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Public understanding and use of antibiotics in England: findings from a household survey in 2017

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ABSTRACT

Objectives To describe public understanding and use of antibiotics.

Design Ipsos MORI Capibus survey of randomly-selected households.

Setting England, January–April 2017.

Participants 2283 adults (≥15 years) including 777 parents of children <5 years old.

Data collection and analysis The main survey was undertaken in January 2017 (n=1691); data from an additional sample of parents were collected in April 2017 (n=592). Analyses were weighted to obtain estimates representative of the population.

Main outcome measures Responses to questions about antibiotics (awareness and perceptions), recent illness (expectations and experience), delayed and leftover antibiotics, and child illness stratified by demographic and socioeconomic characteristics.

Results Most respondents (83% (1404/1691)) recognised that antibiotics kill bacteria/treat bacterial infections, but a sizeable minority (35% (592/1691)) thought that antibiotics kill viruses/treat viral infections. Overall levels of understanding have not changed substantially since similar surveys in 2003 and 2008/2009. One sixth of respondents who were prescribed antibiotics reported having leftovers (14% (64/498)) and 33% (22/64) kept these for possible future use. 1.3% of all respondents (23/1691) reported taking left-over antibiotics in the past year and 1.6% (26/1691) reported taking antibiotics obtained without a prescription. Higher social grade and educational qualifications were strongly positively associated with antibiotic knowledge; youngest (15–24 years), oldest (65 +years) and black, Asian and minority ethnic adults were less knowledgeable. Among 1319 respondents who had an infection or antibiotics within the past year, 43% (568/1319) said that they had not received any advice or information about antibiotics.

Conclusions Despite many campaigns, public understanding of antibiotics in England continues to combine correct basic knowledge held by most people with less prevalent but persistent and potentially harmful misunderstandings. These could be addressed through active provision of advice and information during primary and secondary care consultations and more effective public health interventions.

Strengths and limitations of this study

- Data were collected using well-established survey methodology yielding a representative sample of the population in England.
- Public surveys on the theme of antibiotics using the same methodology have been conducted several times since 2003.
- Some survey interviewers can conduct interviews in other languages, but translation is not routinely offered.
- Some of the survey questions require respondents to recall events during the past 12 months.
- Potentially sensitive questions for example, asking about antibiotics obtained via the internet, might underestimate such practices.

INTRODUCTION

The first of ten interventions recommended by the Review on Antimicrobial Resistance commissioned by the UK Government in 2014 was a sustained public awareness campaign to provide knowledge about antimicrobial resistance (AMR) and support positive behaviour change related to antibiotic use.[1] Yet, despite global initiatives such as WHO World Antibiotic Awareness Week, European Union initiatives such as e-Bug school and community resources and national campaigns such as Public Health England's (PHE) 'Keep Antibiotics Working', a recent assessment by the All-Party Parliamentary Group (APPG) on Antibiotics concluded that, while the UK and many EU member states had been successful in implementing AMR strategies, education and awareness about antimicrobial use and AMR was one of three key areas with scant evidence of progress.[2] The APPG suggested that this could be due partly to an absence of outcome measures for raising awareness.

A series of nationwide household surveys conducted by PHE generated several important findings, including: (2003) an inverse association between greater knowledge and more prudent use of antibiotics, with more highly educated people being more likely to keep leftover antibiotics for future use[3 4]; ineffectiveness of national

campaigns (2008 and 2009)[5] and poor completion rates among people prescribed antibiotics for respiratory tract (2011)[6] and urinary tract infections (2014).[7] Prescription of delayed antibiotics has been encouraged in UK clinical guidelines for the management of respiratory tract infections since 2008.[8] The 2014 survey found that only 17% of people understood the term 'delayed antibiotic', less than 40% were in favour of them and only 15% of those prescribed an antibiotic in the past year were offered one, suggesting a need to increase public awareness and General Practitioner prescribing of delayed antibiotics.[9]

Here we report the findings of our most recent (2017) national household survey, describing current public knowledge and recent use of antibiotics, including delayed antibiotics and awareness among parents of young children. We have compared responses with those obtained in previous surveys, to determine whether there have been any changes over the last 3 years.

