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1 **Factors affecting dairy farmers' attitudes towards antimicrobial medicine usage in**

2 **cattle in England and Wales**

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10

11 **Abstract**

12 There has been growing concern about bacterial resistance to antimicrobials in the farmed

13 livestock sector. Attention has turned to sub-optimal use of antimicrobials as a driver of

14 resistance. Recent reviews have identified a lack of data on the pattern of antimicrobial use

15 as an impediment to the design of measures to tackle this growing problem. This paper

16 reports on a study that explored use of antibiotics by dairy farmers and factors influencing

17 their decision-making around this usage.

18 We found that respondents had either recently reduced their use of antibiotics, or planned to

19 do so. Advice from their veterinarian was instrumental in this. Over 70% thought reducing

20 antibiotic usage would be a good thing to do. The most influential source of information used

21 was their own veterinarian. Some 50% were unaware of the available guidelines on use in

22 cattle production. However, 97% thought it important to keep treatment records.

23   The Theory of Planned Behaviour was used to identify dairy farmers' drivers and barriers to

24   reduce use of antibiotics. Intention to reduce usage was weakly correlated with current and

25   past practice of antibiotic use, whilst the strongest driver was respondents' belief that their

26   social and advisory network would approve of them doing this. The higher the proportion of

27   income from milk production and the greater the chance of remaining in milk production, the

28   significantly higher the likelihood of farmers exhibiting positive intention to reduce antibiotic

29   usage. Such farmers may be more commercially minded than others and thus more cost-

30   conscious or, perhaps, more aware of possible future restrictions.

31   Strong correlation was found between farmers' perception of their social referents' beliefs

32   and farmers' intent to reduce antibiotic use. Policy makers should target these social

33   referents, especially veterinarians, with information on the benefits from, and the means to,

34   achieving reductions in antibiotic usage. Information on sub-optimal use of antibiotics as a

35   driver of resistance in dairy herds and in humans along with advice on best farm practice to

36   minimise risk of disease and ensure animal welfare, complemented with data on potential

37   cost savings from reduced antibiotic use would help improve poor practice.

39

1. Introduction

At a therapeutic level, antimicrobials are vital medicines for treatment and control of bacterial infections. However, there are increasing reports of resistance to antimicrobial drugs used in veterinary medicine and, also, concerns about the threat that may pose to both animal and human health, through the selection of resistance (WHO, 2000; Marshall et al., 2011; WHO, 2014a). Development of antimicrobial resistance also threatens to restrict the effectiveness of existing drugs used on farms and the treatment of veterinary bacterial pathogens.

There is increasing evidence that overuse and sub-optimal use of antimicrobials may be a factor in the development of bacterial resistance to veterinary antimicrobials (e.g. Barbosa and Levy, 2000). Antimicrobial stewardship is now internationally recognised as a challenge. A multifaceted approach – concerted effort between industry and government bodies and a variety of initiatives including alternatives to antibiotics and a better consumption recording system - is required to optimise the use of antibiotics (Prescott, 2014).

In response to these concerns, several countries (Denmark, France, the Netherlands and the UK) have developed strategies for monitoring incidents of bacterial resistance in farm animals, as a first step towards designing measures to reduce antimicrobial usage and for promoting prudent and responsible use of antimicrobials by farmers, farm staff and veterinarians (Anon, 2007; Anon, 2012a; Anon, 2013; Anon, 2014a; EPRUMA, 2008; Landers, 2012; Levy, 2014; OIE, 2013 and WHO, 2014b). In 2011, the European Commission (EC) launched a 5-year action plan, including 12 actions to tackle antimicrobial resistance covering areas such as 'development of new effective antimicrobials or alternative treatment', 'improving surveillance and monitoring in human and animal medicine' and 'making sure antimicrobials are used appropriately' (Anon, 2011).

In the UK, various guidance on best practice for the responsible use of antimicrobials in livestock is available to farmers and veterinarians such as that published by Responsible Use of Medicines in Agriculture (RUMA) alliance (RUMA, 2004). The British Veterinary

66 Association (BVA) has actively promoted responsible use of antimicrobials to veterinarians,

67 most notably by publishing a poster with a simple and effective 8-point plan (Anon 2009). In

68 2013, the UK Government published the 'UK Five Year Antimicrobial Resistance (AMR)

69 Strategy 2013 to 2018', in line with the 2011 EC strategy, which proposed actions to slow the

70 development and spread of AMR (Anon, 2013) and in 2014, the British Cattle Veterinary

71 Association published a poster on medicine residues in milk for farmers (BCVA, 2014). While

72 guidance documents have been published, there has been little or no assessment of the

73 impact of the recommendations on farming practices and on antimicrobial consumption.

74 Antibiotic sales for all food producing animals have remained relatively stable between 2008

75 and 2013 despite the guidance. Furthermore, recommendations on the appropriate first and

76 second antimicrobial treatments for specific conditions have been adopted in other European

77 countries (e.g. the Netherlands (Teale and Moulin, 2012) and Denmark (Pedersen et al.,

78 1999)) but not in the UK.

