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1 **Social and professional influences on antimicrobial prescribing for**
2 **doctors-in-training: a realist review**

3 Running title: Realist review of antimicrobial prescribing

4

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22

23 **Abstract**

24 **Background:** Antimicrobial resistance has led to widespread implementation of interventions
25 for appropriate prescribing. However, such interventions are often adopted without an adequate
26 understanding of the challenges facing doctors-in-training as key prescribers.

27 **Methods:** The review followed a realist, theory-driven approach to synthesising qualitative,
28 quantitative and mixed-methods literature. Consistent with realist review quality standards,
29 articles retrieved from electronic databases were systematically screened and analysed to elicit
30 explanations of antimicrobial prescribing behaviours. These explanations were consolidated
31 into a programme theory drawing on social science and learning theory, and shaped through
32 input from patients and practitioners.

33 **Results:** By synthesising data from 131 articles, the review highlights the complex social and
34 professional dynamics underlying antimicrobial prescribing decisions of doctors-in-training.
35 The analysis shows how doctors-in-training often operate within challenging contexts
36 (hierarchical relationships, powerful prescribing norms, unclear roles and responsibilities,
37 implicit expectations about knowledge levels, uncertainty about application of knowledge in
38 practice) where they prioritise particular responses (fear of criticism and individual
39 responsibility, managing one's reputation and position in the team, appearing competent).
40 These complex dynamics explain how and why doctors-in-training decide to: a) follow senior
41 clinicians' prescribing habits, b) take (or not) into account prescribing aids, advice from other
42 health professionals, or patient expectations, and c) ask questions or challenge decisions. This
43 increased understanding allows for targeted tailoring, design and implementation of
44 antimicrobial prescribing interventions.

45 **Conclusions:** This review contributes to a better understanding of how antimicrobial
46 prescribing interventions for doctors-in-training can be embedded more successfully in the
47 hierarchical and inter-professional dynamics of different healthcare settings.

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49

50

51 **Background**

52 The impact of Anti-Microbial Resistance (AMR) is becoming increasingly clear and efforts to
53 curtail its emergence are gaining priority at a global scale.¹⁻⁵ These efforts are driven by
54 recognition of the projected substantial human and financial costs associated with reduced
55 efficiency of existing antimicrobial agents. It has been estimated that by 2050 there will be 10
56 million deaths a year globally due to drug resistance and the total cost of lost production will
57 come to US\$100 trillion.⁶

58 A broad range of interventions have been implemented worldwide to improve antimicrobial
59 stewardship.⁷ In the United Kingdom (UK), such interventions include the TARGET toolkit in
60 primary care and the 'Start Smart Then Focus' approach in secondary settings, among other
61 initiatives.⁸⁻¹⁶ Encouraging signs of reduction in total antimicrobial consumption have already
62 been identified in primary and secondary care settings in England, but these improvements are
63 insufficient to address the scale of the problem.¹⁷

64 In the United States (US), rising rates of broad-spectrum antibiotic prescribing have been
65 recorded across age groups and overall antibiotic prescribing has risen for older patients, with
66 a large proportion of prescriptions considered inappropriate.^{18, 19} The Infectious Diseases
67 Society of America and the Society for Healthcare Epidemiology have published guidelines
68 for the implementation of antibiotic stewardship programmes, featuring core strategies and
69 supplementary interventions.^{20, 21} In an attempt to address current rates of low
70 implementation,²² all healthcare facilities are required to establish antibiotic stewardship
71 programmes by 2017.²³

72 Despite the wealth of antimicrobial stewardship programmes, it is often difficult to know how
73 best to target resources to maximise intended outcomes. Previous systematic reviews have
74 compared effect sizes of different intervention strategies,^{24, 25} favouring restrictions in

75 prescribing options (e.g. compulsory order forms or expert approval) over purely educational
76 or feedback programmes.²⁵ Yet, less attention has been paid to how intervention strategies work
77 differently in different contexts and for different groups of prescribers. With social norms and
78 informal influences increasingly recognised as important in antimicrobial prescribing,²⁶⁻²⁸
79 uncertainty still exists about how to implement different types of interventions and what
80 refinements are needed for local circumstances.

81 There is also less understanding of how antimicrobial prescribing interventions should be
82 tailored to address the specific needs of doctors-in-training (i.e. medical school graduates
83 undergoing clinical training to become specialists or general practitioners). Postgraduate
84 trainees across all stages are classed as independent prescribers and will typically prescribe
85 medicines, including antimicrobials, on a daily basis. In the UK they are numerically the largest
86 prescribers in the hospital setting.²⁹ In many countries, they form the foundation of the medical
87 workforce and carry out a significant proportion of core medical work, often under little
88 supervision. Their learning and training needs are of critical importance since they are
89 developing skills to lead clinical teams as senior practitioners in the future. Yet, most
90 antimicrobial prescribing interventions target both junior and senior doctors as a uniform body
91 of health professionals assuming they have similar needs and operate under the same
92 circumstances.³⁰

93 To account for the context in which antimicrobial prescribing decisions are made and the
94 significant challenges encountered by doctors-in-training at different levels, we followed a
95 realist approach for evidence synthesis.

96

97

98

99 **Methods**

100 A realist review is particularly relevant to complex interventions characterised by significant
101 levels of heterogeneity. This is because it follows an interpretive, theory-driven approach to
102 synthesising evidence from qualitative, quantitative and mixed-methods research. Its main
103 strength comes from providing findings that explain how and why context can influence
104 outcomes.

105 Our review on IMProving Antimicrobial prescribing for doCtors-in-Training (IMPACT) was
106 structured around the following questions:

- 107 1. What are the 'mechanisms' by which antimicrobial prescribing behaviour change
108 interventions are believed to result in their intended outcomes?
- 109 2. What are the important 'contexts' which determine whether the different
110 mechanisms produce intended outcomes?
- 111 3. In what circumstances are such interventions likely to be effective?