METHODS

Survey design and conduct

The main survey was conducted between 24 January and 5 February 2017, using multistage sampling to recruit 1691 adults aged 15+ from across England for face-to-face interviews in their own home. A subset of data (only questions pertaining to children) from an additional sample (n=592) of parents of children under 5 years old was collected between 6 and 19 March 2017. The interviews were computer assisted, that is answers were entered immediately onto the computer during the interview. A market research company, Ipsos MORI, conducted the interviews as part of their weekly Face-to-Face Omnibus (Capibus) survey that collects a wide range of information from across the country in a single week (see www.ipsos.com/ipsos-mori/en-uk/face-face-omnibus-capibus). Ipsos MORI Capibus uses a controlled form of random location sampling in a two-stage sampling process. The initial sampling frame is a bespoke amalgamation of output areas (OA, used for output from the Census in Great Britain) which are regrouped into primary sampling units (PSUs) taking account of their A Classification Of Residential Neighbourhood (ACORN) characteristics. A total of 170–180 of these PSUs are randomly selected from the stratified groupings with probability of selection proportional to size. The use of ACORN ensures all types of area are fully represented and that selection of respondents is largely taken out of the hands of the interviewers, helping to eliminate any possible bias in the sample caused by interviewing people all with the same background. At the second stage, typically two adjacent OA, made up of about 125 addresses each, are randomly selected from each PSU. Interviewers are given age and gender, household tenure and working status quotas of respondents for each sample point. Fieldwork times and quotas are set to control for likelihood of being at home (based on age, working status and gender). Interviewers go door-to-door and invite people who are at home and are over 15 years old to participate (the interview does not proceed if the respondent falls within a filled quota). Interviewers do not revisit non-responding households. One interview is completed on average for every 3–4 doors knocked.

Box 1 New questions asked in 2017 about antibiotic resistance (with correct answers)

- Q1. People can carry antibiotic resistant bacteria for over a year (true)
- Q2. Antibiotics don't work for everything (true)
- Q3. Taking antibiotics when you don't need them encourages bacteria that live inside you to become resistant (true)
- Q4. Antibiotic resistance is not caused by taking antibiotics (false)
- Q5. If you have taken antibiotics recently and then have a new infection, antibiotics are more likely to work on this new infection (false)
- Q6. All antibiotic resistant bacteria are harmful (false)
- Q7. Antibiotics work for colds or flu because they're viral infections (false)
- Q8. We can carry antibiotic resistant bacteria in our bodies without knowing (true)

Questionnaire

The interview schedule was based on previously-published PHE public surveys about antibiotics and delayed prescribing.[3–7 9] To facilitate comparison with previous surveys, many of the questions were asked in an identical manner. Computer-assisted interviewing ensures that the questionnaire is followed correctly for all respondents. Partially-completed interviews, for example, if the respondent ended the survey because it was taking longer than they had anticipated, are excluded. One new questionnaire item exploring antibiotic resistance and its relationship to antibiotic use was added (box 1). This item comprised eight statements covering a range of concepts where we know that the public have some misunderstanding. Participants were asked to indicate whether they agreed/disagreed with the statements, or thought that statements were true/not true, with possible responses: strongly agree/definitely true; tend to agree/probably true; neither agree nor disagree/don't know; tend to disagree/probably not true; strongly disagree/definitely not true. The statements were randomly ordered, and the response scale was reversed for half of respondents.

Patient and public involvement

All questions in the current and previous household surveys were developed in collaboration with GPs, non-healthcare advisors, PHE's marketing team and Ipsos MORI's health questionnaire team, and were piloted by the PHE Peoples' Panel.

Data analysis

Weights provided by Ipsos MORI were used to correct for known selection biases. Capibus uses a Random Iterative Method weighting system which weights to the latest set of census data or mid-year estimates and National

Readership Survey profiles for age, social grade, region and working status, within gender and additional profiles on tenure and ethnicity. Pearson's χ^2 test corrected for survey design[10] was used to test for differences in proportions across levels of categorical variables and between responses to identical questions in the current and 2014 survey (which used the same survey methodology).[9 11] Logistic regression was used to explore factors independently associated with knowledge about antibiotic resistance and its relationship to antibiotic use by creating a binary outcome variable indicating seven or more correct responses (an arbitrary cut-off) to a set of nine questions comprising the eight questions in box 1 plus the question 'What do you think an antibiotic is?' (correct response = 'they fight bacteria/infections/bacterial infections'). Unweighted frequencies and weighted percentages are shown for all results. Stata was used for all analyses (StataCorp 2017 Stata Statistical Software: Release 15).

