359 **Authors' contributions**

15 360 MJ carried out quantitative analysis and wrote the paper with contributions from MM. MJ and NS
16
17 361 developed the post-implementation survey and, with TM, carried out qualitative analysis. LC carried
18
19 362 out the Herts Valleys CCG implementation study. JS, NS and MM developed the LES framework and
20
21 363 other resources, and engaged with the NHS. TM provided methodological input and MM provided
22
23 364 clinical guidance. All authors commented on drafts of the paper and have read and approved the
24
25 365 final manuscript.
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29 366 **Patient consent for publication**

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31 367 Not applicable.
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34 368 **Data sharing statement**

35 369 Not applicable.
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41
42 372 implementation study.
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48 374 **References**

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STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Mixed-methods design reported in title (page 1), and described in more detail in abstract (page 2)
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3-5
Objectives	3	State specific objectives, including any pre-specified hypotheses	Page 5
Methods			
Study design	4	Present key elements of study design early in the paper	Described briefly in abstract (page 2), and in more detail in methods (page 5-8)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Separately reported for engagement work (page 5-6), qualitative component (page 7), and quantitative component (page 8)
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 <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	Separately reported for engagement work (page 5-6), qualitative component (page 7), and quantitative component (page 8)
		(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	Not applicable. Quantitative component used intervention/control arms, but not matched; purposive sample and basis for comparison described (page 8)
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Described for quantitative component (page 15)
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement).	Described for quantitative

		Describe comparability of assessment methods if there is more than one group	component (page 8)
Bias	9	Describe any efforts to address potential sources of bias	Acknowledged potential bias arising from quantitative component (page 14), however not possible to quantify and address in analysis
Study size	10	Explain how the study size was arrived at	Recruitment of participants/study size separately reported for engagement work (page 6), qualitative component (page 7), and quantitative component (page 8)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Reported for quantitative component (page 15)
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Reported for quantitative component (page 15)
		(b) Describe any methods used to examine subgroups and interactions	Not applicable
		(c) Explain how missing data were addressed	Not applicable
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(e) Describe any sensitivity analyses	Not applicable
Results			
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	Reported for quantitative component (page 15), including eligibility criteria (page 8)
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Not applicable
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	Reported duration of quantitative component follow-up period (page 8 and 15)

Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	Reported for quantitative component (page 15)
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	Not applicable
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	Not applicable
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	Quantitative analysis reported briefly in appendix (page 15). Adjusted odds ratios presented, with confidence intervals and confounding variables
		(b) Report category boundaries when continuous variables were categorized	Reported for quantitative component (page 15)
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	Reported for all study components throughout discussion (page 11-14)
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	Overall study limitations discussed (page 12), including specific acknowledgement of potential for bias arising from quantitative component (page 14)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Overall interpretation of results discussed (page 13-14)
Generalisability	21	Discuss the generalisability (external validity) of the study results	Statements on generalisability given (page 12, 14)
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 16

*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.

BMJ Open

Funding and policy incentives to encourage implementation of point-of-care C-reactive protein testing for lower respiratory tract infection in NHS primary care: a mixed-methods evaluation

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3 1 **Funding and policy incentives to encourage implementation of point-of-care**
4 2 **C-reactive protein testing for lower respiratory tract infection in NHS primary**
5 3 **care: a mixed-methods evaluation**
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9 5 **Matthew Johnson (corresponding author)**

10 6 mj1c13@soton.ac.uk

11 7 NIHR CLAHRC Wessex Data Science Hub, Faculty of Health Sciences, University of Southampton, UK
12
13
14
15 8

16 9 **Liz Cross**

17 10 liz.cross@nhs.net

18 11 NIHR CLARHC East of England, Attenborough Surgery, Bushey Medical Centre, Herts Valleys Clinical
19 12 Commissioning Group, UK
20
21
22
23 13

24 14 **Nick Sandison**

25 15 N.J.Sandison@soton.ac.uk

26 16 NIHR CLAHRC Wessex, Faculty of Health Sciences, University of Southampton, UK
27
28
29
30 17

31 18 **Jamie Stevenson**

32 19 jamie.stevenson@soton.ac.uk

33 20 NIHR CLAHRC Wessex, Faculty of Health Sciences, University of Southampton, UK
34
35
36
37 21

38 22 **Thomas Monks**

39 23 thomas.monks@soton.ac.uk

40 24 NIHR CLAHRC Wessex Data Science Hub, Faculty of Health Sciences, University of Southampton, UK
41
42
43
44 25

45 26 **Michael Moore**

46 27 mvm198@soton.ac.uk

47 28 Head of Academic Unit, Primary Care and Population Sciences, University of Southampton
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33 **Abstract**

34 **Objectives:** Utilisation of point-of-care C-reactive protein testing for lower respiratory tract infection
35 has been limited in UK primary care, with costs and funding suggested as important barriers. We aimed
36 to use existing National Health Service funding and policy mechanisms to alleviate these barriers, and
37 engage with clinicians and healthcare commissioners to encourage implementation.