112 Rather than defining effectiveness in terms of effect size as in a standard systematic review,
113 the IMPACT review examined how the responses of doctors-in-training to the resources
114 offered to them (*mechanisms*) were triggered in particular circumstances (*contexts*) to generate
115 certain behaviours or *outcomes* for antimicrobial prescribing (see Supplementary data – Part 1
116 for relevant definitions).

117 The review followed a detailed, published protocol³¹ based on Pawson's five iterative stages:
118 (1) Locating existing theories, (2) Searching for evidence, (3) Selecting articles, (4) Extracting
119 and organising data, (5) Synthesising the evidence and drawing conclusions.³² To this we have
120 added Step (6) Writing and engaging with substantive theory, to highlight the importance of
121 developing a narrative from realist analysis as extending beyond Context-Mechanism-
122 Outcome Configurations (CMOCs) – see Glossary in Supplementary data Part 1 for definition

123 – and to foreground the role of theoretically substantiating findings (drawing on substantive
124 theory).

125 The review is registered on PROSPERO (CRD42015017802) and ran for 18 months (June
126 2015 - November 2016). The Central University Research Ethics Committee (CUREC) at the
127 University of Oxford granted exemption from ethical approval. This paper reports the IMPACT
128 realist review according to the RAMESES publication standards.³³ More details are included
129 in the full project report published on the National Institute for Health Research (NIHR)
130 Journals Library as per standard practice for projects funded by the Health Services and
131 Delivery Research (HS&DR) programme:
132 <https://www.journalslibrary.nihr.ac.uk/programmes/hsdr/139724/#/>.

133

134 **Step 1: Locating existing theories**

135 Before any literature searching had taken place, we devised an initial programme theory as a
136 starting point for the review, drawing on experiential, professional and content knowledge of
137 the research team (including a primary care practitioner and GP trainer, academic experts in
138 medical education, clinical training and implementation science). This initial programme
139 theory acted as a guide for refining assumptions against the data in the literature.

140 To begin refining this initial programme theory and to identify the focus of the review, we
141 carried out exploratory searching using keyword-, author- and project-based methods in
142 MEDLINE/PubMed and Google Scholar (see Supplementary data – Part 2 for example
143 keywords). We also found initial literature through citation tracking and snow-balling, searched
144 for grey literature and elicited key studies from experts.³⁴ The aim was to identify a range of
145 possible explanations about how antimicrobial prescribing interventions work for doctors-in-
146 training at different levels, and why they may work in particular circumstances and not in

147 others.^{35, 36} Iterative programme theory building required discussions within the team to make
148 sense of, interpret and synthesise the different components.

149 A diverse stakeholder group was recruited to provide content expertise for programme theory
150 refinement. The group included patients, carers, senior consultants, doctors-in-training at
151 different stages, pharmacists, microbiologists, academics and policy-makers (n=21 in total).
152 Consultations with stakeholders took place in four two-hour meetings (including one policy
153 workshop) at regular intervals throughout the project, but also through telephone calls and
154 email exchange. Detailed notes were kept in all consultations with stakeholders to inform
155 programme theory and create a clear audit trail.

156

157 **Step 2: Searching for evidence**

158 We carried out two distinct formal literature searches, which were tested, refined and conducted
159 by an Information Specialist (SB). The search strategies were developed iteratively in
160 MEDLINE to reach appropriate sensitivity and specificity. A combination of free-text and
161 indexing terms were used. The search syntax and indexing terms used in MEDLINE were then
162 translated for use in other databases. Relevant studies identified using hand searching were
163 used to benchmark the search strategy. We also undertook forward citation chasing (using
164 Google Scholar) and manually searched citations contained in the reference lists of articles and
165 reports important for the development of programme theory. Google alerts were set up and
166 articles received from content experts were also included.

167

168 ***Main search***

169 Drawing on adaptations from a related systematic review,³⁰ the main search strategy used
170 combinations of search terms for the concepts 'doctors-in-training', 'prescribing', and

171 'antimicrobial' (see MEDLINE main search strategy example in Supplementary data – Part 2).
172 In September 2015 we searched the following databases: Embase, MEDLINE, MEDLINE-in-
173 process, PsycINFO, Web of Science, CENTRAL, Cochrane Database of Systematic Reviews,
174 HTA database and ASSIA. These databases were chosen as the most appropriate to search
175 potentially relevant literature in this area, following the exploratory search in Step 1. We
176 included all studies on antimicrobial prescribing behaviour or interventions that referred to
177 doctors-in-training (any specialty and level), regardless of study design (quantitative,
178 qualitative and mixed methods) or setting (hospital or primary care), and including all
179 prescribing related outcome measures. We excluded studies when they focused on drug
180 administration only (no prescribing decision).

181

182 ***Additional search: hierarchies, team-working and decision-making***

183 Following analysis of the literature from the main search and discussions with the stakeholder
184 group, an additional search was undertaken to allow the review to focus on issues emerging as
185 significant. This additional search focused on social and professional influences in clinical
186 training, and more specifically related to hierarchies, team-working and decision-making. It
187 was not intended to be exhaustive, but to purposefully draw together relevant literature from a
188 different range of disciplines and provide an explanatory backbone for the wider contextual
189 influences identified as important from the analysis of the literature in the main search.

190 The additional search strategy was developed in a similar way to the main search. We used
191 combinations of keywords for the concepts 'hierarchy', 'decision making', 'team work' and
192 'junior doctor' (see MEDLINE additional search strategy example in Supplementary data –
193 Part 2). In January 2016 the following databases were searched: MEDLINE, MEDLINE-in-
194 process, PsycINFO, CENTRAL, Cochrane Database of Systematic Reviews, HTA database

195 and ASSIA. Studies were included when they discussed the role of hierarchies, teamwork and
196 decision-making, in relation to doctors-in-training (any specialty and level), regardless of study
197 design or setting (hospital or primary care). We had no pre-specified exclusion criteria.
198 Included studies were not necessarily linked to prescribing as we were looking to understand
199 the wider context in which doctors-in-training practise.

