

1 A national quality incentive scheme to reduce antibiotic overuse in hospitals; evaluation of
2 perceptions and impact.

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17 **Short title:** Perceptions of hospital quality incentive for antibiotic use

Structured Synopsis

Background: In 2016/2017, a financially-linked antibiotic prescribing quality improvement initiative (AMR-CQUIN) was introduced across acute hospitals in England. This aimed for >1% reductions in Defined Daily Doses / 1000 admissions of total antibiotics, piperacillin/tazobactam and carbapenems compared with 2013/2014 and improved review of empiric antibiotic prescriptions.

Objectives: To assess perceptions of staff leading antimicrobial stewardship activity about the AMR-CQUIN, the investments made by hospitals to achieve it and how these related to achieving reductions in antibiotic use.

Methods: We invited antimicrobial stewardship leads at acute hospitals across England to complete a web-based survey. Antibiotic prescribing data were downloaded from the Public Health England Antimicrobial Resistance local Indicators resource.

Results: Responses were received from 116/155 (75%) acute hospitals. Due to yearly increases in antibiotic use, most trusts needed to make >5% reductions in antibiotic consumption to achieve the AMR-CQUIN goal of 1% reduction. Additional funding was made available at 23/113 (20%) trusts, and in 18 (78%), this was <10% of the AMR-CQUIN value. Nationally, the annual trend for increased antibiotic use reversed in 2016/2017. In 2014/2015 year-on-year changes were +3.7% (IQR[-0.8, +8.4], +9.4%[+0.2, +19.5] and +5.8%[-6.2, +18.2] for total antibiotics, piperacillin/tazobactam and carbapenems respectively and +0.1%[-5.4, +4.0], -4.8%[-16.9, +3.2] and -8.0%[-20.2, +4.0] in 2016/2017. Hospitals where staff believed they could reduce antibiotic use were more likely to do so ($p < 0.001$).

Conclusions: Introducing the AMR-CQUIN was associated with a reduction in antibiotic use. For individual hospitals, achieving the AMR-CQUIN was associated with favourable perceptions of staff and not availability of funding.

Introduction

Antimicrobial consumption is linked to antimicrobial resistance (AMR) both in populations and in individual people.^{1,2} As much as 50% of human antibiotic use may be unnecessary³ and reducing this overuse is a major priority in healthcare systems across the world.^{4,5}

In the United Kingdom NHS, hospitals are responsible for a minority of total antibiotic use but they are almost exclusively where the most broad-spectrum antibiotics such as piperacillin/tazobactam and the carbapenems are prescribed.⁶ Avoiding antibiotic overuse in hospitals is challenging because patients with clinically significant bacterial infections require prompt administration of effective antibiotics, almost always before definitive diagnostic information is available. Initiatives to prevent avoidable deaths from infection encourage rapid administration of reliably active antibiotics to patients who meet broad clinical criteria for sepsis; however, many of these antibiotics are subsequently deemed unnecessary.⁷ Despite a succession of initiatives in the NHS, such as increased funding for antimicrobial stewardship (AMS) (2003),⁸ a requirement in law for hospital trusts to ensure appropriate antimicrobial use (2008),⁹ and development of an Antimicrobial Toolkit for English hospitals called 'Start Smart Then Focus' (SSTF) (2011),¹⁰ antibiotic use in National Health Service (NHS) hospitals has increased, year-on-year up until 2014.¹¹