38 **Design:** A mixed-methods study design was adopted, including a qualitative survey to identify
39 clinicians' and commissioners' perceived benefits, barriers and enablers post-implementation, and
40 quantitative analysis of results from a real-world implementation study.

41 **Interventions:** We developed a funding specification to underpin local reimbursement of general
42 practices for test delivery based on an item of service payment. We also created training and
43 administrative materials to facilitate implementation by reducing organisational burden. The
44 implementation study provided intervention sites with a testing device and supplies, training and
45 practical assistance.

46 **Results:** Despite engagement with several groups, implementation and uptake of our funding
47 specification were limited. Survey respondents confirmed costs and funding as important barriers in
48 addition to physical and operational constraints, and cited training and the value of a local champion
49 as enablers.

50 **Conclusions:** Although survey respondents highlighted the clinical benefits, funding remains a
51 barrier to implementation in UK primary care, and appears not to be alleviated by the existing financial
52 incentives available to commissioners. The potential to meet incentive targets using lower cost
53 methods, a lack of policy consistency, or competing financial pressures and commissioning programmes
54 may be important determinants of local priorities. An implementation champion could help to catalyse
55 support and overcome operational barriers at the local level, but widespread implementation is likely
56 to require national policy change. Successful implementation may reproduce antibiotic prescribing
57 reductions observed in research studies.

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5 59 **Strengths and limitations of this study**

- 6
7 60 • Use of a mixed-methods study design to assess the benefits, barriers and enablers of
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9 61 implementation from multiple perspectives.
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11 62 • The study did not involve research funding for participating sites to enable evaluation of the
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13 63 impact of real-world financial structures associated with NHS commissioning.
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15 64 • Development of a pack of resources that could contribute to future implementation projects.
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17 65 • The study was undertaken against a background of general financial constraint within the NHS,
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19 66 which may have adversely impacted upon outcomes.

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24 68 **Background**

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26 69 Acute uncomplicated lower respiratory tract infection (LRTI) is the one of the commonest acute illnesses
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28 70 managed in primary care, and even in low antibiotic prescribing countries most patients receive
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30 71 antibiotics^{1 2}. There is a clear national and international agenda to reduce unnecessary antibiotic
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32 72 prescribing³. The recently updated Cochrane review⁴ of antibiotics for acute bronchitis demonstrated
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34 73 modest benefits, with a reduction of cough duration of around half a day. These findings were not
35
36 74 replicated in a recently published large trial of antibiotics against placebo⁵. Limited benefit was
37
38 75 demonstrated from antibiotics likely to be balanced by harms, and no subgroup was identified in whom
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40 76 there was a clinically relevant benefit^{5 6}.

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43 77 In the absence of clear benefit then what are the drivers of continued prescribing? Patients are
44
45 78 concerned about their symptoms⁷, and clinicians are worried about missing severe infection and to
46
47 79 avoid medico-legal consequences⁷⁻⁹. However, continued prescribing of antibiotics carries direct
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49 80 prescribing costs, increased re-consultations¹⁰ and the major threat of antibiotic resistance¹¹. Moreover,
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51 81 a large cohort study has shown that adverse events following primary care consultation with LRTI
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53 82 patients are rare, and may not be directly influenced by prescribing strategy¹².

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3 83 There is evidence that antibiotic prescribing in LRTI may be limited by appropriate use of near patient
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5 84 tests (NPT)¹³⁻¹⁵. Two candidates are available: C-reactive protein (CRP) and procalcitonin (PCT)¹⁶⁻¹⁸. An
6
7 85 individual patient data review and meta-analysis supported the use of PCT to guide antibiotic use in
8
9 86 acute settings including primary care, emergency units and intensive care, and demonstrated equivalent
10
11 87 clinical outcomes with reduced antibiotic uptake¹⁹. Similarly, a recent Cochrane review examining the
12
13 88 role of CRP in acute respiratory illness in primary care²⁰ included six trials with 3,284 participants and
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15 89 demonstrated a reduction in antibiotic use, although the results were interpreted with caution due to a
16
17 90 high degree of heterogeneity. The recently published National Institute for Clinical Excellence (NICE)
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19 91 pneumonia guidelines²¹ have also endorsed the use of CRP to aid decision making in primary care,
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21 92 selecting this ahead of PCT given the current non-availability of an NPT for PCT.