200 The results of both searches were exported to Endnote X7 bibliographic management software
201 (Thomson Reuters Corporation, Toronto, Ontario) and de-duplicated using automated and
202 manual checking. All citations were reviewed by CP against the inclusion criteria and a 10%
203 random sub-sample was reviewed independently by GW.

204

205 **Step 3: Selecting articles**

206 The selection process primarily focused on the extent to which articles included data that could
207 contribute to the development and refinement of programme theory. CP screened all titles and
208 abstracts in reverse chronological order (to gain a better understanding of shifts in the topics
209 reported) and assessed whether the full text should be obtained. For those articles that met the
210 inclusion criteria, CP retrieved the full texts and classified them into categories of high and low
211 relevance, depending on their relevance to programme theory development (e.g. current
212 situation in the National Health Service (NHS) and the wider UK context, or the extent to which
213 the role of doctors-in-training was discussed). At the point of inclusion based on relevance, the
214 trustworthiness and rigour of each study was also assessed.³⁶ Considerations of rigour and
215 relevance were often interrelated, as papers were more likely to include data useful for
216 programme theory refinement when they had followed their chosen methodology to the
217 standard required. Again, a random 10% sample was reviewed by GW to ensure selection
218 decisions were made consistently.

219

220 **Step 4: Extracting and organising data**

221 Once the core dataset was established, initial manual coding was carried out chronologically
222 (from the most recent article) for familiarisation with the data. In the first rounds of analysis
223 the content was classified in broad descriptive, conceptual categories. Analysis then continued
224 in NVivo 10 (QSR International), focusing first on the richest sources, i.e. articles with most
225 potential to inform the programme theory, and then applying the coding framework to the rest
226 of the papers (deductively) and creating new codes as needed (inductively). By looking at each
227 of the conceptual categories more closely, CP and GW applied a realist logic and analysed
228 sections of texts as related to contexts and/or mechanisms for specific reported outcomes – this
229 was subsequently confirmed with the rest of the team. In doing this, we followed a realist
230 philosophy of science focusing on generative causation, to interpret and explain how different
231 groups of doctors-in-training reasoned about and responded (by way of 'hidden' mechanisms)
232 to contextual influences available in their environment to produce reported outcomes and to
233 identify the specific contexts or circumstances when these mechanisms were more likely to be
234 'triggered'. As the review progressed we iteratively refined the programme theory driven by
235 interpretations of the data in articles included in the review.

236 The characteristics of the documents were extracted into an Excel spreadsheet (see
237 Supplementary data – Part 3). A sample 10% of coded papers was independently reviewed by
238 GW for consistency. The aim of the analysis was to reach theoretical saturation, in that
239 sufficient information has been captured to explain the wide range of antimicrobial prescribing
240 experiences of doctors-in-training reported in the included articles.

241

242 **Step 5: Synthesising the evidence and drawing conclusions**

243 Excerpts coded under specific concepts in NVivo were exported into Word documents, to
244 provide a more flexible space to examine the viability of different CMOCs, experiment with
245 different formulations and work towards building the narrative of the synthesis. To develop a
246 programme theory of the antimicrobial prescribing experiences of doctors-in-training we
247 moved iteratively between the analysis of particular examples, stakeholder interpretations,
248 refinement of programme theory, and further iterative searching for data in our existing dataset
249 to refine particular subsections of the programme theory (for more details on the analysis and
250 synthesis processes see Supplementary data – Part 4).

251 We continued to apply a realist logic of analysis to synthesise the data. This means that we
252 followed a process of constantly moving from data to theory (abductive analysis defined in
253 Supplementary data – Part 1) to refine explanations about why certain behaviours are occurring
254 and tried to frame these explanations at a level of abstraction that could cover a range of
255 phenomena or patterns of behaviour in different settings. This included inferences about which
256 mechanisms may be triggered in specific contexts, as these often remained hidden or were not
257 articulated adequately in the literature. Relationships between contexts, mechanisms and
258 outcomes were sought not just within the same articles, but also across sources. For example,
259 mechanisms inferred from one article could help explain the way contexts might be seen to
260 influence outcomes in a different article.

261

262 **Step 6: Writing and engagement with substantive theory**

263 Beyond analysis and synthesis, the writing process also helped us finalise the programme
264 theory, as it allowed us to bring together the different CMO configurations and to create a
265 narrative that synthesises and explains the data presented in the literature. This process also
266 enabled us to fine-tune our interpretations, to debate the meaning and relevance of different
267 aspects of the programme theory and to develop shared understandings of our arguments. By
268 drawing on a range of social science and learning theories (identified in the literature reviewed
269 or separately) we were able to substantiate the inferences made about mechanisms, contexts,
270 outcomes and the configurations between these elements, and to enhance the plausibility and
271 coherence of the arguments.³⁷⁻⁴⁵

272

273

274 **Results**

275 **Search results**

276 The process of screening and article selection resulted in 131 references. Of those, 81
277 references came from the main literature search and 35 references from the additional search.
278 The remaining 15 articles resulted from citation-tracking, targeted searches and expert
279 suggestions, on the basis of relevance to programme theory.

280 Of the 131 references, 78 used quantitative methods, 37 used qualitative methods, 12 were
281 mixed methods papers, and there were also 3 position papers and 1 report. Supplementary data
282 – Part 3 provides more details on the characteristics of the studies included in the dataset for
283 the review.

