

RESEARCH

Open Access



Educational interventions and contextual factors for optimising antibiotic prescription in paediatric uncomplicated acute respiratory tract infections in primary care: scoping review of reviews

Usue Elizondo-Alzola^{1,2} , Claudio Rocha^{3,4} , Leire Leache^{5,6} , Montserrat León-García¹ , Luis Carlos Saiz^{6,7} , Ivan Solà^{3,8} , Camila Montesinos-Guevara⁹ , Adriana-Gabriela Meade³ , Andrea Boldú³ , Ignasi Bolívar^{10,11,8} , Ena Niño-de-Guzmán^{3,12,13*} and Pablo Alonso-Coello^{3,8*}

Abstract

Background Inappropriate antibiotic prescription in paediatric uncomplicated acute respiratory tract infections (ARTIs) in primary care (PC) settings contributes to antimicrobial resistance. We aimed (1) to identify and describe educational interventions and their components to optimise antibiotic prescription for paediatric uncomplicated ARTIs in PC, and (2) to map contextual factors that may influence antibiotic prescription and the implementation of interventions.

Methods We searched three electronic databases (Medline, CINAHL and Epistemonikos) to identify reviews on the effectiveness of educational interventions and contextual factors, for optimising antibiotic prescription (*Concept*) in paediatric uncomplicated ARTIs (*Population*) in PC (*Context*). We included reviews that reported explicitly the search strategy used. Two previously calibrated reviewers independently screened the literature, extracted data, and assessed the methodological limitations. We applied the “best-fit framework synthesis approach”, based on the main constructs of the Consolidated Framework for Implementation Research, and coded the data deductively by groups of analysis for reviews reporting effectiveness (e.g. antibiotic or consultation rate) or by thematic synthesis for reviews reporting contextual factors (e.g. healthcare professionals’ knowledge) based on a logic model.

Results We identified 11 reviews evaluating education intervention and their characteristics, including 182 interventions with at least one educational component (educational intervention plus another type, educational or non-educational), with 136 providing information on characteristics and effectiveness. Successful interventions’ characteristics were related to the kind of intervention (e.g. communication skill training), mode of delivery (e.g.

*Correspondence:
Ena Niño-de-Guzmán
ena.ninodeguzman@gmail.com
Pablo Alonso-Coello
palonso@santpau.cat

Full list of author information is available at the end of the article



© The Author(s) 2025. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

face to face), and target population (e.g. parents/caregivers). From the 22 reviews on contextual factors, healthcare professionals' attitudes and perceptions, knowledge, and health system and professionals' teams' organization (inner setting), were the most frequent themes; less information was available on individuals' characteristics (parents/children) and on outer setting (e.g. policies).

Conclusion We identified a large number of heterogeneous educational interventions. Combining educational interventions plus another type targeting both parents/caregivers and healthcare professionals, and considering their needs and their context may improve antibiotic prescribing in children. Further research is needed on consultation rate, knowledge, attitudes, and satisfaction outcomes and contextual factors, as well as on the cost-effectiveness of the interventions.

Registration The protocol was published in OSF iRegistries in May 2021 (Elizondo-Alzola, U).

Keywords Antibiotic prescription, Respiratory tract infections, Children, Paediatrics, Primary care, Educational interventions, Scoping review.

Background

Infections caused by resistant bacteria pose a major threat to public health and economic wellbeing worldwide [1], and the situation is likely to worsen if it is not addressed appropriately [2]. In 2015, the number of deaths in the European Union and the European Economic Area attributed to antimicrobial resistance (AMR) was 33,000, which is 32% more than the estimated annual attributable deaths in 2007 [3]. Around 700,000 people die each year from antimicrobial resistant infections, costing between 35 and 55 billion dollars in lost productivity in the United States of America (USA) [4]. According to an assessment of the global burden of AMR in 2019, AMR is a leading cause of death around the world, with the highest burdens in low-resource settings, being the highest rates of death in sub-Saharan Africa (deaths associated to AMR 98.9 per 100,000 and deaths attributed to AMR 23.7 per 100,000) and south Asia (deaths associated to AMR 76.8 per 100,000 and deaths attributed to AMR 21.5 per 100,000) [5]. Inappropriate use of antibiotics is the most important factor in the emergence of AMR; therefore, implementation Antimicrobial Stewardship Programs is crucial to reduce the burden of these infections [3, 4, 6].

