

Using evidence-based infographics to increase parents' understanding about antibiotic use and antibiotic resistance: a proof-of-concept study

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Received 26 August 2020; accepted 19 October 2020

Background: Communities need to see antibiotic stewardship campaigns as relevant to enhance understanding of antibiotic use and influence health-seeking behaviour. Yet, campaigns have often not sought input from the public in their development.

Objectives: To co-produce evidenced-based infographics (EBIs) about antibiotics for common childhood infections and to evaluate their effectiveness at increasing parents' understanding of antibiotic use.

Methods: A mixed-methods study with three phases. Phase 1 identified and summarized evidence of antibiotic use for three childhood infections (sore throat, acute cough and otitis media). In phase 2, we co-designed a series of prototype EBIs with parents and a graphic design team (focus groups). Thematic analysis was used to analyse data. Phase 3 assessed the effect of EBIs on parents' understanding of antibiotic use for the three infections using a national online survey in the UK.

Results: We iteratively co-produced 10 prototype EBIs. Parents found the evidence displayed in the EBIs novel and relevant to their families. Parents did not favour EBIs that were too medically focused. Parents preferred one health message per EBI. We included eight EBIs in a national survey of parents ($n = 998$). EBIs improved knowledge by more than a third across the board (34%, IQR 20%–46%, $P < 0.001$). Respondents confirmed that EBIs were novel and potentially useful, corroborating our focus groups findings.

Conclusions: Co-designed EBIs have the potential to succinctly change parents' perceptions about antibiotics for acute respiratory tract infections in children. Further research should test EBIs in real-world settings to assess their reach as a potential public-facing intervention.

Introduction

Up to now, the threats of inappropriate antibiotic use and drug-resistant infections have framed as hypothetical or apocalyptic predictions.¹ This is difficult for people to relate to when facing treatment decisions in the here and now. Consequently, people have difficulty understanding and engaging with the concept of antimicrobial stewardship (AMS) and what it means for them.^{2,3} This communication approach to AMS can mean important consequences are overlooked such as the evidence that drug-resistant infections are associated with worse outcomes—even for common infection syndromes.⁴

One such audience where better engagement is needed are parents or carers of young children. Parents are an important

target group because preschool children have the highest antibiotic prescribing rate.^{5,6} This is despite most childhood illnesses being self-limiting acute respiratory tract infections (RTIs), caused by viruses where antibiotics do not provide additional clinical benefit.^{7–9} Evidence from a UK primary care database study showed that the proportion of preschool children prescribed an antibiotic course for acute RTI between 2009 and 2016 was over 45%.¹⁰ This exposes children to antibiotic-related side-effects and other harms like antibiotic resistance.

New approaches are needed to disseminate a comprehensible message about appropriate antibiotic use. Antibiotic awareness campaigns have not had the desired effect in improving public misconceptions about antibiotic use.^{11,12} This may be a result of

following a top-down approach, with messages delivered to the public by experts,¹² or because campaign messages are not reaching their intended audience.¹³ A recent Wellcome Trust report highlighted that to achieve meaningful impact, antibiotic awareness messages need to be relevant to the target audience and focus on the here and now.¹⁴ In addition, these messages need to achieve a wide reach and be delivered in a format that people will engage with.³

Infographics or graphic visual representations are one such approach where complex information can be summarized succinctly.^{15,16} Infographics though are not a new concept. They have successfully been used in education and teaching,¹⁷ in business to improve brand awareness¹⁸ and, more recently, in medicine to convey complex information to patients.¹⁹ Effective infographics are quick to read, visually appealing, easy to understand, relatively cheap and easy to disseminate.^{16,20} Their use as a public-facing AMS intervention has not been explored.

Our aim was to develop and explore a novel concept called 'evidenced-based infographics' (EBIs) about antibiotic use for common infections in children and to evaluate their effectiveness at increasing parents' understanding of antibiotic use and antibiotic resistance.

Methods

This was a mixed-methods study with three phases. Ethical approval was obtained from the Medical Sciences Interdivisional Research Ethics Committee (IDREC), University of Oxford (R62414/RE001).