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24 93 Several trials have explored the use of CRP in the primary care setting for management of LRTI, either
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26 94 alone or in combination with a communications skills training package, and have demonstrated a
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28 95 substantial reduction in antibiotic prescribing¹³⁻¹⁵. Although CRP is widely used in Scandinavian countries
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30 96 uptake has been limited in the UK, despite evidence of effectiveness in trial contexts to direct rational
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32 97 prescribing for LRTI. There is some question, however, of the effectiveness of CRP once adopted in
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34 98 clinical practice; results of tests performed on those with upper respiratory tract infection were found to
35
36 99 have been misinterpreted, and modest effects on prescribing described²². Some have questioned
37
38 100 whether reduced antibiotic prescribing will be seen following implementation in low prescribing
39
40 101 settings²³, while others have reported CRP being the main determinant of antibiotic prescription in
41
42 102 observational cohorts²⁴.

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45
46 103 The reasons for the delayed uptake of NPT in the UK are not clear. Tests to reduce diagnostic
47
48 104 uncertainty were supported by primary care physicians in a multi-country study including the UK²⁵.
49
50 105 Although studies suggest that CRP is a cost-effective means of addressing LRTI in primary care, there is
51
52 106 evidence that concerns around costs and funding remain a barrier to widespread implementation²⁶. As
53
54 107 the UK National Health Service (NHS) model of primary care does not include item of service payments,
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1
2
3 108 implementation of Point of Care testing (PoC) outside of a research setting would generate additional
4
5 109 work and costs for initial purchase, maintenance and consumables, whereas antibiotic prescriptions
6
7 110 have no direct cost at practice level (see **Appendix A** for further detail of primary care testing in the NHS
8
9 111 system). One plausible way to increase utilisation of CRP PoC would be the introduction of an item of
10
11 112 service payment for use of the test in management of LRTI. The NHS England General Medical Services
12
13 113 contract, in addition to defining the scope of standard primary care services to be delivered by general
14
15 114 practices, also includes provision for opt-in to the delivery of additional, 'locally enhanced' services
16
17 115 (LES)²⁷. This study was based on the hypothesis that the LES scheme may provide a mechanism to
18
19 116 introduce a financial incentive to uptake of CRP PoC for the management of LRTI in an NHS primary
20
21 117 care setting.

22
23
24 118 We aimed to evaluate the efficacy of an item of service payment framework introduced at the local
25
26 119 level by way of the LES scheme as a means of encouraging implementation amongst clinicians and
27
28 120 healthcare commissioners. We also aimed to work with other groups and localities to explore
29
30 121 alternative approaches to implementation, and to identify the perceived benefits, barriers and
31
32 122 enablers using a post-implementation survey.

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37 124 **Methods**

38 125 **Leveraging funding and policy incentives**

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41
42 126 Our work has concentrated on making use of the opportunities afforded by existing NHS funding and
43
44 127 policy mechanisms to encourage implementation of CRP PoC in primary care. We did not provide any
45
46 128 research funding to participating organisations to ensure that successful implementation was not
47
48 129 artificial, and could potentially be reproduced by others in the context of the real-world financial
49
50 130 structures and constraints associated with healthcare commissioning in the NHS. All work in this
51
52 131 area was undertaken during 2015 and 2016.

1
2
3 132 We developed a standard LES specification to underpin local implementation, establishing a funding
4
5 133 framework of reimbursement of general practices by Clinical Commissioning Groups (CCGs) for CRP PoC
6
7 134 on a unit basis. In view of the importance given to budgetary concerns by commissioners considering
8
9 135 CRP implementation²⁶, CCGs may be motivated by its potential to open access to national funding
10
11 136 associated with achieving the NHS England 'Quality Premium' (QP) target for reduced antibiotic
12
13 137 prescribing in primary care²⁸.

14
15
16 138 Our research group, NIHR CLAHRC Wessex, is funded by both the National Institute for Health
17
18 139 Research (NIHR) and partner organisations (including CCGs) within the local health system. Partner
19
20 140 funding contributions may be monetary, or comprised of research study involvement. Our locality
21
22 141 covers nine CCGs, each of whom had the opportunity to fulfil this funding obligation by participating
23
24 142 in a CRP implementation study, or similar research. As well as this benefit, there was further
25
26 143 opportunity for any participation costs to be partially or fully offset if the QP was achieved as a
27
28 144 result.

31 145 **Engaging with the NHS**

32
33
34 146 Using materials from the GRACE Intro study¹⁵ we developed resources including an online training
35
36 147 course for general practitioners on the use of CRP, a clinical audit form and patient information
37
38 148 leaflet²⁹. All resources were made available to interested organisations as a means of facilitating
39
40 149 implementation by reducing the associated administrative burden.

41
42
43 150 We visited clinicians and healthcare commissioners in our locality to generate interest, and made
44
45 151 presentations at locality events to promote the LES framework. We also attended an NIHR CLARHC
46
47 152 Wessex showcase event to which local CCGs were invited. We followed up additional enquiries from
48
49 153 other groups outside of our locality who were interested in CRP implementation by offering visits
50
51 154 and presentations, and sharing the resources developed for our local study. Resources were shared
52
53 155 with ten groups across the country.