284 The PRISMA diagram (see *Figure 1*) illustrates the screening and selection process.

285

286

Figure 1: PRISMA diagram

287

288 **Focus of the review**

289 Interventions for doctors-in-training were often focussed on knowledge or skills alone, were
290 not described in enough detail or were mainly evaluated using pre-/post- study designs. On
291 their own, these articles did not provide enough information to adequately develop and refine
292 an in-depth programme theory about how antimicrobial prescribing intervention components
293 contributed to particular outcomes. Therefore, we chose to focus on explaining how
294 antimicrobial prescribing works for trainees as a process more generally. In this way, we were
295 able to overcome limitations of poor description and lack of comprehensive evaluations and
296 develop findings that can be transferable across different settings. Through systematic coding
297 and analysis of the included papers we were able to reach theoretical saturation on the concepts
298 emerging as important for the development of programme theory on antimicrobial prescribing
299 behaviours of doctors-in-training.

300 We attempted to build explanations of how and why trainees engage with antimicrobial
301 prescribing differently under different circumstances. To do this, we focused on situations
302 where antimicrobial prescribing decisions appear more challenging and where there is
303 increased uncertainty about what course of action to take (compared to when decisions are
304 clear-cut, e.g. when history, examination and investigations more clearly support a diagnosis
305 and management plan). Instead of identifying barriers and facilitators to antimicrobial
306 prescribing, we focused on what trainees do in the *presence* of challenges, such as diagnostic
307 uncertainty, inexperience and lack of knowledge, to reach antimicrobial prescribing decisions.

308

309 **Programme theory and CMOCs**

310 The following parts of the *Results* section provide a narrative overview of the programme
311 theories on antimicrobial prescribing practices of doctors-in-training, based on the realist
312 analysis and explanatory CMOCs developed from the literature reviewed. The narrative
313 presents the programme theories organised under four categories: (1) influence of the medical
314 hierarchy on prescribing decisions, (2) influence of the hierarchy on balancing conflicting
315 priorities and using sources of support, (3) assistance seeking and challenging decisions, and
316 (4) changing contexts. These four categories emerged following analysis and clustering of the
317 data from the literature.

318 Only selected CMOCs are presented in this section due to word restrictions. Supplementary
319 data (Part 5) includes the full list of all 28 CMOCs along with examples of data excerpts from
320 the literature. For a more detailed account of the review, we would direct readers to the full
321 report from this project published on the NIHR Journals library (link provided in Methods
322 section).

323

324 ***Influence of the medical hierarchy on prescribing 'decisions'***

325 The literature describes hierarchies as a core and pervasive aspect of professional socialisation
326 in medicine, with senior clinicians (e.g. Consultants) setting the norms about what is
327 appropriate prescribing in practice (i.e. what is and is not acceptable). In the articles reviewed,
328 doctors-in-training are presented as largely compliant with the behaviours considered
329 legitimate by the formal prescribing hierarchy (medical 'chain of command') at any given
330 instance (i.e. the 'prescribing etiquette'). Analysis of the literature suggests this compliance
331 results primarily from fear of criticism and fear of individual responsibility for patients
332 deteriorating. Doctors-in-training are also driven by the need to sustain positive relationships

333 and manage the impressions of others, in the context of their seniors' role in evaluating their
334 performance and influencing career progression. As described by relevant studies, they try to
335 fit in with the teams they are working with by adopting an identity of a competent trainee
336 (which often means '*doing as you are told*'). Findings related to the role of medical hierarchy
337 on prescribing decisions are synthesised in *CMOCs 1 and 2* (the illustrative data excerpts used
338 to develop and refine these CMOC 1 and 2 may be found in Supplementary data – Part 5 and
339 a detailed example of how we developed a CMOC is illustrated in Supplementary data – Part
340 6);^{27, 46-66}

341 *CMOC1: In a context of learning through role-modelling within hierarchical*
342 *relationships (C), junior doctors passively comply with the prescribing habits and*
343 *norms set by their seniors (O), due to fear of criticism (M) and fear of individual*
344 *responsibility for patients deteriorating (M).*

345 *CMOC2: In a context where career progression depends on hierarchical power*
346 *relationships (C), junior doctors feel they have to preserve their reputation and*
347 *position in the hierarchy (fitting-in) (M), by actively following the example of their*
348 *seniors and avoiding conflict (O).*

349 The literature discusses particular examples of how norms are set differently in different
350 specialties. When rotating in different environments, doctors-in-training encounter a number
351 of different 'rules' depending on the specialties, teams or seniors they are working with. In this
352 respect, antimicrobial prescribing becomes situated - to respond to the norms and needs of
353 particular situations, and relational - to respond to the requirements and norms of particular
354 relationships within hierarchical and inter-professional modes of working (*CMOC3* in
355 Supplementary data – Part 5).^{27, 49, 50, 52-55, 60, 64, 67-76}

356 According to the articles reviewed, perceptions of responsibility and accountability also play a
357 role in influencing the extent to which doctors-in-training follow the norms set by the hierarchy.
358 When trainees perceive that it is their seniors who have responsibility for patient outcomes,
359 they tend to follow the practices indicated as legitimate by those seniors who have ultimate
360 responsibility (*CMOC4* in Supplementary data – Part 5).^{50, 57, 60, 63, 77, 78}

361

362 ***Influence of the hierarchy on balancing conflicting priorities and using sources of support***

363 Role-modelling from senior to junior levels of the hierarchy extends to how conflicting goals
364 should be prioritised (*CMOC5* in Supplementary data – Part 5). The way senior clinicians
365 engage in decision making indicates to trainees how they should prioritise between more
366 immediate, individual short-term goals of patient recovery (e.g. from possible sepsis) and long-
367 term, collective goals of minimising antimicrobial resistance. In examples included in the
368 literature, it is suggested that seniors also role-model how to find a balance between the need
369 for antimicrobial prescribing against the risk of side effects (e.g. *Clostridium difficile*
370 infection).^{60, 61, 79}