Phase 1: Identifying suitable evidence summary statements

Co-researchers (C.C.B., J.J.L., M.M., O.V.H.) independently listed suggested evidence related to antibiotic use for three common infection syndromes in preschool children (i.e. acute cough, sore throat, earache), and antibiotic resistance. Through a process of rapid review and collaborative discussions, we identified between five and seven candidate evidence statements (Appendix S1, available as [Supplementary data](#) at JAC-AMR Online). These statements had to be suitable to be represented graphically, and for dissemination to the public. We then selected and refined three to five evidence statements for each condition through consensus agreement by the research and graphic design teams. The content of each message was informed by findings from relevant systematic reviews; the current NICE guidance and TARGET toolkit; observational studies exploring parents' beliefs about antibiotic use for common infections; and meta-analyses investigating harms of antibiotics. We also included specific information related to misconceptions about childhood illness, e.g. duration of illness with and without antibiotics.

Phase 2: Development of prototype EBIs and evaluation

During phase 2, we co-developed a series of prototype EBIs with our graphic designers, by transforming the evidence summary statements from phase 1 into infographics.^{15,16,20} This process was iterative and entailed graphically transforming the evidence statements into EBIs, initial review by the research team, then feedback from parents/carers (participants) in focus groups over two cycles for further refinement. Final EBIs were piloted with parents in the focus groups prior to use in phase 3.

As an introduction to the focus group, participants were asked about their awareness and understanding of antibiotics, and their views on information sources on antibiotics. We then handed out the prototype paper-based EBIs and discussed these one at a time. Topics covered in the

interview guide included: feedback on the face validity of each EBI (i.e. the extent to which an EBI subjectively covers the concept it purports to convey); its content validity (i.e. the extent to which an EBI is relevant to the content being conveyed); their usefulness in conveying information; and potential locations where EBIs might be displayed or used (Appendix S2).

We sought participants through community networks by advertising through local and national parent support groups (e.g. parent toddler groups), social media, local newspapers and online advertising platforms (e.g. [www.mumsnet.com](#)). As this was a feasibility study, we sought a convenience sample of parents. Focus groups were conducted by an experienced qualitative researcher (O.V.H.) and supported by J.J.L., who took notes. We obtained prior written consent from each participant. Focus groups were audio-recorded and transcribed verbatim. In recognition of their time to participate, participants received a £20 gift voucher. Transcripts were checked for accuracy against the recording and anonymized. Anonymized transcripts were analysed (O.V.H.) using thematic analysis aided by specialist software (NVivo version 11) to organize data. Constant comparison was used to compare and code data across interviews, taking an inductive approach.²¹ Codes were compared with one another to create categories, grouping similar codes together. Categories were organized into a framework to provide themes and subthemes.

Phase 3: Online parent survey of EBIs

We conducted a web-based survey to assess the impact of EBIs on parents' understanding about antibiotic use and antibiotic resistance (Appendix S3). Survey development was informed by piloting with parents and co-researchers.

The survey had three parts:

- In part A, respondents were asked eight multiple-choice questions about antibiotics for children with sore throat, earache and cough. These questions were the evidence-summary statements from phase 1 that had been transformed into EBIs in phase 2. Respondents selected an answer from a given list of five answers.
- In part B, we showed respondents eight infographics in turn from phase 2. Respondents were briefed that these infographics reflected the best available evidence about the use of antibiotics in children with RTIs. After each infographic, respondents were asked about the infographic's novelty, its usefulness and whether the infographic changed their perceptions of antibiotic use in children.
- In part C of the survey, we repeated the same questions from part A and respondents selected an answer from a given list of five answers. Respondents were only shown the infographics in part B of the survey.

We used the McNemar test in order to determine whether any differences between responses in part A and part C of the survey were statistically significant. We adjusted for multiple testing using the Bonferroni correction.

We used a data collection and market research company (Dynata) to obtain a sample of 1000 completed responses, representative of parents or carers of young children in the UK, in terms of sex, age, ethnicity and geographic region. The invitations were sent over 3 weeks in February and March 2020 (before COVID-19 lockdown started in the UK). Details of the survey process can be found in Appendix S4.