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3 156 **Post-implementation survey**
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5
6 157 In August 2017, following our period of NHS engagement, we issued an electronic survey to a
7
8 158 convenience sample of clinicians and commissioners who had expressed an interest in, or were known
9
10 159 to have contributed to, CRP implementation projects. Overall, nineteen individuals were invited to
11
12 160 participate, including healthcare commissioners, pharmacists, primary and secondary care clinicians,
13
14 161 and public health professionals.

15
16
17 162 We adopted a qualitative approach to explore in more depth the factors motivating respondents' initial
18
19 163 interest, their experience of the implementation process and perceived barriers and enablers. Survey
20
21 164 questions were written in line with these underlying objectives as deductively generated main themes³⁰
22
23 165 **(box 1).**
24
25

26 We asked participants:

- 27 • What were your/your organisation's reasons for implementing CRP testing?
- 28 • What was your experience of implementing and using CRP testing, and what is happening now?
- 29 • Which aspects of the implementation worked well?
- 30 • What were the barriers to implementation and/or continued use?
- 31 • How did you overcome these barriers?
- 32 • What would have helped, or would help in the future to encourage continued use?
- 33 • What would facilitate the implementation process?
- 34 • What would be your recommendations for those looking to implement CRP testing in the future?

35 **Box 1: Post-implementation survey questions**
36

37 166
38 167 Following the method of thematic analysis described by Nowell and colleagues³¹, three members of the
39
40 168 research team (MJ, NS, TM) individually reviewed all survey responses to inductively identify more
41
42 169 specific subthemes. Reviewers took a systematic and iterative approach to analysis, later using
43
44 170 researcher triangulation to reach consensus.
45
46

47 171 **Implementation case study**
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50 172 In parallel with our work to evaluate the use of an item of service payment framework as a means of
51
52 173 encouraging CRP implementation, a separate study was undertaken in Herts Valleys CCG to evaluate
53
54 174 CRP utilisation over three winter months (November 2016 – January 2017). This case study did not use
55
56 175 the LES framework, being separately funded by an NHS England Innovation Challenge Prize and driven
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1
2
3 176 by a local champion. However, in view of the successful implementation in this locality we present
4
5 177 further detail in **Box 2** and results in **Appendix B** to demonstrate the potential effects of implementation
6
7 178 of CRP PoC on antibiotic prescribing.
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11
12 Funded by an NHS England Innovation Challenge Prize, an implementation study was undertaken in Herts
13 Valleys CCG to evaluate CRP utilisation over three winter months (November 2016 – January 2017) and in
14 five general practices, purposively sampled using standardised practice-level prescribing data to target high
15 and medium antibiotic prescribers. The study aimed to evaluate whether, compared to standard care, the
16 availability of CRP PoC for LRTI in primary care was associated with reduced acute and follow-up antibiotic
17 prescribing, and unscheduled primary care reattendances and healthcare contacts in the 28 days following
18 presentation.

19
20 Participating practices received an intervention consisting of one testing device and supplies to perform 100
21 tests, training on the NICE guidelines and equipment use, a review visit and practical assistance from the
22 study team where appropriate; all other costs were borne by the practice. Each practice was free to select
23 an appropriate device location and means of operationalising patient flow based on the physical layout of
24 the practice, available resources and staff skill mix.

25
26 In line with the NICE guidelines, patients aged 18-65 presenting to intervention practices with suspected LRTI
27 of less than three weeks' duration where there was diagnostic uncertainty were eligible to receive a test.
28 Eligibility was assessed by the clinician during patient consultation. Patients with acute pneumonia,
29 pregnant, immunocompromised, terminally ill or under follow up for Chronic Obstructive Pulmonary Disease
30 were excluded²¹. As the offer was made on clinician discretion, and the patient entitled to refuse, some
31 eligible patients did not receive a test. However, all eligible patients presenting to intervention practices
32 were included in the evaluation, irrespective of whether they received a test.

33
34 The five intervention practices were compared to three Herts Valleys CCG control practices of similar size
35 and prescribing level, all of which continued to provide standard care. Control practices did not receive
36 training. One member of the study team (LC) conducted a retrospective electronic search at control
37 practices to identify new clinical consultations (during the same study period) with patients who met the
38 CRP eligibility criteria. Presentations were identified using a set of Read codes³² commonly used to record
39 clinical activity related to LRTI in NHS primary care, and relevant information collected for analytical
40 purposes.