In 2015, NHS England required Clinical Commissioning Groups to submit their local baseline prescribing data to enable validation of prescribing patterns and antibiotic use.¹² The following year saw the introduction of the first Commissioning for Quality and Innovation (CQUIN) for antibiotic prescribing (AMR-CQUIN).¹³ CQUINs are the main mechanism by which the NHS encourages hospitals to focus on the quality of care delivered by making a proportion of income conditional on achieving specific quality measures. The AMR-CQUIN was worth 0.25% of acute trust income (approximately £650,000 for an average size hospital based on the number of inpatient beds). Given the emphasis in SSTF on review and revision of antibiotic prescriptions as a key activity to control antibiotic use in hospitals, the four AMR-CQUIN components included empiric review of >90% of antibiotic prescriptions within 72 hours along with reductions in antibiotic use (defined daily doses per 1000 admissions) of $\geq 1\%$ compared with baseline (2013/2014 data) for 1) total antibiotics 2) piperacillin/tazobactam and 3) carbapenems.¹³ Hospital trusts were required by NHS

74 England to submit antibiotic consumption data to PHE for the preceding years, 2014/2015
75 and 2016/2017, and received an additional payment for the submission of this data. All data
76 submitted were published on the 'Fingertips' Antimicrobial Resistance (AMR) Local Indicator
77 data portal as part of the English Surveillance Programme for Antimicrobial Utilisation and
78 Resistance (ESPAUR).¹⁴ Fingertips provides access to a wide range of local public health data
79 presented as thematic profiles. It acts as an important national repository of data on
80 antimicrobial use, AMR, infection prevention control data and hospital acquired infection
81 data.¹⁵ Following the introduction of the AMR-CQUIN, AMS leads at individual hospitals
82 anecdotally reported varying success in securing financial investment to support achieving
83 these quality improvements and expressed anxiety about achieving the antibiotic reductions
84 needed to meet the AMR-CQUIN. The aim of this study was to establish how the AMR-
85 CQUIN was perceived by the staff responsible for achieving it at individual hospitals,
86 evaluate to what extent trusts made funding available to achieve it and finally explore
87 whether these factors had an impact on hospitals achieving reductions in antibiotic
88 consumption.

89 **Methods**

90 A web-based survey (www.surveymonkey.com) was developed, piloted with three hospital
91 AMS leads and refined. The full survey is available in the supplementary materials. An email
92 invitation to participate was sent to AMS leads at acute hospital NHS trusts on Dec 8th, 2016.
93 The names and contact details used were compiled by one of the investigators (D-AO) as
94 part of network development within ESPAUR. The people contacted had agreed to
95 represent their organisations in communications with ESPAUR particularly related to the
96 AMR-CQUIN activities. The survey was voluntary, two reminders were sent to recipients
97 who didn't respond initially. No incentives were offered and there was no advertising of the
98 survey. The survey asked for information about: AMS team structures and activity, the
99 reductions needed to achieve each AMR-CQUIN component, whether funding was in place
100 to achieve this and perceptions about the AMR-CQUIN. The survey closed to respondents on
101 5th March 2017. Where more than one survey was submitted from a hospital, the survey
102 containing the greater number of completed fields was included. Any discordant answers
103 were checked with the submitting hospital before removing the duplicate survey. In
104 reporting the survey we have used the CHERRIES checklist for reporting results of Internet E-
105 Surveys.¹⁶ A completed checklist is available in the supplementary materials.

106 Hospital trust level data on antibiotic consumption were downloaded from ESPAUR using
107 data submitted by acute hospital NHS trusts since 2013 using a standardised spreadsheet
108 provided to organisations. Data extracted from the survey was analysed using SPSS Version
109 24 (IBM®, UK) and GraphPad Prism™. Categorical variables were compared using Fisher's
110 exact tests and continuous variables using the Wilcoxon signed-rank test. According to
111 current NHS Health Research Authority (HRA) guidance (available at www.hra.org.uk) ethical
112 approval was not required for this study as this was a service evaluation of NHS staff. All
113 antibiotic consumption data included was openly available.

114 **Results**

115 **AMS at hospital trusts included in the survey**

116 Responses were received from a total of 116/155 (75%) acute hospital trusts in England. The
117 majority of surveys were completed by the lead antimicrobial pharmacist (64/116 [55%]),
118 followed by another pharmacist (28/116 [24%]), the hospital lead-antimicrobial clinician
119 (22/116 [19%]) and in two cases the infection prevention control nurse (2/116 [2%]).