371 In such a context of learning through implicit or explicit role-modelling within hierarchical
372 relationships, junior doctors follow the example of seniors, not just in their prescribing
373 decisions, but also in what they count as legitimate sources of support for making prescribing
374 decisions (*CMOCs 6-8* in Supplementary data – Part 5).^{27, 49, 53-56, 60, 61, 66, 70, 74, 76, 80-94} Data from
375 included studies indicates that doctors-in-training will be more inclined to follow guidelines
376 when this is clearly signalled as appropriate behaviour by the senior clinical staff they are
377 accountable to. The primary influence behind guideline use seems to be whether these are
378 adopted and perceived as credible by senior colleagues (*CMOC 9* in Supplementary data – Part
379 5 for factors influencing guideline credibility and use).^{27, 53, 83, 95} The way seniors negotiate

380 patient expectations also seems to play an overriding role in how doctors-in-training decide to
381 respond to perceived patient pressures to prescribe antibiotics (*CMOC10* in Supplementary
382 data – Part 5).^{53-55, 61, 96}

383 Besides the role of guidelines and patient expectations, the literature suggests that senior
384 doctors also role-model how the opinions of other health professionals should be taken in
385 account. By creating a legitimate role for other health professionals in the antimicrobial
386 prescribing process, senior doctors signal to their trainees what is appropriate behaviour to
387 follow, whose opinion counts, in what cases and to what extent (*CMOCs 11-12* in
388 Supplementary data – Part 5).^{28, 53, 71, 76, 97, 98} Some contexts are described in the literature where
389 inter-professional (where relative status differences are more ambiguous) supervision and
390 contribution may play an important role. For example, newly-qualified doctors may turn to the
391 pharmacist as a source of support external to the medical hierarchy, as they will feel less fear
392 of appearing ignorant or having negative repercussions (*CMOC13* in Supplementary data –
393 Part 5).^{27, 28, 47, 51, 53, 60, 61, 65, 70, 75, 77, 97, 99, 100}

394 Analysis of the data in the included studies shows role-modelling may result in positive
395 learning, when (for example) senior doctors follow appropriate prescribing behaviours and
396 clearly explain the rationale of their decisions (e.g. how these correspond to the evidence base
397 or why they diverge based on specific patient needs). According to the literature, optimal role-
398 modelling means explicitly setting the rules about how hierarchical relationships operate in
399 different environments and how trainees should expect to be embedded within them (*CMOC14*
400 in Supplementary data – Part 5).^{28, 50, 53, 55, 61, 83, 97, 101-109} Conversely, role-modelling may result
401 in the reinforcement of suboptimal prescribing habits and prescribing etiquette(s) if rules
402 remain implicit or are only enforced through authority and the rationale is not clarified to
403 facilitate learning (*CMOC15* in Supplementary data – Part 5).^{27, 28, 50, 53-55, 64, 77, 84, 97, 109-113} Such
404 hierarchical environments where the rationale for prescribing decisions is rarely discussed, are

405 often perceived to contribute to a culture of using doctors-in-training to provide service rather
406 than prioritising their learning needs (*CMOC16* in Supplementary data – Part 5).^{15, 63, 110, 111,}
407 113-115

408

409 *Asking for advice and challenging decisions*

410 In hierarchical environments, rules on how to interact with other health care professionals and
411 on how to effectively apply knowledge in practice at different training levels often remain
412 implicit (or unspoken). As a result, doctors-in-training face difficulties making ‘choices’ and
413 navigating relationships with health professionals that could provide them with assistance
414 (*CMOC17* in Supplementary data – Part 5).^{28, 63, 69, 71, 73, 77, 79, 83, 98-100, 102-104, 116-122}

415 Detailed analysis of the literature highlights how trainees make detailed judgments about: a)
416 *whether* or not it would be acceptable to ask for assistance when making certain antimicrobial
417 prescribing decisions, b) *what* types of topics would be acceptable to ask about, c) *who* they
418 should address their questions to, and d) *how* they should frame and communicate their
419 questions. Doctors-in-training make judgments on these points, depending on the condition of
420 the patient, whether they feel a case falls within their remit or knowledge, and depending on
421 what they think the consequences of seeking assistance from particular colleagues would be
422 (*CMOCs 18-20* in Supplementary data – Part 5).^{28, 63, 69, 71, 73, 77, 79, 83, 98-100, 102-104, 116-122}

423 Similar dynamics seem to apply in cases where trainees consider challenging the decisions of
424 their seniors. The literature discusses how reluctance to challenge stems from the belief that it
425 is unlikely that the senior would change their decision, that any error would not be major
426 enough to result in direct patient harm and that it would be more appropriate for someone else
427 at a different position in the hierarchy to identify and intercept the error (*CMOCs 21-22* in
428 Supplementary data – Part 5).^{27, 47, 50, 60, 64, 78, 103, 110, 115, 122-129} In contrast, where senior clinicians

429 signal openness to receiving questions and set relevant norms of behaviour, they may increase
430 trust in junior-senior relationships and allow doctors-in-training to feel more comfortable in
431 raising questions (*CMOCs 23-24* in Supplementary data – Part 5).^{50, 60, 78, 115, 123, 125, 127, 129, 130}
432 Yet, the literature suggests that even when seniors are perceived as approachable, some
433 doctors-in-training still refrain from asking for help and/or advice, out of fear of upsetting
434 established relationships and due to a perception that this will negatively impact on their
435 reputation. This shows that collective hierarchical norms are often more powerful than norms
436 or rules set by individual senior doctors (*CMOC25* in Supplementary data – Part 5)^{100, 117} while
437 discrepancies in perceptions of communication openness between hierarchical levels are
438 prevalent (*CMOC26* in Supplementary data – Part 5).^{63, 123, 131, 132}

439

440 **Changing contexts**

441 As training progresses, doctors become more comfortable negotiating the boundaries of
442 responsibility, knowledge expected and its application in practice at different stages. Through
443 professional socialisation in different environments they learn how to operate under different
444 rules set by the local hierarchies. Their ability to ask questions and confidently argue alternative
445 positions changes over time, as with increasing seniority they are expected to assume more
446 autonomy and responsibility (*CMOCs 27-28* in Supplementary data – Part 5).^{55, 57, 72, 76, 77, 100,}
447 ^{111, 115, 116, 129}

448 *Figure 2* provides an overarching programme theory which consolidates the relationships
449 between the 28 detailed explanations (i.e. *CMOCs*) emerging from the data, organised around
450 the important outcomes identified.