RESULTS

Data were available from the 2017 survey for 2283 adult respondents, including 777 parents of children under 5 years old (all results reported below and in tables show unweighted frequencies). Representativeness of the main survey sample against the general population is summarised in online supplementary table S1.

Awareness and perceptions

Responses to questions about antibiotics and antibiotic resistance showed some changes in knowledge compared with 2014, including more people understanding that antibiotics work for bacterial but not viral infections (table 1). In broad terms though, levels of understanding had not changed substantially over the past 14 years, as indicated by survey results from 2003 and 2008/2009 (although questions in these earlier surveys were not directly comparable with 2014 and 2017). For example, although a majority (72%–83%) of respondents between 2003 and 2017

Table 1 Trends in awareness and perceptions about antibiotics and resistance (2003–2017)

Question (response)	2003 (n=3080)	2008 (n=1706)	2009 (n=1707)	2014 (n=1625)	2017 (n=1691)
Antibiotics can kill bacteria (agree/strongly agree)	80%	72%	72%	–	–
Which of the following conditions, if any, do you think can be effectively treated by antibiotics? (bacterial infections)	–	–	–	77%	83%†
Antibiotics can kill viruses (agree/strongly agree)	43%	41%	39%	–	–
Which of the following conditions, if any, do you think can be effectively treated by antibiotics? (viral infections)	–	–	–	40%	35%*
Antibiotics work on most coughs and colds (agree/strongly agree)	32%	30%	27%	–	–
Which of the following conditions, if any, do you think can be effectively treated by antibiotics? (colds or influenza)	–	–	–	14%	15%
Most coughs, colds and sore throats get better on their own without the need for antibiotics (strongly agree)	–	–	–	49%	52%
A course of antibiotics should be stopped when a person feels better (agree/strongly agree)	–	24%	20%	–	–
You don't need to finish a course of antibiotics if you are feeling better (tend to agree/strongly agree)	–	–	–	13%	13%
I trust my GP's advice as to whether I need antibiotics or not (tend to agree/strongly agree)	–	–	–	88%	85%*
I trust my nurse's advice as to whether I need antibiotics or not (tend to agree/strongly agree)	–	–	–	69%	73%*
I (am happy to) trust the pharmacist's advice as to whether I need antibiotics or not (agree/tend to agree/strongly agree)	–	71%	70%	66%	71%*
Antibiotic resistant bacteria could infect me or my family (agree/strongly agree)	80%	68%	67%	–	–
Healthy people carry antibiotic resistant bacteria (tend to agree/strongly agree)	–	–	–	45%	43%
Bacteria that are resistant to antibiotics spread easily from person to person (tend to agree/strongly agree)	–	–	–	53%	50%
In most instances you cannot drink alcohol while taking antibiotics (tend to agree/strongly agree)	–	–	–	76%	72%*
Taking antibiotics weakens your immune system (tend to agree/strongly agree)	–	–	–	51%	44%†

*Pearson's χ^2 p≤0.01 2017 cf 2014.
†P≤0.001; denominators (N) are unweighted.

recognised that antibiotics kill bacteria/treat bacterial infections, a sizeable minority (35%–43%) over the same period thought that antibiotics kill viruses/treat viral infections (table 1). In 2017, the latter belief was held regardless of whether the respondent recognised correctly that antibiotics kill bacteria. The 2014 and 2017 surveys showed that 14%–15% of people thought that colds or influenza could be effectively treated with antibiotics (an improvement on the 27%–32% who thought that antibiotics work on most coughs or colds in earlier surveys), and 13% in both years thought that a course of antibiotics did not need to be completed if symptoms resolved (compared with 20%–24% in 2008/2009). Responses elicited by the new question on antibiotic resistance showed uncertainty around concepts such as carriage of resistant bacteria, whether resistance was caused by taking antibiotics, and whether all resistant bacteria were harmful (online supplementary table S2).