41 Results from the implementation study are given in **Appendix B**.

42
43 **Box 2: Herts Valleys CCG implementation study**

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48 **181 Patient and public involvement**

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50
51 182 There was no patient and public involvement (PPI) in development of the research question, although
52
53 183 implementation of CRP PoC flowed from the NICE pneumonia guidelines²¹, the development of which
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1
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3 184 involved substantial PPI input. There was no PPI in development of the LES specification. This would not
4
5 185 be normal practice in respect of a contractual arrangement for the funding of general practices.
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10 11 187 **Results**

12 13 188 **Adoption of the LES framework and implementation of CRP**

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16 189 Whilst there was initial interest in CRP PoC facilitated by use of the LES framework, ultimately no
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18 190 CCGs within the NIHR CLAHRC Wessex locality participated in implementation projects. CRP was
19
20 191 under consideration by one local CCG as part of a range of measures that might contribute to
21
22 192 achieving a 'Quality, Innovation, Productivity and Prevention' programme target around improving
23
24 193 detection of pneumonia in primary care, with the aim of enabling earlier intervention and reducing
25
26 194 hospital admissions. The CCG had planned to implement CRP across all of its general practices, but
27
28 195 concluded that the associated upfront capital cost was too substantial and did not proceed.
29

30
31 196 Another CCG outside of our locality was interested in more widespread CRP implementation based
32
33 197 on antibiotic prescribing reductions observed during a pilot undertaken in a single general practice.
34
35 198 Although ten testing devices were procured and were initially regularly used, declining utilisation in
36
37 199 the face of operational barriers prompted the CCG to cease procurement of PoC consumables.
38
39 200 Financial incentivisation by way of the LES framework was considered as a means of encouraging
40
41 201 utilisation, but ultimately failed to reengage interest.
42
43

44
45 202 We are not aware of any other CCGs having adopted the LES framework, or having engaged in
46
47 203 implementation projects.
48

49 204 **Post-implementation survey**

205 Of the nineteen individuals invited to participate, seven (37%) submitted full responses. Several
 206 subthemes emerged from inductive analysis, with a high level of consistency amongst respondents
 207 **(table 1)**.

208 All respondents reported being organisationally motivated by the potential for CRP PoC to help
 209 reduce antibiotic prescribing, while some further specified a desire to reduce variation in prescribing
 210 rates amongst practices in their locality. However, respondents also described mixed clinician
 211 utilisation: while some regularly incorporated PoC into consultations for suspected LRTI, others did
 212 not use it at all. Furthermore, one respondent noted that while utilisation had initially been high, it
 213 had declined over time.

Benefits:
<ul style="list-style-type: none"> • A clinical aid to appropriate antibiotic prescribing • An objective measure to improve patient confidence in the prescribing action
Barriers:
<ul style="list-style-type: none"> • Limited time available during consultation • Layout of facility and placement of testing device • Cost of implementation and continued use • Source of funding • Resistance to change • Maintaining engagement
Enablers:
<ul style="list-style-type: none"> • Early adopters to share experience and provide mentorship • Training and education • Champions within practice/locality • Collaboration at local and national level • Better utilisation of IT to facilitate testing process
Table 1: Benefits, barriers and enablers of implementation

214

215 **Benefits**

216 Most respondents agreed that CRP is a valuable clinical aid to appropriate antibiotic prescribing for
 217 patients with symptoms of LRTI. Furthermore, some highlighted its value as an objective measure to
 218 improve patient confidence in the chosen prescribing action, particularly in consultation with those
 219 who are “very keen” to receive antibiotics. Two respondents noted that, in their experience, patients
 220 had responded positively to the test and were satisfied with the outcome.

1
2
3 221 **Barriers**
4

5 222 In general, respondents reported that interest amongst clinicians was sometimes poor, and
6
7 223 suggested a need for financial incentives and support to encourage widespread uptake. Most
8
9 224 mentioned cost pressures, while some questioned who should be responsible for funding: general
10
11 225 practices or the CCG. Despite the evidence base for the clinical benefits, one respondent suggested
12
13 226 that there remains a need to “clearly demonstrate short term benefits in costs, workload and safety”
14
15 227 to develop and maintain engagement.
16
17

18 228 Most respondents commented on the impact of operational constraints, such as the physical layout
19
20 229 of the practice, how to accommodate multiple users, and the time required to carry out the test,
21
22 230 particularly in the context of high workload and limited consultation duration. Although some
23
24 231 respondents argued that other benefits justified its use despite these barriers, others specifically
25
26 232 cited them as disincentives, especially for clinicians who may have a negative attitude to CRP or be
27
28 233 resistant to change.
29
30

31
32 234 **Enablers**
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34
35 235 Most respondents discussed the importance of collaboration, although interpretations of this
36
37 236 differed. Some suggested that early adopter sites share lessons learned to help others and avoid
38
39 237 duplicated effort. The value of training and education during the implementation process were
40
41 238 consistently emphasised, and development of a standard programme was suggested. Others
42
43 239 mentioned the role of NIHR in fostering collaborative working, and the potential for general practice
44
45 240 or CCG champions to improve engagement and resolve problems. Some respondents also suggested
46
47 241 better use of IT to facilitate testing. Specific examples included the deployment of standard
48
49 242 templates to record the test and result in the practice management system, and use of electronic
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51 243 alerts during consultation to prompt clinicians to PoC if indicated.
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245 **Discussion**

246 **Summary of main findings**

247 Despite initial interest, there was no implementation in the NIHR CLAHRC Wessex locality, and no
248 CCGs formally adopted the LES framework. The research team were unable to gain significant
249 traction with CCG management, and when contact was established CCGs were unwilling to prioritise
250 antibiotic stewardship over other local initiatives. The policy levers seemed to have little impact in
251 this locality, where CCGs were struggling to remain in budget. The financial rewards arising from the
252 QP only applied to CCGs meeting financial targets. Elsewhere, one CCG implemented CRP and,
253 following declining utilisation in response to operational barriers, found that the LES framework was
254 insufficient as a mechanism to reengage interest.