79 The Veterinary Medicinal Product Directive 2001/82/EC sets out the control on veterinary

80 medicines. This EC Directive provides the basis for UK controls which are applied through

81 the Veterinary Medicines Regulations. All veterinary medicines, including those containing

82 antibiotics, require authorisation before they are marketed or administered to animals. All

83 antibiotic veterinary medicines in the UK must be prescribed by a veterinarian. Routine

84 prophylactic use of antibiotics is not a recommended practice by the Veterinary Medicines

85 Directorate (VMD) in the UK (Anon., 2014c); and the prophylactic use of antibiotics at very

86 small doses in animal feed - better known as growth promotors - has been banned in the

87 European Union (EU) since 2006 (Regulation 1831/2003/EC on additives for use in animal

88 nutrition).

89 Nevertheless, how medicines are prescribed is down to the professional judgement of the

90 veterinarian which can be influenced by various factors. A study suggested that widely

91 differing patterns of antimicrobial usage exist between 10 European countries. These

92 patterns could not be explained by simple differences in animal species demographics which

93 suggests that other factors, such as farm management or social factors were involved

94 (Grave et al., 2010). The Heads of Medicines Agencies across the EU worked in

95 collaboration with the Federation of Veterinarians of Europe to explore antimicrobial

96 prescribing habits and influencing factors among veterinarians for food producing animals,

97 companion animals and equines (De Briyne et al., 2013). That survey confirmed that

98 veterinarians were most likely to prescribe antimicrobials following sensitivity test results but

99 also based on their experience and ease of use in the absence of test results. Similarly,

100 another study which looked at antimicrobial use in a companion animal teaching hospital in

101 Italy concluded that there was a need to improve procedures for antimicrobial prescription;

102 published guidelines with further implementation of policies of prudent prescriptions were

103 suggested (Escher et al., 2011).

104 Although veterinarians are usually responsible for choosing the appropriate antimicrobials for

105 treatments, choices may also be influenced by farmers' own opinions and needs based on,

106 for example, cost and profit margin, ease of medicine administration and withdrawal period

107 (De Briyne et al., 2013; Gibbons et al., 2013). Then, once prescribed, little is known on how

108 medicines are administered and managed by the farmers and whether alternative practices

109 are taken into consideration by the farmer to reduce reliance on antibiotics.

110 Until 2013, direct marketing of veterinary antimicrobials by animal health companies to

111 farmers was permitted in the UK, unlike in mainland Europe, where such advertising has

112 been banned since 2011 (Anon, 2012b), on the grounds that information supplied may not

113 be used or interpreted adequately by farmers. Indeed, in a study which explored farmers'

114 knowledge and attitudes towards antimicrobial usage in livestock, a lack of knowledge about

115 antimicrobials and bacterial resistance was highlighted (Friedman et al., 2007). For example,

116 it was found that farmers mostly relied on their own or a neighbour's experience rather than

117 scientific evidence or advice from their veterinarian to decide which treatment to adopt.

118　Though veterinarians were the main source of information, limited finances for expenditure

119　on veterinary support was a key barrier to seeking out antibiotic protocols (Friedman et al.,

120　2007). If factors other than those directly related to the effective treatment of disease (whilst

121　minimising the emergence of resistance) have a large impact on the eventual therapy

122　selected and subsequently applied, then these factors (e.g. marketing, price, availability,

123　neighbour's experience) are potentially an important issue to consider.

124　Clearly, legislation would over-ride any drivers and barriers but in the absence of legislation

125　to reduce antimicrobial usage the question remains:

126　　'What factors (knowledge, social, economic) could influence farmers' perceptions,

127　　attitudes and behaviours in participating in an animal health management programme

128　　relating to prudent usage of antimicrobials?'

129　To help ensure the responsible use of antimicrobials as a disease control measure on dairy

130　farms, further research is needed to understand farmers' and veterinarians' behaviour and

131　attitudes towards their use, and to identify which factors and motives are most important in

132　influencing current and proposed practice (Busani et al., 2004).

133　Understanding farmer attitudes and the factors that influence decision-making and the

134　translation of intentions into sustained changes in behaviour, is seen as an increasingly

135　useful discipline in policy making and health scheme implementation. The relatively small

136　scale survey described here is part of the larger Emerging and Major Infectious Diseases in

137　Animals (EMIDA) initiative. The overarching objective of the EMIDA project was to gain

138　insight into the determinants of behaviour that influence farmers' willingness to participate in

139　animal health management programmes. As a starting point, this pilot study aimed to: look

140　into the extent to which recommended guidance on responsible veterinary use of

141　antimicrobials in England and Wales is being followed by farmers; explore reasons why

142   deviations from prudent use by farmers may be occurring; and identify the factors influencing

143   farmers' decisions on antimicrobial usage.

144   **2.   Method**

145   **2.1   Procedure**

146   Data on farmer attitudes and behaviours connected with antimicrobial use were collected by

147   a postal survey of dairy farmers in England and Wales. The researchers developed a

148   questionnaire based on the Theory of Reasoned Action (TORA) and Theory of Planned

149   Behaviour (TPB) and relevant literature (e.g. Ajzen, 1991; Fishbein and Yzer, 2003; Garforth

150   *et al.*, 2006 and Garforth *et al.*, 2013). It was then piloted with 5 farmers.

151   The questionnaire had 7 sections with questions on: the farmer and their dairy enterprise;

152   use of antibiotics and attitudes towards use of antibiotics; and knowledge on guidelines for

153   their use. Attitudinal questions were framed on a 5-point Likert scale system, while a choice

154   of answers was provided for the socio-demographic questions.