Respondents trusted their GP's advice (85%–88%) more than advice given by nurses (69%–73%) or pharmacists (66%–71%) (table 1). In 2017, higher social grade and higher qualifications were strongly positively associated with knowledge of antibiotics and antimicrobial resistance (table 2, online supplementary table S3). Adults in households with children or who had visited a doctor or pharmacy in the preceding 12 months were more knowledgeable; youngest (15–24 years), oldest (65+years) and black, Asian and minority ethnic (BAME) adults were less knowledgeable.

Antibiotic use

Three-quarters of respondents (72% (1226/1691)) reported having had at least one infection in the past 12 months. Reported antibiotic use (one or more courses) for each type of infection was: throat 30% (67/246),

Table 2 Factors associated with seven or more correct responses to nine questions exploring knowledge about antibiotic resistance and its relationship to antibiotic use

Overall (n=1691)		0–6 correct responses	7–9 correct responses	Unadjusted OR (95% CI)	Adjusted odds ratio (95% CI)
Overall		58% (970)	42% (721)		
Age (years)	15–24	60% (141)	40% (102)	1.00 (ref)	1.00 (ref)
	25–34	55% (135)	45% (114)	1.18 (0.81 to 1.73)	1.18 (0.76 to 1.83)
	35–44	55% (124)	45% (98)	1.22 (0.83 to 1.81)	1.17 (0.75 to 1.84)
	45–54	54% (127)	46% (108)	1.23 (0.84 to 1.81)	1.17 (0.76 to 1.80)
	55–64	49% (141)	51% (140)	1.52 (1.05 to 2.20)	1.44 (0.95 to 2.19)
	65+	67% (302)	33% (159)	0.71 (0.50 to 1.00)	0.64 (0.43 to 0.96)
Sex	Male	59% (497)	41% (338)	1.00 (ref)	1.00 (ref)
	Female	57% (473)	43% (383)	1.08 (0.88 to 1.33)	1.12 (0.89 to 1.41)
Social grade	AB	40% (173)	60% (250)	1.00 (ref)	1.00 (ref)
	C1	52% (311)	48% (276)	0.61 (0.46 to 0.80)	0.65 (0.49 to 0.88)
	C2	66% (215)	34% (108)	0.34 (0.24 to 0.46)	0.45 (0.31 to 0.65)
	DE	74% (271)	26% (87)	0.23 (0.17 to 0.32)	0.36 (0.25 to 0.52)
Education	Degree or equivalent	40% (206)	60% (288)	1.00 (ref)	1.00 (ref)
	A-level or equivalent	51% (155)	49% (163)	0.64 (0.47 to 0.87)	0.86 (0.61 to 1.21)
	GCSE or equivalent	64% (314)	36% (189)	0.37 (0.29 to 0.49)	0.55 (0.40 to 0.75)
	No formal education	81% (190)	19% (45)	0.16 (0.10 to 0.24)	0.29 (0.18 to 0.46)
	Other	74% (105)	26% (36)	0.23 (0.15 to 0.36)	0.34 (0.21 to 0.55)
Has children age under 15 years in household	Yes	57% (708)	43% (543)	1.00 (ref)	1.00 (ref)
	No	60% (262)	40% (178)	0.87 (0.69 to 1.10)	0.72 (0.54 to 0.97)
Been to doctor or pharmacy in past 12 months	Yes	52% (622)	48% (570)	1.00 (ref)	1.00 (ref)
	No	69% (348)	31% (151)	0.48 (0.38 to 0.61)	0.44 (0.34 to 0.57)
Ethnic grouping	White	55% (796)	45% (650)	1.00 (ref)	1.00 (ref)
	BAME	70% (163)	30% (68)	0.53 (0.38 to 0.73)	0.53 (0.37 to 0.76)

BAME, Black, Asian and Minority Ethnic; GCSE, General Certificate of Secondary Education.