255 Although the small sample size limits inference and generalisability, our post-implementation survey
256 identified several financial, operational and physical barriers in common with previous qualitative
257 research²⁶. Respondents confirmed that implementation would be unlikely without financial
258 incentives but also highlighted difficulties integrating PoC into practice workflow, and constraints
259 arising from a lack of dedicated space, equipment sharing and limited time. Reported enablers
260 included adequate training and the value of a local champion.

261 Some respondents also emphasised the clinical benefits of CRP, giving anecdotal examples of cases
262 where testing had prevented antibiotic prescription. The potential for more widespread repetition of
263 this outcome is suggested by quantitative results from the Herts Valley CCG implementation study,
264 where a successful, separately funded implementation scheme was run for a three month period,
265 driven by a local champion. Observation of substantial prescribing reductions amongst intervention
266 practices suggests that implementation in the NHS might replicate the prescribing reductions
267 reported in research studies.

268 **Comparison with other literature**

1
2
3 269 We are unaware of any other implementation studies concerning CRP PoC in the UK. In other health
4
5 270 settings PoC is widely adopted²², and following government directives has been introduced in the
6
7 271 Netherlands³³. The financial barriers to implementation have been identified in a previous study
8
9 272 including European and UK participants²³, which noted that countries with high rates of use had
10
11 273 alternative reimbursement models, and that widespread implementation in Europe followed health
12
13 274 policy change. The same study also highlighted issues around workflow and time as potential
14
15 275 barriers to implementation in the UK.

18 276 **Strengths and weaknesses**

21 277 Our study describes the results of attempts at CRP implementation without the resources associated
22
23 278 with research, and without specific policy directives. It is unclear how generalisable our findings
24
25 279 might be; it would appear that CCG partnership with NIHR CLAHRC Wessex and national level
26
27 280 incentives via the QP should have maximised the potential for local implementation. The scheme
28
29 281 was devised during a time of general financial constraint within the NHS, which may have had
30
31 282 particular impact in the Wessex locality.

34 283 **Limitations around funding mechanisms**

37 284 The criteria required to achieve the QP, even taking the antibiotic prescribing element alone, has
38
39 285 been inconsistent. Some changes have been significant, such as a move to greater emphasis on
40
41 286 antibiotic prescribing for urinary tract infection as of 2018/19²⁸. Furthermore, as the QP is awarded
42
43 287 retrospectively and is contingent upon meeting other financial targets, the funding mechanism is not
44
45 288 guaranteed, making it difficult to engage commissioners and to create a firm financial framework to
46
47 289 underpin CRP implementation.

50 290 A further feature of the QP is that no method of achievement is stipulated; the antibiotic prescribing
51
52 291 element simply requires an absolute prescribing reduction. The NHS has reported a national ~7%
53
54 292 reduction in primary care coinciding with the implementation phase of this study³⁴⁻³⁶, which may

1
2
3 293 have resulted from a general policy shift and increased focus of clinical training in primary care. This
4
5 294 suggests that overall improvements could be gained and the QP target potentially achieved by way
6
7 295 of alternative, lower cost methods alone, negating commissioners' financial incentive for CRP
8
9 296 implementation irrespective of the clinical benefits.

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11
12 297 The pressures of multiple, competing commissioning programmes may limit engagement with
13
14 298 certain initiatives, while the overall funding structure of the NHS may also influence commissioners'
15
16 299 preferences and priorities. One CCG within our locality suggested that, despite evidence of a net cost
17
18 300 saving associated with CRP³⁷, whilst the upfront implementation costs reside with primary care, any
19
20 301 savings would principally be realised by the secondary care sector. In this instance, therefore,
21
22 302 concerns that the costs and benefits of the initiative may be distinctly localised within separate areas
23
24 303 of the health system acted as a disincentive to its adoption.

25 26 27 304 **Implications**

28
29
30 305 Whilst the use of existing financial structures appeared appealing as a mechanism, it was not
31
32 306 possible to fully test the hypothesis that modest financial incentives to general practices at local
33
34 307 level would enable CRP implementation, as financial pressures impeded CCG adoption of the policy.
35
36 308 National incentives for CCGs did not appear to override the financial constraints because a) financial
37
38 309 rewards were only available to CCGs meeting financial targets, and b) antibiotic targets were being
39
40 310 achieved through other mechanisms not requiring financial investment.