155   The 8 page A4-size questionnaire was sent out in July 2013 with a covering letter explaining

156   the survey objectives with a reply-paid envelope. It went to 118 farmers who had agreed to

157   be involved in the research out of the 250 random sample of dairy farmers initially

158   approached to take part. Questionnaires in both English and Welsh were provided to farmers

159   in Wales. A copy of the questionnaire is available from the corresponding author. To

160   maximise response rate, a reminder letter with a duplicate copy of the questionnaire was

161   sent out in August 2013 and again in September 2013. The survey was closed on 30

162   September 2013.

163   **2.2   Survey representativeness**

164   Demographic characteristics were verified to ensure that the sample was representative of

165   the population from which it was drawn. Table 1 shows some characteristics of the

166   respondents and their dairy herds. Survey farmers were mostly (64%) over 50 years and

167   experienced with an average of 35.3 years working in the dairy industry. These

168   demographics compare well with official statistics which show that the mean age of farmers

169   in the UK in 2010 was 59 years old, with only 39% under 55 years old (Defra, 2013a).

170   The mean herd size of the respondents was 180 adult cows, while the England mean for

171   2013 was 134 (DairyCo, 2013). The mean yield of the respondents' cows was 7487 l/cow

172   and the mean price for their milk was 31.1 p/l; Defra (2013a) figures were 7445 l/cow and

173   28.1 p/l. Thus, for five measures, the survey sample matched dairy farmers overall well,

174   although the sample herd size was somewhat larger than the national average.

175   Survey non-response bias was assessed by comparing the observable characteristics of the

176   first 30% replying against those of the last 30% replying. When the comparison was made

177   for these measures, it was found that there were no statistically significant differences

178   between the 'early' and 'late' responders and that 'non-response' bias was unlikely to be

179   present. If there had been a significant difference it could have been concluded that those

180   not replying at all would be likely to be comparable to the 'late' responders (Armstrong and

181   Overton, 1977; Barclay et al., 2002; Groves, 2006; MacDonald et al., 2009).

182   **2.3   The theoretical model used**

183   To develop successful interventions to change particular behaviours, such as reducing

184   farmers' use of antibiotics, it was necessary to understand the determinants of that

185   behaviour. In recent years there has been more recognition of the usefulness of behavioural

186   theory in understanding the determinants of behaviour (e.g. Fishbein and Cappella, 2006).

187   While several behavioural theories have been developed, taken together they have shown

188   that only a few variables need to be taken into account in understanding, and even

189   predicting, a given behaviour (Fishbein, 2000). A model that brings together these variables,

190   capturing both internal (i.e. psychological) and external (e.g. cultural and population) factors

191   is TPB (Ajzen, 1991; Fishbein and Yzer, 2003).

192 The theory states that a person's 'intention' to perform a particular behaviour is the best

193 predictor of whether they actually do so. The theory also identifies three determinants that

194 influence the intention to perform a behaviour:

195 i)   attitude towards the expected outcome of the behaviour (Outcome Attitudes) i.e. what

196   they expect the outcome of their behaviour to be, and the value placed on it;

197 ii) beliefs about what valued others expect them to do in relation to the behaviour

198   (Normative Referents); and

199 iii) beliefs about their ability to implement the behaviour (Perceived Behavioural Control).

200 TPB suggests that more favourable attitudes towards the outcomes of the behaviour, more

201 favourable opinions of valued peers towards the behaviour, and greater perceived

202 behavioural control strengthen the intention to perform the behaviour.

203 The TPB framework allowed us to understand why some members of the target population

204 intended to undertake this behaviour and others not, through identification of the relative

205 influences of attitudes (towards reduced use of antibiotics), normative referents (opinions of

206 peers) and perceived behavioural control perceptions, as well as socio-demographic

207 characteristics, on behavioural intent (intent to reduce use of antibiotics in the next year). A

208 focus was made on the roles of the above as drivers and barriers to the development of this

209 intention. Once understood in this way, these drivers and barriers will inform the design of

210 messages and other interventions to impact well on this target behaviour.

211 **2.4   Statistical analysis**

212 Data were transcribed from the returned questionnaires to create an electronic Excel

213 dataset. Data quality checks were carried out to ensure correct data entry and accurate

214 transcription. Data analysis was carried out using SAS Version 9.3, SAS Inc., Rayleigh,

215   North Carolina, USA. The questionnaire elicited three types of information relating to

216   farmers' use of information to support their decisions on livestock disease control measures:

217   i)   frequency of use of the different sources;

218   ii)   a rank for the amount of information obtained from each source; and

219   iii) a rank for the value placed on the opinions of each source.