120 108/116 (94%) respondents reported their hospital had an AMS committee which met
121 quarterly or more often. AMS committees always included a microbiologist and
122 antimicrobial pharmacist. Additional committee members varied with representation from
123 acute medicine (78/116, 67%), surgery (64/116, 55%), paediatrics (49/116, 42%), intensive
124 care (42/116, 36%), infection prevention director (47/116, 41%) and clinical commissioners /
125 General Practice representatives (55/116, 47%). Microbiology / Infection trainee doctors
126 were on the AMS committee in only 27/116 (23%) trusts.

127 NICE guidance on AMS processes and systems had been considered at the AMS committee
128 in 108/116 (93%) trusts and 94/116 (81%) respondents reported completing the NICE AMS
129 baseline audit tool which helps identify areas to improve compliance with the guidance. A
130 total of 72/116 (62%) trusts had formally reviewed SSTF, a further 27/116 (23%) trusts had
131 informally reviewed SSTF and 64/116 (55.3%) had an action plan for its implementation.
132 Most respondents (105/116, 91%) reported that their trust had accessed the AMR Local
133 Indicators data on 'Fingertips' and this data has been shared with their AMS committee
134 (82/116, 71%), immediate colleagues (79/116, 68%), Trust Boards (37/116, 32%) or
135 commissioners (33/116, 28%). Only six respondents (5%) indicated data had been shared
136 with front-line clinical staff.

137 **Achieving the CQUIN measures**

138 Although the AMR-CQUIN aimed to achieve reductions of $\geq 1\%$ compared to baseline
139 (2013/14), in many trusts antibiotic consumption had continued to rise between 2013/2014
140 and the introduction of the AMR-CQUIN in April 2016. Consequently, most trusts needed to

141 achieve much larger reductions than $\geq 1\%$ in 2016/2017 compared with 2015/2016 (Table
142 1).

143 **Changes in antibiotic use after introduction of the AMR CQUIN**

144 Data gathered by ESPAUR from 130 acute hospital NHS trusts reporting annual data from
145 2013 onwards showed that increases in antibiotic use began to reverse in the 2015/2016
146 financial year, when trusts were first obliged to report usage data to ESPAUR (Figure 1). In
147 that year, small but statistically significant year-on-year reductions were measured for total
148 antibiotic use ($p < 0.0001$), piperacillin/tazobactam use ($p < 0.0001$) and carbapenem use
149 ($p = 0.05$). In the AMR-CQUIN year (ending March 2017) there was no evidence that total
150 antibiotic consumption changed compared to the previous year $+0.1\%$ ($-5.4, +4.0, p = 0.05$),
151 but there were substantial and statistically significant reductions in piperacillin/tazobactam
152 use of -4.8% ($-16.9, +3.2, p < 0.0001$) and carbapenem use of -8.0% ($-20.2, +4.0, p < 0.001$).
153 However, there was striking variation between trusts. Changes in antibiotic consumption in
154 2016/2017 compared to a baseline of 2013/2014 ranged from -43% to $+71\%$ for total
155 antibiotic use, -17% to $+72\%$ for piperacillin/tazobactam use and -79% to $+44\%$ for
156 carbapenem use.

157 Of the surveyed trusts participating in the AMR-CQUIN, 41/111 (37%) achieved the quality
158 measure for piperacillin/tazobactam, 61/111 (55%) for carbapenems and 48/111 (43%) for
159 total antibiotic use (Table 2) based on information reported to PHE. The median reduction in
160 antibiotic consumption compared to the 2013/2014 baseline achieved in those trusts
161 surveyed was -0.2% ($-11.9, +10.1$) for total antibiotic use, $+2.2\%$ ($-18.0, +18.3$) for
162 piperacillin/tazobactam and -7.8% ($-29.4, +12.1$) for carbapenems. The attitudes of AMS
163 leaders to the AMR-CQUIN or availability of additional trust funding were not associated
164 with achieving the CQUIN goals ($p > 0.3$, Table 2). Substantially more trusts achieved the
165 AMR-CQUIN where the survey respondents were optimistic about meeting the CQUIN
166 ($p < 0.0001$, Table 2).