Results

Phase 1

From 18 candidate statements, we selected 10 evidence summary statements that could usefully be transformed into a prototype infographic. We further refined these into 10 prototype infographics for development in phase 2.

Phase 2

Eight parents split evenly (six mothers, two fathers) participated in two focus groups between July and September 2019. Most (75%) parents identified themselves as white British. One parent participated in both focus groups. Focus groups lasted 73 and 99 min, respectively.

For the purposes of our main research objective, emphasis is given to themes with original findings relevant to the development process of the EBIs illustrated below with quotations.

The development of a sample of infographics over time from initial design, changes after focus group 1 and 2 can be visualized in Figures 1 to 4.

Theme: Parents' reflections on infographics

Most of the evidence displayed in the infographics was entirely novel to parents. The EBIs challenged their existing beliefs about antibiotics for children.

'...[this infographic (Figure 1)] is showing that the [antibiotic] you take in January could still be affecting you in December, I think that's something that I never thought about. And that, to me, is quite [novel] ... you kind of think, well, you've finished taking a course of antibiotics and that's it, isn't it? It's got rid of your disease and there's nothing left going on.'

(P3; focus group 2)

'I thought it is a clear message (Figure 2) and it is a new message.'

(P3; focus group 1)

However, parents were quickly overwhelmed when too much information was presented in the infographic. The manner in which the information was displayed influenced their understanding e.g. difficulty interpreting graphs (Figure 1). For example, in the early version of infographic 1 (Figure 1), parents were doubtful about the evidence and were surprised that the effects of one antibiotic course can persist for up to 12 months. Their perceptions were more accepting in the second focus group.

'Is this an accurate representation of what happens if your child takes [an antibiotic course]?'

(P1; focus group 1)

'Yet the potential of having resistant bacteria over a year, it's really an argument against giving antibiotics if you're not

really sure what the problem is. And I think it's an important message to send across.'

(P4, focus group 2)

Extraneous components of the infographic were regularly questioned (Figure 2, initial design) They preferred one health message per visual (Figure 3).

'I just think it's confusing to have two messages in the same picture [infographic 5 sore throat].'

(P3; focus group 2)

In other infographics, the evidence presented was too medically focused (e.g. infographic 4 acute cough and hospitalization, not shown) where the outcome was not relevant to parents.

'This infographic [#4], it feels like it's more important for a research perspective, like as a researcher I would like to say that my study had 8000 participants. [...] But the message here, it's not that important to parents.'

(P4; focus group 2)

Parents placed a hierarchy when certain medical terms were used. For example, parents accepted that antibiotics were not needed for 'sore throat', however were more resolute that antibiotics were needed when the term 'tonsillitis' was used (Figure 3, initial design).

Theme: Potential value of infographics as a public health intervention

All parents were confident about where to source information about caring for their sick child e.g. from NHS websites, NHS 111, or a trained health professional. However, parents were less certain about where they would source information specifically about antibiotic use in children. Some parents thought that EBIs would not dissuade them from seeking advice from a health professional but rather would change their expectations for antibiotics or help assure them that antibiotics would not provide any additional benefit.

'It wouldn't reduce how much I go to the healthcare professional, but it would make a difference to what my expectations are from the appointment.'

(P2; focus group 1)