220   These information types were put into a combined measure of the broad level of influence (I)

221   of each source. First, the ranking of the amount of information provided ($\bar{x}a$) was weighted

222   by the value placed on each source ($\bar{x}b$). The product ($\bar{x}a.\bar{x}b$) was then weighted by the

223   frequency of nomination of each source (n) and then divided by the number in the sample

224   (N) to rebase to a zero to 25 rating scale. In equation form, the calculation was:

225    $$I_j = \frac{\left(\left(\bar{x}a_j \times \bar{x}b_j\right) \times n_j\right)}{N}$$

226   Where: I_j = Influence of source (j)

227   N = Total number in sample $(N=71)$

228   n = Number nominating source (j)

229                  $\bar{x}aj$ = Mean rank of amount of information supplied from source (j)

230                  $\bar{x}bj$ = Mean rank of value attached to source (j)

231   The questionnaire had no single direct measures for two of the behavioural components

232   traditionally used in TPB analysis i.e. outcome attitudes (OA) (beliefs about the outcomes of

233   reduction in antibiotic use) and perceived behavioural control (PC). These components were

234   measured indirectly via a suite of targeted questions. In the case of normative referents i.e.

235   subjective norms (SN), there was a candidate for direct measurement which was assessed

236   alongside a composite construction of the same component. Composite variables were

237   calculated for each of the components (OA, SN and PC) by summing the rank scores over

238   the contributing questions (i). All SN, and some PC, 5-point rank scores (b) were weighted

239   by a 5-point importance score (e) before aggregation, while all OA and some PC questions

240   were un-weighted.

241   Cronbach's Alpha was calculated to test the coherence of each of the three composite

242   components. A high Cronbach's Alpha (>0.6) indicated that the items contributing to a

243   measure, when summed, produced a coherent composite measure. Because of the variation

244   in the ranges of the TPB measures, the standardised Cronbach's Alpha Coefficient was

245   used. In each of the three composite TPB measures, even when coherence based on

246   available items exceeded 0.6, one or more of the contributing questions was deleted in order

247   to maximise coherence.

248   The coherence of each of the three composite components of behaviour are shown in Table

249   7. One or more of the contributing questions deleted from the analysis were included

250   individually in the correlation analyses reported below and are in italicised text in Table 9.

251   The TPB variables identified as correlated with intent were used with variables representing

252   farmers' socio-demographic characteristics in a regression model to predict intention (the

253   dependent variable) to reduce antibiotics use over the next 12 months. As the dependent

254   variable was based on an ordinal scale, and some of the independent variables had ordinal

255   or binary scales, a multivariate logistic regression was undertaken. Specifically, a

256   cumulative logit model was fitted using the SAS LOGISTIC procedure. Variables were

257   manually removed from the regression model where they yielded non-significant Maximum

258   Likelihood Estimates (MLE), beginning with the variable with the highest P>Chi Sq value.

259   This process was repeated until all remaining variables had significant MLEs.

260   **3.   Results**

261   **3.1   Descriptive measures of the respondents and their dairy herds**

262   Seventy one sufficiently completed responses were received (28.4% of those initially

263   approached). Only one spoilt questionnaire was returned and, thus, was excluded from the

264   dataset. Of the total sample of respondents of 71, 60 (85%) farmed conventionally with the

265   remaining 11 respondents being wholly, or largely, organic. Most respondents (80%) housed

266   their dairy cows for at least 6 months of the year. The mean total milk production was 1.17

267   million litres per farm per year with a range from 250,000 litres to 6.1 million litres.

268   The Rolling Somatic Cell Count for a 12 month period ranged widely from 65,000 per ml to

269   337,000 per ml with a mean of 186,708 per ml. The national mean for 2013 was 199,000

270   cells/ml (Anon., 2014). It can be concluded that the survey respondents had a marginally

271   better Somatic Cell Count than dairy farmers nationally.

272   All respondents had farm income sources other than from their dairy enterprise, with a third

273   deriving 25% of their farm income from non-dairy activities. The mean milk price obtained by

274   respondents at the time of survey was 31.1 pence per litre ranging from 24.7 to 38.0 pence

275   per litre. Some 30 different milk buyers were listed by the respondents with the most

276   common being: ARLA, Dairy Crest, First Milk, Mueller, OMSCO and Wiseman.

277   Membership of Assurance and Certification Schemes was common for survey farmers with

278   67 of the 71 belonging to at least one Scheme. Of respondents who were in an Assurance

279   Scheme, some 50% were required by that Scheme to act relating to antibiotic use.

280   Almost all (69) of the 71 respondents had a Herd Health Plan and, for the 48 who indicated

281   when it was last revised, the mean year was 2012; of these respondents, 58% stated when

282   they last consulted their plan, with a mean year of 2008. It was found that 7% had a routine

283   visit from their veterinarian weekly, 23% fortnightly, and 70% monthly or less.

284   Those surveyed were asked 'Looking ahead, how likely is it that your dairy enterprise will still

285   be operating in 5 years' time?'. This needs to be contextualised by figures in DairyCo (2013)

286   that showed a steady decline in the number of UK dairy herds over the last decade to less

287   than 10,000. Around 16% of respondents said they were either very unlikely or unlikely to be

288   still operating in 5 years' time, 8% said they were neither likely nor unlikely to be, whereas

289 69% said they were either likely or very likely to be still running their dairy enterprise in 5

290 years' time. The remaining 7% said they did not know what they would be doing.

291 Respondents were asked to indicate their highest level of educational attained. The most

292 commonly experienced type/level of education by 44% was 'Further education (agriculture

293 related)'. This is consistent with Defra (2013b) findings for farmers in the Farm Business

294 Survey. The proportion having a university degree in an agriculture related subject (26%)

295 was somewhat higher than that reported by Garforth et al. (2006) and Tranter et al. (2011).