41
42
43 311 Although a small case study suggests that implementation outside of research studies may result in
44
45 312 similar prescribing reductions, since it was driven by local investment and a local champion it may
46
47 313 not fully reflect implementation in routine practice, or be generalisable to other areas. Furthermore,
48
49 314 and recalling questions over the primacy of lower cost measures, the fact that this intervention
50
51 315 provided training and support in addition to testing materials limits the extent to which the
52
53 316 observed prescribing reductions can be confidently attributed to CRP PoC alone.

1
2
3 317 The value of an enthusiastic, local champion to catalyse support for implementation emerged from
4
5 318 both the qualitative and quantitative strands of this study. Knowledge mobilisation and
6
7 319 implementation in practice may be assisted by way of a Researcher-In-Residence model³⁸, while
8
9 320 further qualitative and observational research could improve understanding of how champions are
10
11 321 able to persuade and engage clinicians and to encourage commissioners to look beyond the
12
13 322 immediate financial disincentives, and whether they may be effective in other areas and settings.
14
15 323 Further economic research might also model different modes of implementation to assess the costs
16
17 324 and consequences across the system, and to find alternative funding models to overcome the
18
19 325 financial barriers. Multi-purpose testing devices, for example, may have the advantage of spreading
20
21 326 investment across several funding streams.

22
23
24 327 In conclusion, it seems unlikely that financial schemes falling outside of national policy will gain
25
26 328 much traction in a financially constrained NHS. Full-scale implementation of CRP PoC is likely to
27
28 329 require central implementation via government policy or contractual changes.
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31 330

331 **List of abbreviations**

332 LRTI: Lower respiratory tract infection; NPT: Near patient test; CRP: C-reactive protein; PCT:
333 Procalcitonin; NICE: National Institute for Clinical Excellence; NHS: National Health Service; PoC:
334 Point of care testing; LES: Locally Enhanced Service; CCG: Clinical Commissioning Group; QP: NHS
335 England Quality Premium; NIHR: National Institute for Health Research; PPI: Patient and public
336 involvement

337

338 **Declarations**

339 **Ethical approval**

340 The Integrated Research Application System (IRAS) confirmed that formal ethical approval was not
341 required for the Herts Valleys CCG implementation study; a service evaluation project.

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2
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5
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9
10 346 NHS, the NIHR or the Department of Health and Social Care.

11
12
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14
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16
17
18 349 **Competing interests**

19
20 350 MJ, NS, JS, TM and MM have no competing interests to declare. LC has received honoraria from
21
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23
24
25 352 **Authors' contributions**

26
27 353 MJ carried out quantitative analysis and wrote the paper with contributions from MM. MJ and NS
28
29 354 developed the post-implementation survey and, with TM, carried out qualitative analysis. LC carried
30
31 355 out the Herts Valleys CCG implementation study. JS, NS and MM developed the LES framework and
32
33 356 other resources, and engaged with the NHS. TM provided methodological input and MM provided
34
35 357 clinical guidance. All authors commented on drafts of the paper and have read and approved the
36
37 358 final manuscript.

38
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40 359 **Patient consent for publication**

41
42 360 Not applicable.

43
44
45 361 **Data sharing statement**

46
47 362 No additional data available.

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51
52 365 implementation study.

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Appendix A: Primary care testing in the NHS health system

In the UK healthcare is free at the point of contact and funded through central taxation. There is no co-payment or health insurance needed for patients to access the NHS. General practices rarely perform tests on the primary care site, with few exceptions such as urine dip tests, pregnancy tests and sometimes coagulation monitoring. The majority of laboratory tests are organised by the local hospital, with patients either attending the hospital directly for sampling, or samples being taken at the general practice and sent to the laboratory. Payment for the test is by way of a 'block contract' arrangement, and paid for by the CCG so that neither the patient nor the practice bear any cost. Under the current contractual arrangement the general practice is unable to charge the patient for NPTs and so, if performed, bears the full cost from its own income, as well as an additional time burden. For these reasons NPTs such as CRP are unfamiliar to practitioners in the UK, necessitating an examination of alternative means to encourage their implementation.

Appendix B: Results from Herts Valleys CCG implementation study

Five intervention practices with a total list size of 63,743 patients recorded 682 eligible LRTI presentations during the study period, of which 176 (26%) involved a CRP test. Three control practices recorded 258 presentations (based on the same eligibility criteria) from 35,928 patients.

The conversion of initial LRTI presentations to CRP tests (intervention arm only) and to other primary care healthcare events (both study arms) were reported descriptively. A binary outcome variable was created to represent antibiotic prescription during the 28 days following the initial LRTI presentation.