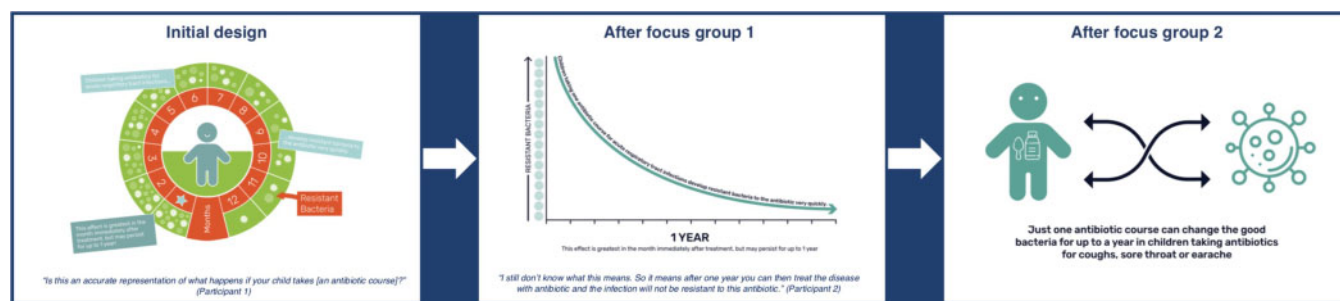


Figure 1. Example of an infographic on antibiotic resistance.



Figure 2. Example of an infographic on acute cough.



Figure 3. Example of an infographic on sore throat.

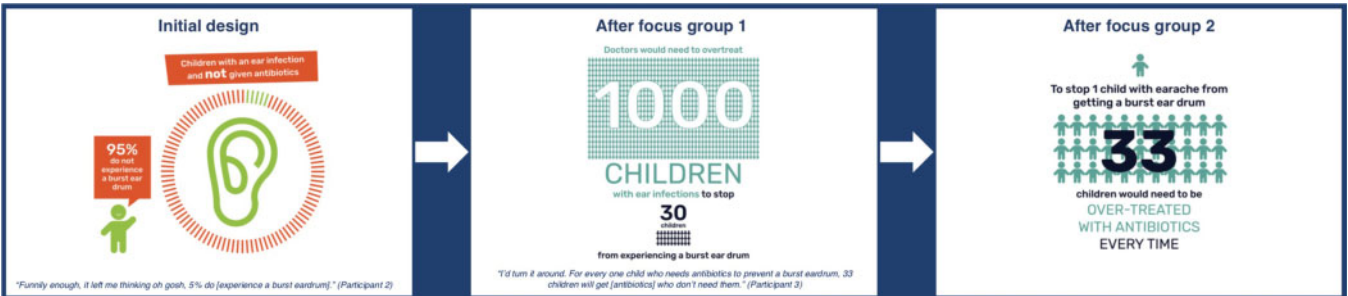


Figure 4. Example of an infographic on earache.

Other parents were less sure. EBIs might sway their perception to consult a health professional but this would depend on the child’s symptoms.

‘I don’t know. I am undecided. Some of it, like the earache one, I might think twice before going, but ultimately, you have a sick child in front of you, you have got to do what you have got to do.’
(P3; focus group 1)

Although parents suggested many areas where such infographics might be displayed in typical healthcare settings e.g. NHS websites, GP notice boards/waiting room TV screens, they also listed other non-healthcare opportunities where such infographics could usefully be displayed and used e.g. parenting websites, charities such as the National Childbirth Trust, advertisements on public transport and consumer products.

‘... it would be helpful to have these infographics on the NHS website, which makes me not have to read all the small detail, but I can have a quick visual.’
(P4; focus group 1)

Phase 3: Online survey

Based on feedback from phase 2, we included the best eight EBIs in the online survey. There were 998 respondents to the online survey with the key characteristics shown in Table 1. Respondents predominately identified as white and were educated to at least school leaving age. Over two-thirds of respondents were female, and in full-time or part-time employment. Most families had two children with at least one child under the age of 5 years.

Knowledge at baseline and after infographic

Eight multiple-choice questions (Table 2) were incorporated into parts A and C of the survey. The median score percentage correct

Table 1. Demographic characteristics of respondents in survey (March 2020, *N* = 998)