296 **3.2   Current and future use of antibiotics**

297 Almost 59% of respondents reported that their antibiotic use was 'about the same as a year

298 ago' and 37% said 'less frequently than a year ago'. The reasons for the decline in the use of

299 antimicrobials were circumstantial, rather than planned i.e. a fall in the incidence of mastitis,

300 and drier weather leading to healthier cows and less lameness. In terms of intentions

301 regarding antibiotic usage over the next year, 42% said they strongly intended to reduce

302 antibiotics use, while 52% were neutral and only 6% were weakly motivated to do so.

303 Table 2 shows how respondents ranked these statements by their level of agreement where

304 the lower the mean ranking score, the higher their level of agreement with the statement.

305 The highest level of agreement was achieved with the statement about following best

306 practice in all aspects of antibiotic use and fully recording such use.

307 For the other eight statements there was more variation in responses. For example, there

308 was little agreement on whether 'The use of antibiotics in dairy herds leads to antibiotic

309 resistance in dairy cows' (mean ranking score: 2.78) and 'Preventative use of antibiotics in

310 the dairy herd helps me meet production goals' (mean ranking score: 3.03). Whilst only 6%

311 agreed that antibiotic usage in dairy farming was a major cause of antibiotic resistance in

312 humans, 22% agreed that 'If every dairy farmer followed best practice, there would be less

13

313 resistance to antibiotics in the human population'. Nevertheless, 68% agreed that human

314 infections resistant to antibiotics were a serious problem (mean ranking score: 2.26).

315 Almost 60% of the respondents agreed with the two resource-use based statements - 'If all

316 dairy farmers followed best practice in the use of antibiotics, overall use of antibiotics would

317 fall' and 'Antibiotics are expensive and I minimise usage to reduce costs' - although, with the

318 second of these statements, 25% disagreed, implying that cost was not a factor in how they

319 used antibiotics. Finally, 55% seemed not to ask advice from their veterinarian before using

320 antibiotics on their cows, with just 17% doing so (mean ranking score: 3.42). This implies,

321 possibly, that farmers used antibiotics, from time to time, from those 'held back' from

322 previous prescriptions as a perceived way of saving money and such 'under-dosing' is an

323 important risk factor for antibiotic resistance.

324 To gauge respondents' current antibiotics use practice, they were presented with a set of 12

325 health problem scenarios that might occur in a dairy herd and asked how likely or unlikely

326 (on a 5 point scale) they would be to use antibiotics in the next year to treat them. This

327 allowed a more comprehensive review of practices, rather than one limited to recent

328 personal experience. Table 3 summarises respondents' answers. Farmers were more likely

329 to use antibiotics for some health conditions than others, with the most likely being: 'Clinical

330 mastitis with watery milk' (90% of the respondents); 'Calf pneumonia' (89%); and 'Clinical

331 mastitis clots' (83%). In contrast, the health problem scenarios that they were least likely to

332 use antibiotics for were: 'High cell count cows and cows with repeated cases of clinical

333 mastitis' (71%); 'digital dermatitis' (71%); and 'Lame cow before trimming' (67%).

334 **3.3   Attitudes towards use of antibiotics in their dairy herds**

335 Just over 70% of respondents agreed with the statement that 'Reducing the use of

336 antibiotics in my dairy herd over the next year would be a good thing to do' with only 6%

337 disagreeing with it. Around 58% agreed that 'People I respect in the industry would approve

338 of my reducing the use of antibiotics in my herd over the next year'.

339 Nearly 59% of respondents said they had the skills and knowledge needed to reduce

340 antibiotics use in their herds in future, whilst 39% were not sure. Almost 32% agreed that

341 'Reducing the use of antibiotics in my dairy herd over the next year would be difficult to

342 achieve' but 19% disagreed with this statement and the remaining 49% were not sure.

343 Table 4 shows why farmers thought it would be good to reduce antibiotic usage in their herd.

344 The most cited benefit was cost reduction (64% of respondents). Only 18% thought that milk

345 output would decline, and 15% thought it would decrease resistance in the human

346 population if farmers reduced their antimicrobial usage, but there was a high level of

347 uncertainty on the impact on the health of their cows (56% unsure). When asked whether

348 reductions in antibiotic usage would lead to loss of animal welfare, there was a fairly even

349 spread of responses with 27% agreeing, 37% disagreeing and 36% being unsure. There

350 was considerable uncertainty in relation to health, however, with 56% not sure and 20%

351 believing that health would be worse. There was also much uncertainty over whether

352 reducing antibiotic use would reduce the incidence of bacterial antibiotic resistance with 45%

353 uncertain and 18% believing that this benefit would not be delivered.

354 Farmers were asked to rank a list of business and management outcomes in terms of their

355 importance to assess a range of motivations and goals that underpin their business

356 decisions (Table 5). Dairy enterprise profitability, and animal health and welfare, were highly

357 important drivers of farmer decision-making, with cost minimisation close behind. In addition,

358 quite highly rated was concern that consumers remained confident in milk safety, as this

359 underpinned the marketability of milk and the price obtained. Relative to these concerns, the

360 issue of antibiotic resistance was viewed as of lesser importance, especially in connection

361 with such resistance in humans. This may be a reflection of the farmers' view of these being

362 issues over which they had little direct control.