167 **Funding towards achieving the CQUIN**

168 Five of the trusts surveyed reported a decision had been taken not to participate in the
169 AMR-CQUIN. A total of 68/116 (59%) trusts set out to meet the nationally set CQUIN

reductions. Within the remaining trusts, 43/116 had negotiated local variations in some (18/116, 16%) or all (25/116, 22%) of the components. Funding had been made available to support achieving the AMR-CQUIN at only 23/113 (20%) participating trusts. Even where funding was made available in 18/23 (78%) trusts, the funding amount was <10% of the overall AMR-CQUIN value.

Perceptions and achieving the CQUIN

At the time the survey was conducted, the AMR-CQUIN had been in place for approximately 6 months. Respondents were pessimistic about achieving the targets, and only a minority felt their trust would achieve the necessary reductions for piperacillin/tazobactam (31/116, 27%), carbapenems (42/116, 36%) and total antibiotic use (34/116, 29%). Exactly half of the respondents (58/116, 50%) agreed with the statement that the AMR-CQUIN had changed AMS activity in their trust and 35/116 (30%) felt the AMR-CQUIN would reduce antibiotic consumption. However, only 22/116 (19%) felt that it would do so safely. Accordingly, 82/116 (71%) respondents were interested in the possibility of participating in research to evaluate how to safely optimize antibiotic review and revise.

185 Discussion

186 Reducing unnecessary antibiotic use among hospitalised patients is challenging because the
187 need to ensure prompt effective empiric antibiotic treatment for patients with suspected
188 life-threatening infection, coupled with fear of antibiotic resistance, drives increased use of
189 the 'ultra-broad-spectrum' antibiotics that include piperacillin/tazobactam and
190 carbapenems that have been linked to AMR. In the UK, NHS 'Start Smart then Focus' (SSTF)
191 attempts to address this challenge by asking prescribers to regularly review and revise
192 empiric antibiotic prescriptions. Similar approaches are applied in other European Countries
193 ¹⁷and in the United States.¹⁸ Prescribers find review and revise is challenging.¹⁹ Without
194 robust measures to support it review and revise may not be effective in balancing drivers to
195 increase use of broad-spectrum antibiotics in hospitalised patients.²⁰ It is encouraging that
196 this survey has demonstrated not only a high level of awareness of NICE guidance and SSTF
197 but also that over half the trusts now have an action plan for SSTF (55.3%) compared with
198 46% in 2014.²¹

199 Our findings that most hospitals have multidisciplinary AMS teams, meeting regularly who
200 had considered the relevant NICE guidance and assessed their activity against it, all illustrate
201 how well AMS is embedded in NHS hospitals, as it is elsewhere in high-income settings
202 where regulatory measures are in force.²² We did not gather detailed data on adequate
203 staffing or specific action plans which have been highlighted as key gaps strategic needs in
204 AMS programmes.²³ We were focused on the impact of the specific AMR-CQUIN
205 intervention but our finding that so little new funding was made available even at trusts
206 which achieved their targets suggests increased staffing was not a key factor.