Characteristic	Number (%) or median [IQR]
Age, years	34 [30–39]
Gender (female)	702 (70%)
Parent or carer of child	
parent	972 (97%)
carer	26 (3%)
Number of children in family	2 [1–2]
Number of children under 5 years old	
1	747 (75%)
2	228 (23%)
3	23 (2%)
UK region	
East Anglia	82 (8%)
East Midlands	72 (7%)
London	143 (14%)
North East	54 (5%)
North West	115 (12%)
Northern Ireland	24 (2%)
Scotland	72 (7%)
South East	147 (15%)
South West	79 (8%)
Wales	40 (4%)
West Midlands	96 (10%)
Yorkshire and Humberside	74 (7%)
Ethnicity (self-reported)	
Asian/Asian British	67 (7%)
black/African/Caribbean/black British	32 (3%)
mixed/multiple ethnic groups	32 (3%)
other ethnic group	7 (1%)
prefer not to say	7 (1%)
white	853 (85%)
Level of education	
‘A’ levels (such as IT, maths or science) ^a	255 (26%)
‘O’ levels, GCSEs, BTEC, NVQ or similar ^b	217 (21%)
apprenticeship	10 (1%)
degree level	271 (27%)
no qualifications	20 (2%)
postgraduate degree	218 (22%)
prefer not to say	7 (1%)
Current employment	
in education	13 (2%)
in paid work (full-time or part-time)	678 (68%)
looking after my family, home or dependents	176 (17%)
on maternity leave	56 (5%)
other	2 (0.2%)
prefer not to say	6 (1%)
unable to work because of disability	22 (2%)
unemployed	45 (5%)

^aAdvanced level qualifications (known as A levels) are subject-based qualifications that can lead to university, further study, training or work.

^bQualification in a specific subject formerly taken by school students aged 14–16, at a level below A level.

at baseline (part A of survey) was 16% (IQR 10%–29%). The lowest score was for statement 8 (8%) and the highest for statement 2 (35%).

In part C of the survey (after respondents were shown the linked infographic), we found the median score correct was now 51% (IQR 48%–57%). The median score percentage improvement was 34% (IQR 20%–46%). Further post-hoc analysis of respondent characteristics can be found in Appendix S5.

Reported novelty of infographics

From part B of the survey, nearly two-thirds (median 63%, IQR 59%–67%) of respondents reported the information conveyed by the infographic was new or novel to them.

Change in perceptions of antibiotic use in children

Two-fifths of respondents (40%) stated that these infographics changed their perceptions of antibiotic use in children ‘some-what’ and in a third (32%) of respondents as ‘very much’ changed. With specific reference to infographic 2, more than two-thirds of respondents (68%) expressed an interest in knowing the number of antibiotic courses their child had taken in the last year.

Usefulness of the antibiotic infographic

Respondents overwhelmingly found the infographics ‘somewhat useful’ (44%) or ‘very useful’ (45%).

Discussion

Summary of main findings

We co-produced and evaluated a series of evidence-based infographics about antibiotic use for acute RTIs in children through a bottom-up, iterative and cross-discipline process. The focus groups showed that most parents found the evidence content displayed in the EBIs novel and it challenged their existing beliefs about antibiotics for children. EBIs that were too medically focused or where the outcome was not relevant to parents were not favoured by participants. Parents preferred one health message per visual.

Through an online survey with just under 1000 parents of pre-school children across the UK, we demonstrated that EBIs improved respondents’ knowledge by over a third (median 34%, IQR 20%–46%, $P < 0.001$). Respondents confirmed that EBIs were novel and potentially useful, corroborating our focus groups findings. Respondents stated that these EBIs ‘somewhat’ (40%) and ‘very much’ (32%) changed their perceptions of antibiotic use in children.

Comparison with existing literature

Although infographics relating to antibiotic use and antimicrobial resistance (AMR) are abundant e.g. WHO,²² they often depict general points about the aetiology of AMR with a One Health focus aimed at the general public. We are not aware of any studies using an evidence-based infographic as a public-facing intervention to

Table 2. Evidence-based summary statements in survey (*N* = 998 respondents; correct answers in bold)