As delayed prescribing was relatively infrequent at both intervention and control practices acute and delayed prescriptions were combined into a single outcome. Multivariate logistic regression was then used to estimate the odds of antibiotic prescription and follow-up consultation following initial presentation to practices in the intervention and control arms, adjusting for age (modelled as a binary variable with categories ' < 44 ' and ' ≥ 45 ') and sex. Model fit was assessed using the likelihood ratio test, which indicated that patient sex was not a statistically significant predictor of either outcome. Adjusted odds ratios from the final models were reported, along with 95% confidence intervals and p-values to assess significance.

Overall, fewer initial presentations to intervention practices resulted in antibiotic prescription (59% of initial presentations, as compared to 79%) and follow-up consultations (30% compared to 38%), although there was little difference to antibiotic prescribing at follow-up (both arms 68%) (**table 2**). Furthermore, initial presentations with antibiotic prescription then resulting in follow-up consultation with an additional prescription were more common amongst control practices (21% compared to 13%).

	Intervention arm (n = 682)		Control arm (n = 258)	
	Outcome events	%	Outcome events	%
CRP test at initial presentation	176	26	-	-
Antibiotic prescription at initial presentation	405	59	204	79
Follow-up consultation after initial presentation	206	30	99	38
Antibiotic prescription at follow-up consultation	140	68 ^a	67	68 ^a
Initial presentation with antibiotic prescription, then follow-up consultation with additional antibiotic prescription	92	13	55	21

Table 2: Primary care healthcare events resulting from initial LRTI presentation
All percentages compared to number of initial presentations, except (ª) compared to number of follow up consultations

We found that the odds of antibiotic prescribing after initial presentation were reduced by 62% amongst intervention practices, and the odds of follow up consultation were reduced by 32% (table 3). In each case we found that the outcome was more likely amongst presenting patients in the older age category.

Outcome	Variable	Adjusted OR (95% CI)	p-value
Antibiotic prescription after initial presentation	Study arm		
	Control	<i>Reference</i>	
	Intervention	0.38 (0.27, 0.53)	< 0.001
	Patient age		
< 44	<i>Reference</i>		
≥ 45	1.35 (1.02, 1.77)	0.035	
Follow-up consultation after initial presentation	Study arm		
	Control	<i>Reference</i>	
	Intervention	0.68 (0.51, 0.92)	0.013
	Patient age		
< 44	<i>Reference</i>		
≥ 45	1.40 (1.06, 1.85)	0.019	

Table 3: Multivariate logistic regression models for the association of practice-level intervention with antibiotic prescribing after initial presentation and follow-up consultation after initial presentation

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study’s design with a commonly used term in the title or the abstract	Mixed-methods design reported in title (page 1), and described in more detail in abstract (page 2)
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3-5
Objectives	3	State specific objectives, including any pre-specified hypotheses	Page 5
Methods			
Study design	4	Present key elements of study design early in the paper	Described briefly in abstract (page 2), and in more detail in methods (page 5-8)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Separately reported for engagement work (page 5-6), qualitative component (page 7), and quantitative component (page 8)
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 <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	Separately reported for engagement work (page 5-6), qualitative component (page 7), and quantitative component (page 8)
		(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	Not applicable. Quantitative component used intervention/control arms, but not matched; purposive sample and basis for comparison described (page 8)
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Described for quantitative component (Appendix B)
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement).	Described for quantitative

		Describe comparability of assessment methods if there is more than one group	component (page 8)
Bias	9	Describe any efforts to address potential sources of bias	Acknowledged potential bias arising from quantitative component (page 14), however not possible to quantify and address in analysis
Study size	10	Explain how the study size was arrived at	Recruitment of participants/study size separately reported for engagement work (page 6), qualitative component (page 7), and quantitative component (page 8)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Reported for quantitative component (Appendix B)
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Reported for quantitative component (Appendix B)
		(b) Describe any methods used to examine subgroups and interactions	Not applicable
		(c) Explain how missing data were addressed	Not applicable
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(e) Describe any sensitivity analyses	Not applicable
Results			
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	Reported for quantitative component (Appendix B), including eligibility criteria (page 8)
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Not applicable
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	Reported duration of quantitative component follow-up period (page 8 and Appendix B)

Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	Reported for quantitative component (Appendix B)
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	Not applicable
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	Not applicable
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	Quantitative analysis reported briefly in appendix (Appendix B). Adjusted odds ratios presented, with confidence intervals and confounding variables
		(b) Report category boundaries when continuous variables were categorized	Reported for quantitative component (Appendix B)
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	Reported for all study components throughout discussion (page 11-15)
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	Overall study limitations discussed (page 13), including specific acknowledgement of potential for bias arising from quantitative component (page 14)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Overall interpretation of results discussed (page 13-14)
Generalisability	21	Discuss the generalisability (external validity) of the study results	Statements on generalisability given (page 12, 14)
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 15

*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.

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2 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE
3 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
4 <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.
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