451

452 Figure 2: Overarching realist programme theory

453

454 **Discussion**

455 **Summary of findings**

456 The IMPACT review adds to a growing literature that acknowledges the importance of the
457 wider context in which an intervention is implemented and attempts to explain how and why
458 trainee prescribing practices differ under different circumstances. In doing this, the review does
459 not aim to produce evidence about the relative advantage of different interventions. Given the
460 complexity and clinical uncertainty inherent in antimicrobial prescribing, it is likely that a
461 context-sensitive combination of top-down and bottom-up, multifaceted solutions and ongoing
462 support will be required to improve practice.^{133, 134} Rather, we looked at how interventions can
463 be *tailored* effectively for doctors-in-training, taking in account the way trainees negotiate
464 antibiotic prescribing in practice.

465 The overarching programme theory of the IMPACT review explains how and why doctors-in-
466 training decide in certain contexts to passively comply or actively follow their senior
467 prescribing habits, the way they take into account prescribing aids and consult other health
468 professionals, along with how they negotiate patient expectations (the most common outcomes
469 in the data). The programme theory also explains what drives reluctance or willingness to ask
470 questions about antimicrobial prescribing or to challenge the decisions made by seniors, as well
471 as how this changes as training progresses. As discussed in the literature reviewed, these
472 outcomes result from complex inter-relationships between the contexts in which doctors-in-
473 training practice (i.e. hierarchical relationships, with powerful prescribing norms, where there
474 is little clarity around roles and responsibilities, and knowledge expectations and how to apply
475 knowledge in practice remain implicit) and the mechanisms triggered in these contexts (i.e.

476 fear of criticism, fear of individual responsibility, need to manage one's own reputation and
477 position in the team, and to appear as competent).

478

479 **Comparison with existing literature**

480 Despite recognition of the significant influence of social norms in trainee prescribing, there is
481 still emphasis on purely knowledge- or skills-based interventions.^{56, 59, 61, 66, 72, 80, 85, 87, 88, 135-139}

482 This emphasis is underpinned by an assumption that, having identified misplaced beliefs and
483 erroneous prescribing decisions, one can improve the knowledge 'deficit' by delivering
484 targeted education. However, our findings show that doctors-in-training often struggle, not just
485 because of knowledge 'deficits', but because they have difficulty applying their knowledge in
486 practice. When education and feedback interventions are disjointed from how prescribing
487 decisions are made in the workplace, they are less likely to result in meaningful and sustainable
488 change. Therefore, there is a need to incorporate an understanding of local prescribing norms
489 and power dynamics in the design and delivery of context-sensitive education and feedback
490 programmes, including training on teamwork, communication, error awareness and
491 management that addresses the influence of hierarchical teams.^{54, 85, 105, 140, 141}

492 Although doctor leadership has been widely discussed, promoted and encouraged in health care
493 globally (and especially in the UK NHS), little attention has been paid to how 'leading from
494 beneath' – building leadership capabilities in the context of a hierarchical setting – could
495 contribute to more appropriate antimicrobial prescribing decisions.^{62, 142-144} It may also be
496 relevant to consider antimicrobial prescribing competencies for senior clinicians (or for more
497 senior trainees) including deliberately role-modelling appropriate prescribing and facilitating
498 assistance from antimicrobial specialists, both within and across specialties and occupational
499 groups. Our findings indicate that accepting antimicrobial prescribing more widely as 'a

500 specialised act' could significantly legitimise the input of antimicrobial specialists and foster
501 collaborative working.^{60, 136, 145, 146} Without senior involvement, however, it would be difficult
502 to set an example for junior doctors.

503

504 **Recommendations for policy and practice**

505 Based on the findings of the review, we have focused our recommendations on six key areas
506 for consideration when designing and implementing antimicrobial prescribing interventions for
507 doctors-in-training (*Figure 3*). These recommendations have been developed so that they are
508 transferable and generic enough to allow local tailoring of different types of interventions for
509 different environments.

510 Figure 3: Areas to consider when designing or implementing antimicrobial prescribing
511 interventions that include or target doctors-in-training.

512

- 513 1. **Making AMR everyone's 'business'**: Given the importance of hierarchical dynamics in
514 influencing prescribing decisions, it would not be adequate to implement interventions that
515 target one specific group of prescribers, especially when this group is considered to have a
516 lower status in the hierarchy. A wider cultural shift is necessary across all professional
517 groups and levels of training.
- 518 2. **Specifying what trainees at different levels of training are responsible for**: Having
519 commonly agreed roles and responsibilities for appropriate antimicrobial prescribing (e.g.
520 reviewing antibiotics prescribed), could mean doctors-in-training would be empowered to
521 take initiative and address how treatment may be optimised for each patient.
- 522 3. **Clarifying knowledge, skills and capabilities needed to fulfil responsibilities**: In
523 addition to setting particular roles and responsibilities, it would also be important to ensure

524 appropriate knowledge and skills (e.g. in the form of training or prescribing resources) are
525 in place, and there is scope to apply this knowledge in practice, so trainees can perform
526 their roles effectively.