Statement	Summary statements	Topic	Correct at baseline (part A), <i>n</i> (%)	Correct after infographic (part C), <i>n</i> (%)	<i>P</i> value ^a
1	Children taking one course of antibiotics for common respiratory tract infections (chest, ear or throat infections) can develop resistant bacteria very quickly. This effect can persist for up to (...). a. 12 months b. 1 month c. 6 months d. Less than 1 month e. I don't know	antibiotic resistance/ antibiotic use	182 (18.24%)	504 (50.5%)	<0.001
2	Antibiotics are more likely to help children with a chest, ear or throat infection who have had (...) in the last year. a. 1 antibiotic course b. 2 antibiotic courses c. More than 2 antibiotic courses d. None e. I don't know	antibiotic resistance/ antibiotic use	346 (34.67%)	442 (44.29%)	<0.001
3	For children with a cough, what kind of phlegm (mucus coughed up) usually indicates that antibiotics are needed? a. The phlegm colour does not matter b. Green phlegm c. Yellow phlegm d. Mixed colour phlegm e. I don't know	acute cough	143 (14.33%)	600 (60.12%)	<0.001
4	Normal coughs in children can last up to (...) days. a. 3 days b. 7 days c. 14 days d. 25 days e. I don't know	acute cough	103 (10.32%)	463 (46.39%)	<0.001
5	If 10 children with a sore throat are not treated with any antibiotics, how many will be better after 1 week? a. 1 out of 10 children b. 2 out of 10 children c. 5 out of 10 children d. 8 out of 10 children e. I don't know	sore throat	327 (32.77%)	508 (50.90%)	<0.001
6	Antibiotics shorten a sore throat in children by (...) day(s). a. 1 day	sore throat	99 (9.92%)	597 (59.82%)	<0.001

Continued

Table 2. Continued

Statement	Summary statements	Topic	Correct at baseline (part A), n (%)	Correct after infographic (part C), n (%)	P value ^a
7	b. 3 days c. 5 days d. 7 days e. I don't know	earache	282 (28.26%)	488 (48.90%)	<0.001
	If we have 10 children with ear-ache, how many of them will settle on their own within three days with simple pain relief?				
8	a. Only 1 child b. 2 out of 10 children c. 5 out of 10 children d. 8 out of 10 children e. I don't know	earache	80 (8.02%)	554 (55.51%)	<0.001
	How many children do you think doctors would need to give unnecessary antibiotics for ear infections to prevent one burst eardrum?				
	a. 3 b. 7 c. 14 d. 33 e. Don't know				

^aMcNemar tests were performed to test whether individual responses had significantly differed between part A and part C of the survey; based on Bonferroni correction, the *P* value threshold was 0.006.

promote people's understanding of antibiotic use and AMR. Infographics have been employed to summarize the key results of a research study in a simple and visual way e.g. the *BMJ*'s visual abstracts,²³ as a decision aid for clinicians to use during consultations with patients,²⁴ or specifically in trial settings.^{25,26}

In other healthcare sectors, infographics have shown potential as public-facing interventions.^{27,28} For example, in cancer risk, participants who viewed an infographic were more likely to know the correct association between cancer risk and old age compared with those simply viewing text information.²⁸

There have been a number of systematic reviews focusing on public-targeted communication interventions to improve the public's understanding of antibiotic use and AMR.^{11,29–32} These have mainly focused on acute RTIs and conducted in high-income countries. Interventions targeting parents with preschool children have also shown promise to increase parents' knowledge.³² The format of these interventions though included pamphlets, posters, animations and mass media campaigns but no infographic use. Importantly, the content of these public-facing interventions is often poorly described and without involvement of their intended audience in the development process. Where they are described, and in contrast to our study, they include non-specific educational messages about the appropriate use of antibiotics, such as the difference between viruses and bacteria, the broad risks of inappropriate use and potential side effects.

Strengths and limitations

This study builds on previous work where we explored what strategies parents would find acceptable to minimize AMR for their families.³ We found that parents wanted future campaigns to use fear-based messages less often and instead have a relevant and accessible message for their families.

We employed a bottom-up approach by incorporating parents' beliefs and understanding about antibiotics and developing materials whose content resonates with parents of young children. We focused on outcomes that parents can relate to, ensuring that the message has relevance to the intended audience. The evidence we incorporated into EBIs was specific to the condition (i.e. antibiotic use for children with acute RTIs). We used an iterative and cross-discipline process to co-produce a series of EBIs and test their face and content validity.

Through our targeted survey, we were able to gather responses illustrative of parents with young children. We showed that EBIs can impart new knowledge quickly and clearly and improve relevant knowledge acquisition by at least a third.