207 A starting point for our study was concern that pharmacists and microbiologists responsible
208 for AMS at individual hospitals doubted both the feasibility and safety of achieving the
209 reductions required to achieve the CQUIN goals. By surveying the staff responsible for
210 implementing AMS at acute trusts in England, we have determined that many staff did
211 indeed have significant concerns about whether the AMR-CQUIN could be safely
212 implemented. Although we did not explore the basis for concern, it is likely that prescribers
213 are worried that efforts to reduce unnecessary antibiotic use may increase the risk of under-
214 treatment of patients who need antibiotics. This is unsurprising given how few studies

215 assessing antimicrobial reduction strategies in hospitalised patients have included
216 meaningful clinical outcome data.²⁴

217 Many hospitals were confronted with needing to make much greater reductions in antibiotic
218 use in 2016/2017 to achieve a >1% reduction in antibiotic use, because of year-on-year
219 increases in antibiotic use from a baseline (2013/2014) set two years prior to the
220 introduction of the AMR-CQUIN. Consequently, several trusts either elected not to try and
221 achieve the goals as set out or, when they did, they were unwilling to allocate even a small
222 amount of the money they would lose for not achieving them, to improve stewardship
223 activity. Nevertheless, while neither concern about safety of the AMR-CQUIN nor lack of
224 financial investment to achieve it appear to have impacted on the AMR-CQUIN being
225 achieved, hospitals where staff were positive about its success were much more likely to
226 achieve the reductions in antibiotic use required.

227 Our finding that only around half the hospitals surveyed achieved the antibiotic reduction
228 targets is in striking contrast with the fact that ESPAUR data record that almost all trusts
229 achieved the CQUIN target of 90% antibiotic prescriptions being reviewed.¹⁴ However the
230 explanation for this is likely to be that review more commonly results in continuing or
231 changing treatment than discontinuation. ESPAUR data also report that only a small
232 minority of antibiotic prescriptions are stopped at review and revise (nationally an average
233 of 7.8% during the last quarter of the financial year 2016-17.¹⁴ This in keeping with how
234 hard prescribers find it to stop antibiotic prescriptions that have already been written.¹⁹
235 Despite this, our data confirm that antimicrobial use in English hospitals started to decline in
236 2015/2016, the year that commissioners were first required to report antibiotic prescribing
237 data from acute hospitals. This may be a 'Hawthorne effect', explained by an increased
238 awareness and modification of prescribing habits by trust staff due to an increase in data
239 collection in the year prior to the introduction of the quality improvement itself. While we
240 find no overall further reduction in antibiotic use in the year the AMR-CQUIN was
241 introduced, the marked reductions seen in piperacillin/tazobactam and carbapenem use
242 suggests a move away from these two 'ultra-broad-spectrum' agents to alternatives,
243 potentially increasing total antibiotic DDD by the use of more than one antibiotic.

244 Our study has limitations. Although the survey highlighted ongoing concern that the AMR-
245 CQUIN may not be able to safely reduce antibiotic consumption we did not collect detailed
246 information about the reasons for concerns. The survey was carried out six months after the
247 AMR-CQUIN had started, which may have influenced respondents' perceptions about
248 whether they would achieve the CQUIN. We sought a single response from each hospital
249 and did not quality control the responses but respondents attested their leadership role in
250 AMS at their trust and were asked to complete the survey in discussion with colleagues so
251 we believe responses are likely to be reliable. Finally, we were not able to extract detailed
252 information about the specific actions taken following introduction of the AMR-CQUIN
253 which may have allowed individual trusts to achieve reductions, nor whether the total
254 reductions resulted from shorter treatment durations or fewer patients being treated and
255 whether overall appropriateness of treatment improved. There is a need for future work to
256 understand these mechanisms better to support antibiotic optimization more widely.

257 Despite these limitations, our findings indicate that the AMR-CQUIN approach of setting
258 goals backed up by robust data gathering and reporting has helped hospitals achieve
259 reductions in antibiotic overuse. Positive staff attitudes rather than availability of new
260 funding are likely to have been important at hospitals which achieved the reduction goals.
261 Further efforts to improve review and revise decision making as a key element of hospital
262 AMS practice will need both evidence and novel tools to support clinical decision and
263 reassure staff that patient safety is not compromised when stopping unnecessary
264 antibiotics.