527 4. **Providing clear processes for seeking advice and support:** Developing explicit processes
528 for seeking assistance, i.e. commonly accepted procedures for seeking help from particular
529 colleagues or seniors (e.g. explicit rules on who should they call and when), would facilitate
530 decision-making for doctors-in-training and would reduce barriers to seeking advice.

531 5. **Ensuring changes are endorsed and reinforced by seniors in the workplace:** As senior
532 doctors play a significant role in setting prescribing norms and influencing junior clinicians,
533 any interventions that do not match accepted norms may not translate to better practice.
534 Hierarchical relationships can play a constructive role when used to role-model and
535 reinforce appropriate prescribing behaviours.

536 6. **Enabling adequate trust so clinicians will ask questions and challenge:** Being explicit
537 about appropriate knowledge levels, skills and capabilities for different stages in training
538 (see point 3 above) would be a necessary first step in building explicit boundaries around
539 what questions are considered legitimate (what is it that one is expected to know and what
540 is not). This may not be sufficient on its own, however, as there is a need to actively develop
541 conditions in which doctors-in-training will feel safe to ask questions, feed back to their
542 clinical teams and challenge decisions made by others.

543

544 To extend the reach of our work, as advised by our stakeholder group, we have also developed
545 an animation video that can be used as part of medical training to trigger reflection and
546 discussion on antimicrobial prescribing (<https://vimeo.com/190717025>).

547 **Strengths and limitations**

548 To conduct this review we have systematically applied rigorous methodological guidance for
549 realist reviews as described in the RAMESES quality standards.¹⁴⁷ Use of a realist approach
550 has allowed us to place emphasis on how contexts influence outcomes and to focus on
551 identifying generative mechanisms, thereby producing findings that are transferable across
552 different types of interventions and across settings. This is reflected in the project outputs
553 (animation and infographic) which have wider applicability.

554 By definition, however, evidence syntheses are reliant on the evidence that is available. We
555 found that interventions were often not described in enough detail to be able to draw
556 conclusions on how their different aspects had resulted in improved prescribing for doctors-in-
557 training. In some of the CMOCs, lack of adequately detailed data in included papers means we
558 have not been able to fully determine some of the fine grained relationships between contexts,
559 mechanisms and outcome. In addition, the majority of the articles were set in secondary care,
560 rather than general practice. This remains a limitation of the study, although our interpretations
561 of the data attempted to account for differences between settings.

562

563 **Conclusions**

564 Few interventions to change the antimicrobial prescribing practice of doctors-in-training are
565 designed and implemented in ways that pay adequate attention to the influence of contexts and
566 the ways these change during clinical training. There is little scope for improvement if the
567 contexts in which antimicrobial prescribing is nested remain unacknowledged. This realist
568 review contributes to our understanding of how antimicrobial prescribing interventions can be
569 better embedded in the hierarchical and inter-professional dynamics of different healthcare
570 settings. Recommendations emerging from this work can be transferable across settings to
571 better support trainees with their antimicrobial prescribing practice. Together with our

572 stakeholder group, we have also developed dissemination materials to enable optimal tailoring,
573 design and implementation of antimicrobial prescribing interventions targeted at doctors-in-
574 training. Further research could focus on how the implications identified in this review can be
575 addressed in practice.

576

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593

594 **Transparency declarations**

595 Geoff Wong is a member of the Health Technology Assessment Primary Care Panel. The other
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597

598 **Authors' contributions**

599 NB, KM, MP and GW developed the research project. SB developed and conducted the search
600 strategies. MP facilitated patient and public involvement for the review. NB, KM, MP, GW
601 shaped the formal search strategies, provided content and theoretical literature, methodological
602 expertise, and contributed to the development and refinement of programme theory. CP
603 contributed to the formal search strategies, carried out screening and article selection processes,
604 applied a realist logic of analysis to the data, identified theoretical ideas for the programme
605 theory, facilitated the stakeholder meetings, drafted the project report and co-authored this
606 paper. GW was the principal investigator, applied a realist logic of analysis to the data, carried
607 out consistency checks and co-authored this paper. All authors read, reviewed and approved
608 the final manuscript.