363 **3.4   Sources of information used to inform disease control**

364 Farmers looked to a range of different people and organisations for advice on farming

365 matters including on the use of antibiotics in dairy herds. Respondents were, therefore,

366 asked the extent to which these social referents would approve of them reducing their use of

367 antibiotics over the next year. The results are summarised in Table 6.

368 Few farmers thought that any of their social referents would disapprove of them reducing

369 their use of antibiotics in the next year except for 14% of respondents who thought their

370 private veterinarian would. However, there was variation in the perceived level of approval.

371 Based on approval ratings, the social referents were divided into two groups. The higher

372 approval group was the end users, or consumers, of the milk produced (milk buyer and retail

373 consumer) whereas the lower approval group was the industry or peers (family, other

374 farmers and the NFU). Private veterinarians fell between these two groups.

375 The most influential source of information on antimicrobial use was farmers' own veterinarian

376 (Figure 1). Indeed, veterinary source scores were close to the theoretical upper maximum

377 possible for this measure. As all respondents scored this source highly, there was little

378 variation in appreciation of the source across sub-groups in the sample.

379 **3.5   Knowledge of guidelines on use of antibiotics**

380 Around 53% reported some level of awareness of the RUMA (2004) guidelines on use of

381 antimicrobials in cattle production, but half of these admitted to an incomplete knowledge.

382 For those aware of the guidelines, 36% followed the guidelines fully, 39% partially followed

383 them and 25% remembered the broad outline of the details only.

384 Those not aware of the RUMA (2004) guidelines were further questioned to determine the

385 extent to which they unwittingly followed the guidelines. This revealed that 89% agreed that

386 it is important to have written protocols for administering antibiotics to minimise mistakes,

387 even though 70% thought this was time-consuming and just 31% said they always consulted

388 their veterinarian if they had left-over antibiotics they wanted to use.

389 Some 80% of respondents always finished the prescribed course of antibiotics even if their

390 animals stopped showing signs of illness, while 14% modified the dosage either for

391 convenience or because the animals did not respond as expected. As many as 96% agreed

392 with the statement 'I always store medicine in the required conditions'. Around 97% agreed

393 with the statement 'It is important to keep treatment records'. Despite this, it should be

394 acknowledged that there might be a gap between what respondents said they will do and

395 what they actually do, the so-called social desirability bias (Crowne and Marlow, 1960).

396 Respondents were asked whether they were aware of concerns about inappropriate use of

397 third and fourth generation cephalosporins leading to increased antibiotic resistance in both

398 people and animals: 66% were aware. Level of awareness of the issues was not correlated

399 to attitudes to first use of cephalosporins in the treatment of a range of conditions, with

400 exception of 'a lame cow before hoof trimming'. In this case, there was a significant positive

401 correlation ($P \leq 0.0168$) suggesting that higher levels of awareness resulted in a lower

402 likelihood of cephalosporins use as a first choice for treatment. A follow-on question asked

403 whether they agreed or not that cephalosporins should not be used for preventative

404 treatments in healthy animals: 48% agreed, 32% were neutral and 20% disagreed.

405 **3.6   Intention to use antibiotics using the TPB framework**

406 Correlation of 'intention' measures revealed a strong positive linear relationship (Spearman's

407 Rho=0.477, P<0.0001) which suggested that combining them would add little, if any, new

408 information. For the purpose of this analysis therefore, the single measure of strength of

409 personal intent to reduce antibiotic usage was employed as the dependent variable.

410 Intention to reduce antibiotic usage was only very weakly correlated with a number of

411 variables capturing current antibiotic use practice as measured by monetary expenditure on

412 antibiotics (Pearson's Rho=0.186, p=0.2994), and recent changes in the frequency of

413 antibiotic use (Spearman's Rho=0.142, p=0.2401). These variables were, therefore,

414 excluded from further analysis of the drivers of intention to reduce usage of antibiotics.

415 Correlation analysis showed that, of the three composite measures, only the OA measure

416 had any significant relationship to intent. In light of this, the composite SN measure was

417 dropped and the single direct measure was substituted, as this variable was seen to be

418 correlated with intent. This SN measure was based on the following question, with elicited

419 responses ranked on a 5-point Likert scale:

420   'People I respect in the industry would approve of my reducing the use of antibiotics in my

421   herd over the next year.'

422 Figure 2 shows the correlations between the OA, SN (single question direct measure), and

423 perceived behavioural control measures with intention to reduce use of antibiotics. Because

424 intention is reflected using an ordinal scale, Spearman's Rho statistics (r_s) were generated to

425 help decide which variable to keep for further analysis. Both OA and SN were seen to be

426 positively and significantly correlated with intention, while perceived behavioural control was

427 not significantly correlated.

428 As shown in Figure 2, OA were positively correlated with SN, but uncorrelated with

429 perceived behavioural control (Table 8). As only the OA variable showed significant

430 correlation with intent, intent was correlated with individual OA questions only. A significant

431 positive correlation between an attitude question and intention indicated a cognitive driver

432 and a significant negative correlation indicated a cognitive barrier. Table 9 shows that just 4

433 of the 13 attitudinal questions (i.e. attitudes to perceived outcomes of reducing antibiotic use)

434 were significantly correlated with intent, with only three showing relatively strong

435 associations (i.e. r_s values of near 0.3 or greater) being:

436 i) 'Reduced use of antibiotics in my herd over the next year would be a good thing to do';

437 ii) 'Reduced use of antibiotics over the next year would lower my costs'; and

438 iii) 'Reduced use of antibiotics over the next year would increase consumer confidence in

439   the safety of milk and milk products'.