Table 3A Reported antibiotic use for infections in the past 12 months

How many courses of antibiotics have you taken for…	…a throat infection	…a cold or a runny nose	…an ear infection	…a cough	…influenza symptoms	…a sinus infection	…a chest infection	…a skin infection	…a urine infection
	n=246	n=853	n=104	n=626	n=350	n=129	n=255	n=49	n=95
None	71% (179)	96% (816)	54% (59)	90% (561)	88% (310)	75% (97)	44% (107)	69% (34)	22% (21)
1	20% (44)	3% (25)	41% (39)	7% (45)	9% (35)	22% (28)	42% (109)	21% (10)	48% (45)
2+	10% (23)	1% (12)	5% (6)	3% (20)	2% (5)	3% (4)	14% (39)	10% (5)	30% (29)

Table 3B Reported retention of leftover antibiotics in the past 12 months

Thinking about the course/courses of antibiotics you have taken within the past 12 months, were there any left-over tablets/capsules?	
	n=498
No	86% (434)
Yes	14% (64)
(if yes) What did you do with the left-over tablets/capsules?	
	n=64
Threw them away	29% (18)
Kept them for personal future use ‘just in case’	32% (21)
Kept them to give to other family members if they become unwell	1% (1)
Put them in a drawer/the medicine cabinet and forgot about them	24% (16)
Returned them to the pharmacist	8% (6)

Table 3C Reported antibiotic reuse

In which, if any, of the following ways have you taken an antibiotic in the past 12 months?	
	n=1691
Taken left-over antibiotics that were originally prescribed to you for a previous episode of the same type of infection	0.8% (14)
Taken left-over antibiotics that were originally prescribed to you for a different type of infection	0.4% (7)
Taken antibiotics obtained abroad without prescription	0.5% (9)
Taken antibiotics obtained in the UK without prescription	0.9% (13)
Taken antibiotics obtained over the internet	0.3% (4)
Taken antibiotics originally prescribed for another family member	0.2% (3)
Taken antibiotics originally prescribed for someone else who was not a family member	0.0% (0)

ear 46% (45/104), sinus 25% (32/129), chest 56% (148/255), urinary 78% (74/95), cold/runny nose 4% (37/853) (table 3A). One-sixth (14% (64/498)) of respondents who had taken antibiotics reported having left-over capsules or tablets, of which 33% (22/64) were kept for possible future use (table 3a). 1% of respondents (23/1691) had taken left-over antibiotics in the preceding 12 months and 2% (26/1691) had taken antibiotics obtained without a prescription (table 3C).

Expectations, advice, information and prescriptions

Of 936 respondents who reported having respiratory (cough, throat, ear, sinus, chest infection) or influenza symptoms in the past 12 months, 242 (27%) visited or contacted a doctor’s surgery or visited a National Health Service (NHS) walk-in centre or GP out-of-hours service (table 4); 14 (2%) visited A&E (online supplementary table S4). Among the 242 respondents who accessed primary care, as many expected antibiotics (38%) as expected treatment for symptoms (34%); overall, 57% were prescribed antibiotics. Respondents with a cold/runny nose who accessed primary care (7% (61/853)) were less likely to expect antibiotics (29%) or treatment for symptoms (25%); 31% were prescribed antibiotics (table 4). Among 1319 respondents who had an infection or antibiotics within the past year, 43% said that they did not receive any advice or information about antibiotics, compared with 55% in 2014 (p<0.001) (table 5). The majority (83%) of those who did receive information in 2017 said that it was provided to them verbally by a healthcare professional.

Table 4 Expectations, advice and antibiotic prescriptions reported by respondents who accessed primary care for their own or their child's respiratory (cough, throat, ear, sinus, chest infection) or influenza symptoms or a cold/runny nose in the past 12 months

	Respiratory or influenza symptoms		Cold/runny nose	
	n=242*	n=141†	n=61‡	n=53§
What did you EXPECT from your contact/visit for this most recent illness?	**Self**	**Child**	**Self**	**Child**
To be prescribed antibiotics	38% (93)	27% (39)	29% (18)	13% (6)
To be prescribed treatment for symptoms	34% (85)	33% (46)	25% (15)	22% (10)
Advice about whether antibiotics were needed	19% (47)	23% (32)	24% (14)	21% (11)
What HAPPENED?				
Antibiotics were prescribed	57% (136)	41% (57)	31% (20)	33% (17)
Treatment to relieve/reduce symptoms was prescribed	30% (72)	24% (36)	26% (16)	16% (9)
Advice was given about whether antibiotics were needed	15% (36)	25% (35)	16% (11)	12% (5)