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351 **Table 1. Reductions in antibiotic use required to achieve the AMR-CQUIN targets.** Of those trusts surveyed, data was available for 107/116
 352 trusts for piperacillin/tazobactam and carbapenems and for 108/116 trusts for total antibiotic consumption.

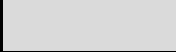
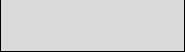
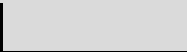
353

Antibiotic reductions needed to achieve AMR-CQUIN (%)	Piperacillin/tazobactam n=107 (%)	Carbapenems n=107 (%)	Total antibiotic ³⁵⁴ n=108 (%) 355
<1%	11 (10%)	23 (21%)	17 (16%)
1-5%	14 (13%)	14 (13%)	24 (22%)
5-10%	11 (10%)	8 (7%)	19 (18%)
10-20%	23 (21%)	15 (14%)	21 (19%)
>20%	25 (23%)	24 (22%)	5 (5%)
Not known	23 (21%)	23 (21%)	22 (20%)

356 **Table 2. Impact of funding and attitudes on Trusts achieving the AMR-CQUIN.** (a) 3 respondents did not answer this question. (b) 39
357 respondents were unsure whether the CQUIN would reduce antibiotic consumption and 13 did not answer this question. (c) 19 respondents
358 were unsure whether the CQUIN had changed AMS and 11 did not answer this question (d) 57 respondents were unsure whether the CQUIN
359 would safely reduce antibiotic consumption and 11 did not answer this question (e) In total 26, 28 and 29 respondents did not answer this
360 question for piperacillin/tazobactam, carbapenems and total antibiotics respectively.

	Piperacillin/tazobactam (n=109)			Carbapenems (n=109)			Total antibiotic (n=108)		
	Achieved n=41 (%)	Not Achieved n=68 (%)	p	Achieved n=61 (%)	Not Achieved n=48 (%)	p	Achieved n=48 (%)	Not Achieved n=60 (%)	p
Funding ^(a) available (n=23)	10 (24%)	13 (19%)	0.63	16 (26%)	7 (15%)	0.32	11 (23%)	12 (20%)	0.60
Funding not available (n=90)	30 (73%)	53 (78%)		43 (70%)	40 (83%)		36 (75%)	46 (77%)	
CQUIN will help reduce antibiotic consumption ^(b) (n =35)	16 (39%)	16 (24%)	0.34	18 (30%)	15 (31%)	0.94	14 (29%)	18 (30%)	0.96
CQUIN will not help reduce antibiotic consumption (n=29)	11 (27%)	16 (24%)		15 (25%)	12 (25%)		10 (21%)	17 (28%)	
CQUIN will change AMS ^(c)	21 (51%)	32 (47%)	0.84	22 (36%)	30 (63%)	0.42	30 (63%)	23 (38%)	0.53
CQUIN will not change AMS ^(c)	10 (24%)	17 (25%)		15 (25%)	12 (25%)		12 (25%)	15 (25%)	
CQUIN will safely reduce antibiotic consumption ^(d)	6 (15%)	14 (21%)	0.87	7 (11%)	13 (27%)	0.87	8 (17%)	12 (20%)	0.99
CQUIN will not safely reduce antibiotic consumption ^(d)	11 (27%)	13 (19%)		10 (16%)	14 (29%)		10 (21%)	14 (23%)	
Trust predicted that they would achieve CQUIN ^(e)	26 (63%)	2 (3%)	<0.0001*	40 (66%)	1 (2%)	<0.0001*	31 (65%)	1 (2%)	<0.0001*
Trust predicted that they	6 (15%)	53 (78%)		4 (6%)	42 (88%)		5 (10%)	48 (80%)	

would not achieve CQUIN ^(e)



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364 **Figure 1. Year-on-year changes in antibiotic use at acute hospitals in England.** Boxes show medians and quartiles, whiskers 5 and 95
365 percentiles. P values are Wilcoxon sign rank, 2-tailed.

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