440 It is noteworthy that the questions correlating most strongly with intent were based on

441 outcomes specific to the issue of reduced use of antibiotics in the respondent's herd, rather

442 than issues related to the use of antibiotics in livestock production more generally. It should

443 be noted that the lower the mean ranking score attached to each question in Table 9, the

444 stronger respondents' agreement with the proposition contained in that question.

445 The regression model results used to predict intention to reduce antibiotics use are shown in

446 Table 10. It can be seen that while some individual OA measures were significantly

447 correlated with intent, the predictive power of the composite measure was only borderline

448 statistically significant and other variables were better predictors. The single directly

449 measured SN measure was the most significant predictor of intent to reduce antibiotic use.

450 The negatively signed estimate suggests that for every 1 unit decline in rank score on the

451 SN measure, there was a 1.44 decline in intention rank (where 1=strong agreement with

452 intention and 5=strong disagreement with intention). Because lower scores mean higher

453 intention and greater agreement, the signs must be reversed when interpreting the results

454 i.e. the opinions of respected peers were seen to be a strong positive driver of intent to

455 reduce antibiotic use.

456 A list of 31 socio-demographic variables were tested in the regression model, with three of

457 these proving to be significant predictors of intent: the proportion of farm income derived

458 from the dairy enterprise; the likelihood of still being in dairy production in five years; and the

459 importance of increased consumer confidence in the safety of milk and milk products. This

460 latter question captured a background business-related attitude i.e. the importance, to the

461 respondent, of increasing public confidence in milk safety in the coming year. In the context

462 of reduced use of antibiotics, respondents may have understood this statement in two ways.

463 First, that reducing antibiotics use might increase consumer confidence by reducing potential

464 antibiotic residues in milk. Second, that reduced use of antibiotics might decrease consumer

465 confidence as it could be associated with higher disease risks in dairy herds. Reversing the

466 sign on the MLE estimate for this variable (Table 10) showed that increased intent was

467 associated with a decrease in concern over consumer perceptions of milk safety.

4. Discussion and conclusion

469 This paper reports on how we used the well-established social psychology TPB to explore

470 the drivers and barriers that existed to intention to reduce antibiotic use among dairy farmers

471 in England and Wales. The analysis was based on 71 dairy farmers, around 0.75% of the

472 target population, a sample size considered large enough, relative to the size of the

473 population, to provide an acceptable confidence interval. On all but one of the measured

474 dimensions, the sample was very representative of the industry, providing confidence in the

475 generalizability of the survey results. The exception to this was herd size. While a random

476 sample draw was the objective, some well-understood self-selection bias towards larger

477 producers was inevitable and has occurred. However, this over-representation of larger

478 herds on the representativeness of the sample is lessened significantly by current re-

479 structuring trends in the UK dairy sector, with producer numbers falling heavily each year

480 and average herd sizes rising. The self-selection bias seen in the sample, therefore,

481 provided some measure of future-proofing for the survey results for two reasons. First,

482 because those with larger farms, who enjoy economies of scale, are more likely to remain in

483 farming than their smaller counterparts and, second, as time passes, the more

484 representative of farming the sample will become.

485 Animal health and welfare issues were of great importance to the survey dairy farmers,

486 ranking equal to the profitability of their dairy enterprise amongst their business goals. In

487 terms of treatments for animal health problems, farmers were prepared to purchase

488 antibiotics as necessary. Almost all the sample had a recent Herd Health Plan, although

489 these would only be useful in disease prevention if farmers actually used them.

490 There was some indication from the survey responses that use of antibiotics for clinical

491 mastitis and calf pneumonia had reached a limit as over 70% of the respondents thought

492   that reducing antibiotic use in their dairy herds would be a good thing to do. However, whilst

493   farmers were well aware of concerns about antibiotic resistance in cows and humans, their

494   primary motivation for wanting to reduce use of antibiotics was not to reduce the risk of

495   bacterial resistance but, rather, to save on medicine costs to their business.

496   Around 30% of respondents were not aware of concerns about the use of third and fourth

497   generation cephalosporins leading to increased antibiotic resistance in bacteria in both

498   people and animals. Whilst 90% of respondents believed they followed best practice, almost

499   50% were not aware of the RUMA guidelines on use of antimicrobials in cattle production;

500   most farmers reported applying good practices and 14% admitted modifying the advised

501   dosage. Just over 80% of respondents said they always finished the prescribed course of

502   antibiotics and almost all thought it was important to keep treatment records.

503   Most farmers (60%) believed that they already had the necessary skills to successfully

504   reduce their use of antibiotics. The most influential source farmers used to help them make

505   decisions on controlling and treating livestock disease was their own veterinarian. As almost

506   70% of respondents believed that their veterinarians would approve of them reducing future

507   antibiotic usage, this strongly suggests that there is a positive advisory environment to

508   achieving this goal. However, this should not be taken to mean that veterinarians, as the key

509   advisory source, were necessarily advising this course of action.