*Respondents with respiratory (cough, throat, ear, sinus, chest infection) or influenza symptoms in the past 12 months (n=936) who visited or contacted a doctor's surgery or visited a NHS Walk-In Centre or GP out-of-hours service for these symptoms (n=242).
†Respondents with a child under 5 (n=777) who had respiratory (cough, throat, ear, chest infection) or influenza symptoms in the past 12 months (n=265) who visited or contacted a doctor's surgery or visited a NHS Walk-In Centre or GP out-of-hours service because of the child's symptoms (n=141).
‡Respondents with a cold or a runny nose in the past 12 months (n=853) who visited or contacted a doctor's surgery or visited a NHS Walk-In Centre or GP out-of-hours service for their illness (n=63).
§Respondents with a child under 5 (n=777) who had a cold or a runny nose in the past 12 months (n=262) who visited or contacted a doctor's surgery or visited a NHS Walk-In Centre or GP out-of-hours service because of the child's illness (n=53).
NHS, National Health Service.

Delayed antibiotics

Overall, 4% (64/1691) of respondents had been given a 'delayed/back-up' antibiotic prescription by a GP, nurse, dentist or other health professional in the past 12 months, the same proportion as in 2014 (online supplementary table s5). Fewer respondents in 2017 (23%) compared with 2014 (28%) were aware of delayed antibiotics (p=0.004) (online supplementary table s6). The proportions of respondents who were ambivalent about delayed antibiotics for urinary, ear and throat infections tended to be lower in 2017 compared with 2014, but changes in opinion between the two surveys were statistically evident only for urine and ear infections among respondents who said that they were unaware of delayed antibiotics (because of the large number of respondents in this group) (online supplementary figures s1-s3, table s6).

Parents of children under 5 years old

A recent episode of respiratory (cough, throat, ear, chest infection) or influenza symptoms in a child under 5 years old was reported by 265 parents, prompting 141 (52%) to visit or contact a doctor's surgery or visit a NHS walk-in centre or GP out-of-hours service (table 4) and 14 (5%) to attend A&E (online supplementary table s4). Among the 141 parents who accessed primary care, a similar number expected antibiotics for their child (27%) as expected treatment for symptoms (33%); 41% (57/141) were prescribed antibiotics. Parents of children who had a recent cold/runny nose and who accessed primary care for their child's illness (53/262) were less likely to expect antibiotics (13%) or treatment for these symptoms (22%) than were parents of children with respiratory or influenza symptoms; 33% (17/53) were prescribed antibiotics (table 4).

DISCUSSION

This nationwide survey has shown that, while most people have a correct basic understanding of antibiotics (that they are used to treat bacterial infections), some misunderstandings persist (that antibiotics kill viruses and that leftover antibiotics can be kept 'just in case'). Given that 43% of people who had an infection or took antibiotics in the past year said that they did not receive any advice or information, and that most people trust their GPs advice as to whether antibiotics are needed, there is scope for providing more information about antibiotics and antimicrobial resistance during primary care consultations. This is particularly important for those groups identified as being less knowledgeable about antibiotics, namely adults under 24 or over 65 years old and black, Asian and minority ethnic adults. Disappointingly, fewer respondents in 2017

Table 5 Advice reported by respondents who had an infection or antibiotics within the past 12 months

Did you receive advice or information about any of the following from a health professional?	2014	2017
	n=1071	n=1319
Alternative remedies for the symptoms	7% (72)	5% (74)
The length of time the infection was expected to last	16% (172)	12% (166)
Whether an antibiotic would work for the infection	10% (110)	8% (110)
Information regarding antibiotic resistance	5% (52)	5% (66)
What symptoms of the infection should prompt me to contact a healthcare professional (again)	13% (134)	9% (112)
How I should deal with side effects of the antibiotics	7% (69)	7% (88)
Information on how to take the antibiotics	18% (195)	20% (270)
Other information or advice about antibiotics or infections	7% (70)	6% (80)
Was not given any advice or information	55% (586)	43% (568)
How was this information provided to you?		
	n=417	n=443
Verbal/spoken (eg, spoken to by a doctor or nurse, health professional, etc)		83% (371)
Printed (eg, they gave me a leaflet, booklet or information sheet, etc)*	38% (158)	21% (100)
Shown to me on a computer screen (eg, in the GP surgery, etc)		2% (10)
Directed me to a website		2% (6)
Shown information in another way (eg, directed to information on a poster on a wall, etc)		2% (11)
Other		2% (7)

*In 2014, participants were asked "Did the healthcare professional give you any printed information, such as a leaflet or a pamphlet about infections or antibiotics?".

were aware of delayed antibiotics than in 2014. We also need to ask why public health campaigns since 2003 have not been associated with any substantial change in overall levels of public understanding about antibiotics and antimicrobial resistance.