609

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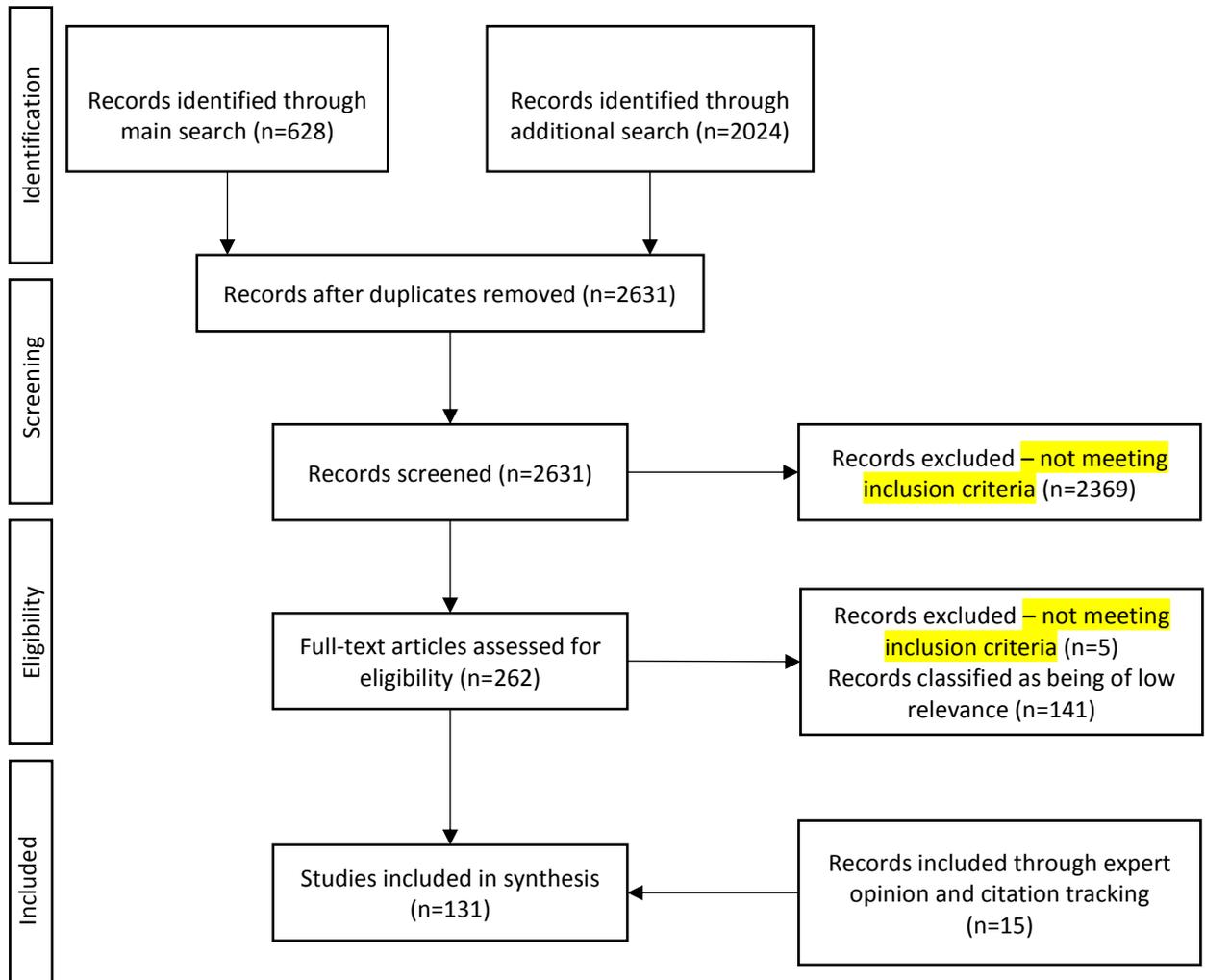
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975 **Figures**

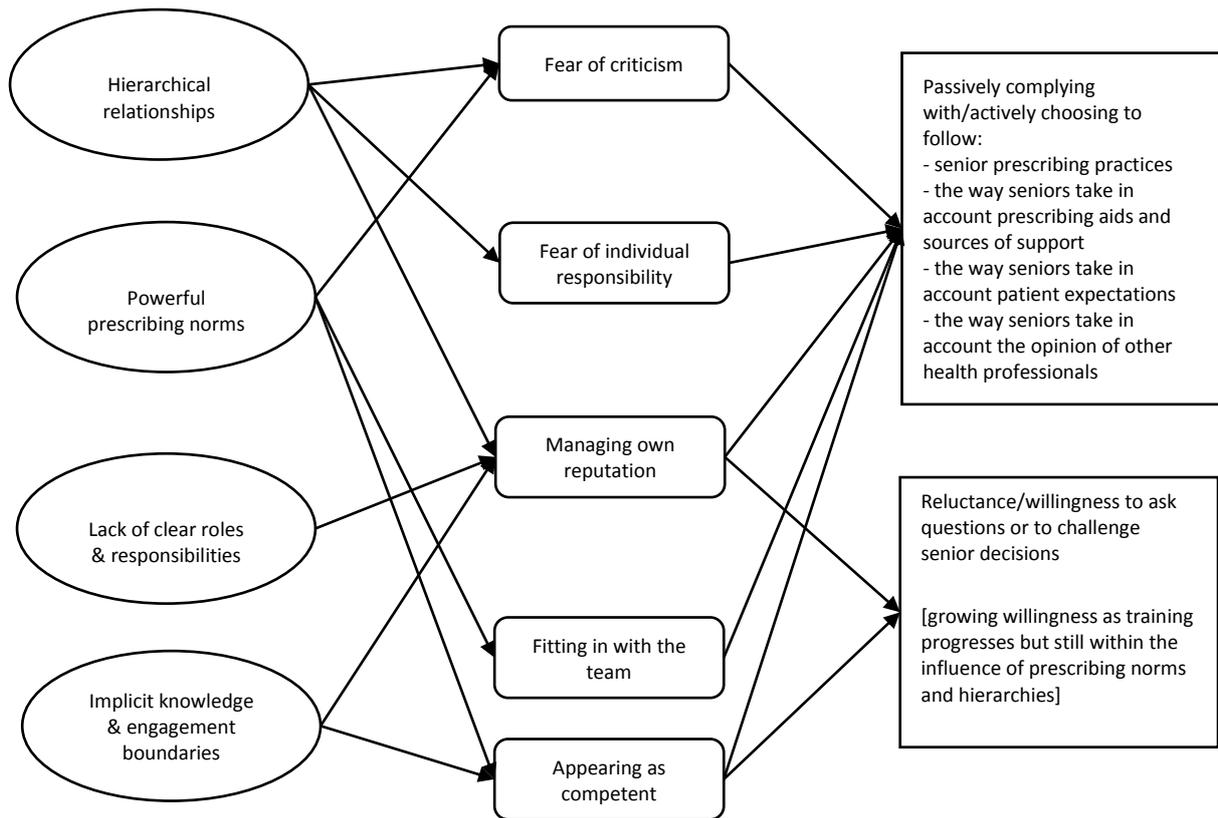
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Figure 1: PRISMA diagram

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Figure 2: Overarching realist programme theory



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984 Figure 3: Areas to consider when designing or implementing antimicrobial prescribing

985 interventions that include or target doctors-in-training.

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