510   There was a clear suggestion that around half of all respondents had either recently reduced

511   their level of antibiotic usage, or were planning to do so. Whilst the reasons behind this were

512   not elicited directly, some assumptions can be made based on respondents' beliefs and

513   attitudes towards antibiotic usage. Whether such reduction was circumstantial or planned, is

514   not clear. Nevertheless, before accepting this statistic as final, some thought should be

515   given to the issue of the 'value action gap'. The Theory of Reasoned Action states that

516   behaviours are shaped by attitudes towards those behaviours, subject to social norms

517   (Fishbein and Ajzen, 1975). On this basis, attitudes towards reducing antibiotics and stated

518   intention use should be a good indicator of actual buying practice. However, numerous

519   researchers have identified a difference between the values derived from consumer attitudes

520   and behavioural intentions and actual behaviour (see, for example, Barr, 2004; Blake, 1999;

521   and Lane and Porter, 2007).   To the extent that societal pressure exists to reduce antibiotic

522   use in livestock production, it is safe to assume that the effects of social desirability bias will

523   be experienced here and so the percentage of farmers who stated an intention to reduce

524   antibiotic use in the next 12 months should be treated as an upper estimate.

525   The relationship between personal attitudes and the perceived attitudes of peers need not

526   necessarily mean a causal relationship as positive attitudes towards the outcomes of

527   reducing antimicrobial use, if they are well attested, will be shared with peers. The lack of

528   significant correlation between own attitude, or attitudes of peers, and perceived behavioural

529   control implies that farmers' perception of whether they can achieve reduced antibiotic usage

530   are not completely influenced by their perceptions of the value of the outcome.

531   Statistical analysis showed that intention to reduce future antibiotic use was only very weakly

532   correlated with current and past antibiotic use practice, whilst the strongest driver appeared

533   to be respondents' belief that their social and advisory network would approve of them doing

534   this. Desire to reduce costs, where this would not impair the health and welfare of their

535   stock, was also found to be a strong driver. Wider societal concerns about inappropriate

536   antibiotics use appeared to resonate with the survey farmers in terms of public confidence in

537   the safety of the milk they produced i.e. in terms of risk to the viability of their business. This

538   outcome makes perfect sense if respondents assumed that consumers associate reduced

539   antibiotic use with increased disease risk and, therefore, decreased milk safety. It is also

540   reasonable, here, that respondents who were least motivated by consumer concerns over

541   milk safety would have fewer qualms about the effect that reduced antibiotic use would have

542   on consumer opinion. However, the way in which respondents interpreted this question

543   about consumer confidence in milk is unclear, because use of antibiotics might have been

544   seen as both creating a health risk (due to antibiotic residues in milk) and reducing health

545   risk (by reducing disease incidence in lactating cows). The value of this socio-economic

546   variable in explaining farmers' attitudes to reducing antibiotic use may be, therefore,

547   somewhat impaired. In this case, it might be appropriate to introduce a 'benchmark' figure so

548   that farmers can compare themselves with others. This business sustainability imperative is

549   also reflected in the socio-economic variables identified as best predictors of intention to

550   reduce the use of antibiotics over the next year i.e. the proportion of farm income from milk

551   production, and the stated likelihood of farmers remaining in such production. The higher the

552   scores on these variables, the greater was the likelihood of positive intention to reduce

553   antibiotic usage, suggesting that those with firm intent to remain in milk production wanted to

554   avoid 'problems' in the years ahead.

555   **5.   Recommendations for policy**

556   It has been seen above that farmers most likely to reduce antibiotic use were those who

557   derived a higher than average share of farm income from the dairy enterprise and were

558   planning to continue operating a profitable dairy enterprise for the foreseeable future (i.e.

559   have no immediate retirement plans). They were aware of, and concerned about, both the

560   risk of misuse of antibiotics in causing antibiotic resistance in the dairy herd and also in the

561   human population as well as consumer concerns about antibiotic residues in milk. They held

562   the belief that, undertaken correctly, reductions in use of antibiotics could yield financial

563   benefits to them, primarily in the form of reduced costs, without affecting the animal welfare

564   of their dairy cows or their herds' milk output.

565   The strong correlation between farmer perception of the beliefs of social referents and intent

566   to reduce antibiotic use, strongly suggests that policy makers should target these advisory

567   groups and institutions with information on the means to achieving reductions in antibiotic

568   use. Amongst these dairy industry social referents, priority should be given to veterinarians

569   who were found to be, by far, the most influential bearing in mind that the majority of the

570   respondents (71%) met with their veterinarian monthly or more frequently. The information

571   that needs to be supplied to farmers would include: the role that sub-optimal use of

572   antibiotics has in causing antibiotic resistance; advice on best practice in antibiotic use i.e.

573   specific management actions or alternative treatments that would permit reductions in

574   antibiotic use without financial losses; data on cost savings that might be obtained from

575   reduced antibiotic use; and assurance that there are low risks to animal welfare from

576   reduced antibiotic use. Care will need to be taken as to how this information is provided to

577   dairy farmers as not all of them will be amenable to electronic communication. With the

578   absence of a publicly-funded advisory service, postal delivery of hard-copy brochures may

579   well be appropriate.

584

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