The main strength of our study is that data were collected using well-established survey methodology yielding a representative sample of the population in England. Public surveys on the theme of antibiotics using the same methodology have been conducted several times since 2003, allowing questionnaire items to be refined and optimised, for example, to minimise ambiguities and optimise the reliability and validity of responses (although these aspects have not been evaluated formally). A disadvantage of this evolutionary process in questionnaire design is that some results from the earliest surveys are not directly comparable with those from the 2014 and current survey. While some Ipsos MORI interviewers can conduct interviews in other languages, translation is not routinely offered. Some of the survey questions require respondents to recall events during the past 12 months. While this inevitably introduce a degree of inaccuracy, we have no reason to suspect systematic biases in responses, for example, by type of infection. However, potentially sensitive questions, for example, asking about antibiotics obtained via the internet, might underestimate such practices.

Our findings in the context of other studies

The proportions of respondents who knew that antibiotics were effective against bacteria has remained relatively constant since 2003, but the same is true of the proportions thinking that antibiotics are effective against viruses. The results of the 2017 survey show the highest percentage for the first question and the lowest percentage for the second, suggesting a favourable trend which requires confirmation in future surveys.

There was a more substantial change in the proportion who think that a course of antibiotics can be stopped when symptoms resolve, from 20%–24% in 2008/2009 to 13% in 2014 and 2017. There is a lack of evidence for an association between stopping antibiotic treatment early and development of antibiotic resistance,[12] and guidance has changed from 'complete your course of antibiotics' to 'take antibiotics as advised by your doctor, nurse or pharmacist'. For example, antibiotics can be started (particularly in secondary care) and then stopped if an alternative diagnosis such as a viral infection is made; a box may contain a 7-day 'course' but with a prescription indicating a shorter course; and sometimes one antibiotic is started, and the patient is then switched to another. This is therefore a potentially difficult area in terms of delivering a consistent message to the public and patients.

The proportions of households with 'forgotten' leftover or 'standby' leftover antibiotics in 2017 were lower than in 2003[3] and 2014, but the 2003 survey was based on visual inspection of household drugs and the 2014 survey asked "what do you usually do [with left-over antibiotics]?" rather than "what did you do…" Therefore, a repeat of the visual

inspection survey would be needed to establish whether the practice of retaining leftover antibiotics is diminishing.

The importance of wording antibiotic survey questions carefully is illustrated by apparently large reductions in antibiotic use over the past 12 months for specific infections comparing 2014 and 2017 survey results. The corresponding questions in the surveys were worded similarly except in 2017 the names of two commonly prescribed antibiotics (amoxicillin or penicillin) were included by way of example and it was made explicit that "We are not asking about paracetamol or ibuprofen or other over the counter products such as cough syrups." These differences indicate that medications were misclassified by survey respondents. In clinical practice, health professionals should consider using specific terms, that is, antibacterial, antiviral, antifungal, for medicines to promote public understanding of different anti-infectives (and antipain, antifever, anti-inflammatory for medicines used to treat symptoms).

An encouraging finding in the current survey is that 38% of patients accessing primary care with respiratory or influenza symptoms expected to be prescribed antibiotics, compared with 53% in 2011.[6] That parents of young children presenting with the same symptoms were less likely to expect an antibiotic prescription (27%) suggests perhaps that parents are more reluctant to give antibiotics to their child unless absolutely necessary. This is the opposite of what was seen in a survey conducted after the 2009/2010 'swine influenza' (influenza H1N1) epidemic, when 7% of parents attending primary care requested an antibiotic for a child under five with a recent respiratory tract infection (RTI) compared with 1% of adults with an RTI who asked for an antibiotic.[13] Less encouraging findings were the one third of respondents who reported being prescribed antibiotics for their own or their child's cold or runny nose, and fewer respondents being aware of delayed antibiotics in 2017 compared with 2014.[9]

Implications for research and/or practice

Although more patients in 2017 were given advice or information compared with 2014, the public are still not receiving enough when they visit a health professional. Written information is particularly important, and the verbal information given to 83% of patients in a short consultation is probably insufficient to change behaviour. The TARGET Antibiotic Toolkit includes patient-facing leaflets for RTI and urinary tract infection (UTI).[14] These are freely available to download from the website but, to increase uptake, health professionals need easy access to them during consultations either as printed copies to hand or electronic copies to print on demand, for example, when prompted by a computer system. Although back-up/delayed antibiotics are mentioned in TARGET leaflets, patients and health professionals may need more detailed information about the advantages and disadvantages of back-up/delayed prescribing to inform discussion during consultations.