Although we were able to get a sense of whether EBIs might alter parents' perceptions of antibiotic use in children, we accept that an important limitation is that a respondent's indication of their future behaviour in response to information may differ from what they would actually do in real life. We accept that overcoming 'knowledge deficits' alone will therefore be insufficient for global AMR behaviour change because there are important

cultural-specific practices around antibiotics and social determinants of health that complicate campaign communication efforts.³³ However, EBIs provide a mechanism where these relevant 'knowledge deficit' barriers (limited time, information overload) can be addressed to understand complex and important information. We aimed to conduct three focus groups but time, resources and an imminent pandemic constrained our efforts to two focus groups. We accept that our survey sample was limited to those with internet access and with an interest in completing surveys. However, this survey strategy also meant that respondent demographic characteristics were broadly representative of the general population in the UK. We accept that an online survey may reflect recall rather than understanding. We accept that if the survey is run at another time or geographic region, different results may be obtained.

Implications of findings for clinical practice, policy and future research

To facilitate better informed decision-making about antibiotic use for children with RTIs, the decision to prescribe antibiotics should be a shared decision between clinician and parent/carer.^{34,35} However, making a shared decision about the risks and benefits of antibiotics should be based on tangible outcomes that parents relate to. Although there are well-developed patient leaflets on antibiotic prescribing for acute RTIs, these tend to be non-specific aimed at the general population, or are extensive and potentially resource intensive to use outside a trial setting.^{26,36,37} EBIs therefore can helpfully bridge this gap by providing a succinct and relevant message for parents prior to consultation e.g. on TV screens in waiting rooms.

Ensuring campaign messages are received by the intended audience is critical. Public-targeted communication interventions tend to skirt around this important stepping stone by simply evaluating whether campaigns have improved antibiotic use. Constructing a visually appealing message is crucial for public health authorities to entice the public to engage with awareness campaigns. Graphically representing evidence succinctly also allows such important antibiotic health messages to traverse languages globally through bodies like UNICEF.

Future campaigns should be co-developed, piloted and evaluated. We ought to engage different target population groups and move beyond the bubble of traditional public health campaigns. Specific to EBIs, policymakers should explore new areas where such EBIs could be displayed beyond the clinical setting and traditional routes like leaflets and social media. Examples include displaying topic-specific EBIs on consumer products or including them with parenting information packs for new or expecting parents. EBIs need to be tested in real-world settings to assess their reach, and refine how EBIs are displayed, in different sectors and geographic regions. Researchers should consider using the EBI approach for communicating evidence-based messages about other public health concerns.

Conclusions

Communities need to see antibiotic campaign messages as relevant to them in order to influence health seeking behaviour and antibiotic use. Our proof-of-concept study demonstrates how EBIs

can be co-developed and shows they have the potential to succinctly improve knowledge about antibiotics for children with acute RTIs. Further research is needed to test EBIs in real-world settings to assess their reach and refine how EBIs are best displayed and in which format and settings.

Acknowledgements

This study was presented at SW SAPC, 5–6 March 2020, Bristol, UK and won best poster presentation (5d.4 'Infographics about antibiotics: making facts accessible'); and at the National Centre for Antimicrobial Stewardship (NCAS) webinar Antimicrobial Awareness Week, 18–24 November 2020 (oral presentation entitled 'Evidence-based infographics to increase parents' understanding about antibiotic use and antibiotic resistance: a proof-of-concept study').

We thank Dan Richards-Doran for designing the study promotional leaflets, the parents and carers who took the time to participate in the study, and a creative graphic design team at <https://monchu.uk>.

We also thank Professor Alastair Hay for providing feedback on the project proposal.

Funding

This study was funded by an NIHR SPGR grant (reference number: 439). This paper presents independent research funded by the National Institute for Health Research School for Primary Care Research (NIHR SPGR).

Transparency declarations

O.V.H. affirms that the manuscript is an honest, accurate and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained. All other authors: none to declare.

Disclaimer

The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health.

Supplementary data

Appendices S1 to S5 are available as [Supplementary data](#) at [JAC-AMR Online](#).

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