Reasons for the apparent ineffectiveness of antibiotic awareness campaigns are likely to be manifold and complex, with a corresponding need for rigorous evaluation. An international survey of antibiotic awareness campaigns found that 60% had not been formally evaluated,[15] and a recent systematic review was unable to identify any high-quality studies.[16] Evaluations have generated disparate findings, including a reduction in antibiotic prescribing that was not matched by an increase in public understanding,[17] and a paradoxical increase in public demand for antibiotics.[18]

Our findings show that BAME respondents were less knowledgeable about antibiotics. Whether we need to target these specific population groups or modify patient leaflets to accommodate social and cultural factors remains to be determined. US studies have found conflicting findings around antibiotics for childhood illness: ethnic minority parents in Massachusetts had less antibiotic knowledge[19] but non-Hispanic white children were more likely to receive antibiotics for a viral acute respiratory tract infection than Hispanic or black children in a geographically diverse study of emergency department prescribing.[20] There is a paucity of research on this topic in the UK,[21] with a need for qualitative evidence to inform possible modification of patient-facing materials (beyond the translated leaflets that are already available) and the development of targeted interventions.

Adolescents and younger adults (aged 16–24 years) are a notoriously difficult group to reach if misperceptions about antibiotics are to be corrected.[22] Social media campaigns, games and email/text messaging may be a more useful avenue to explore than leaflets.[23–25] Educational resources for school-age children developed by the e-Bug project[26] have been deployed across Europe[27] and downloaded worldwide,[28] and a recent feasibility study showed that 72% of those aged 16–18 years who had participated in an e-Bug lesson consented to receive follow-up text messages asking about their antibiotic use (unpublished PHE data). Our survey took place before the launch of PHE's 'Keep Antibiotics Working' campaign which included advertisements on television, radio and social media. Combined with ongoing global campaigns to raise awareness and to create a political imperative around the threat posed by antimicrobial resistance, we would hope to be able to detect improved knowledge about antibiotics in the next generation of young adults. Another key element is to improve antibiotic prescribing practice through medical education, continuous professional development and dissemination of evidence and prescribing indicators. This needs to accommodate emerging evidence on approaches to treatment and on antibiotic resistance.[29] Given the public's continuing trust in their GP's advice, although with scope for improvement and a real need for raising levels of trust in advice given by nurses and pharmacists, we would expect to see favourable trends in appropriate antibiotic use as outlined in the UK's 5-year national action plan for tackling antimicrobial resistance.[30]

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Competing interests All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: CM leads the development of and writes evidence-based antibiotic guidance for primary care and leads the RCGP TARGET antibiotic toolkit development including a patient leaflet encouraging delayed/back-up prescribing; EC and DL manage the development and maintenance of products within RCGP TARGET antibiotic toolkit including a patient leaflet encouraging delayed/back-up prescribing; CCB is an NIHR Senior Investigator and Director of University of Oxford Primary Care and Vaccines Clinical Trials Collaboration. All other authors declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

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Ethics approval The Ipsos MORI surveys and interviews were undertaken outside the NHS setting, and NHS Research Ethics Committee (REC) review is not required for healthcare market research conducted by professional market researchers. This ethical position was confirmed by the Head of Research Governance, Research Translation & Innovation Division at Public Health England. Ipsos MORI is an independent research agency bound by the rules of the Market Research Society. The surveys are regular household 'consumer' surveys into which clients of Ipsos-MORI can insert sets of questions. Consent for personal responses to be used by Ipsos-MORI clients for research purposes is indicated by verbal agreement and by the member of the household voluntarily completing the survey questionnaire/interview. There were no financial or other incentives and respondents were free to withdraw their participation during the interview. All data processing and storage comply with the General Data Protection Regulation (GDPR) and UK Data Protection Act 2018.

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