Children with uncomplicated acute respiratory tract infections (ARTIs) often receive an inappropriate antibiotic prescription in primary care (PC), and in most cases, antibiotic effectiveness in these self-limiting infections is negligible and of low added value [7–9]. They are also associated with avoidable side effects. Antibiotic prescription rates vary across countries. In the USA, it is estimated that up to 50% of the antibiotic prescriptions for ARTIs in PC are unnecessary [10]. Southern and Eastern European countries report the highest prescriptions rates overall [11]. Moreover, paediatricians prescribe in Southern Europe antibiotics more frequently than their counterparts in Central and Northern Europe [12]. A systematic review concluded that antibiotics are commonly prescribed in PC settings in low- and middle-income

countries. Although several studies reported a high proportion of inappropriate use, the actual magnitude of the problem remains unclear due to methodological limitations in the available research [13].

Several strategies have been developed to optimise antibiotic prescription, including the use of rapid diagnostic tests, clinical decision support systems, Antimicrobial Stewardship Programs, and educational interventions targeting health professionals, patients and their families [14, 15]. The present review focuses on educational interventions to provide a detailed examination of their role, while fully recognizing the critical importance of other strategies in addressing the broader challenge of antimicrobial resistance.

Several factors have been identified as contributing to the high rate of inappropriate antibiotic use, including dispensing of antibiotics without medical prescription, such as over-the-counter-sales in community pharmacies, self-medication, high workload pressure in PC settings, and lack of continuous training of healthcare professionals (HCPs) in infection management [16]. In addition, some contextual factors that can influence the implementation of strategies aimed at promoting the appropriate use of antibiotics have been identified [17]. Furthermore, several educational strategies to prevent unnecessary antibiotic prescriptions in children have been developed over the last two decades [18]. However, no prior systematic analysis of the reviews that explore the effectiveness of the educational interventions and the contextual factors relevant to their design and implementing them.

Scoping reviews synthesise evidence on how research is conducted, identify key characteristics or factors related to a concept, and identify and analyse knowledge gaps [19]. We, therefore, conducted a scoping review to inform the development of two eHealth based educational interventions to optimise antibiotic prescription in uncomplicated ARTIs in children attending the PC, in the context of the OptimAP project in four regions of Spain (Clinical

Trials Register number NCT05166369). One intervention will provide online training in communication skills, and educational materials to PC paediatricians. The other intervention will provide parents or caregivers with educational information on uncomplicated ARTIs [20].

Methods

Study design

We conducted a scoping review of reviews, following the methodological steps outlined by the Joanna Briggs Institute (JBI) Methodological Guidelines for scoping reviews [21]. We adopted the PRISMA Extension for Scoping Reviews (PRISMA-ScR) for data reporting [22]. The protocol was published in OSF iRegistries [23].

Stage 1: Identifying the research questions

We proposed two research questions: (1) to identify and describe educational interventions and their components to optimise antibiotic prescription in children with uncomplicated ARTIs in PCs (reviews assessing educational interventions), and (2) to map contextual factors that may influence the implementation of interventions addressing antibiotic prescription optimisation in uncomplicated ARTIs in PCs (reviews assessing contextual factors).

Stage 2: Identifying relevant studies

We designed a search strategy based on previous reviews and included the main components of our research questions (Additional File 1. I Search Strategy. Tables 1, 2, 3 and 4). The search was conducted in MEDLINE (via PubMed), CINAHL and Epistemonikos to identify systematic reviews published from January 2010 to December 2022. We also reviewed the lists of references from the included reviews.

The eligibility criteria we applied is listed in Additional File 1. (II Eligibility Criteria. Table 1, and 2).

Type of reviews

We included reviews that reported using a search strategy, including systematic reviews, scoping reviews, overviews, literature or narrative reviews, qualitative evidence synthesis, and mixed methods research synthesis. For reviews assessing the effectiveness of educational interventions, we included those with at least one randomised clinical trial (RCT). Primary studies, editorials, research letters, and thesis dissertations were excluded.

Population of interest

We included reviews addressing (1) HCPs from PC settings, including paediatricians, nurses, PC pharmacists, and community pharmacists; and/or (2) parents or caregivers of children with uncomplicated ARTIs.

To identify the contextual factors, we also included reviews addressing the public.

Interventions

Interventions to improve antibiotic prescription with at least one educational component. We defined educational interventions as any attempt to encourage HCPs to modify antibiotic prescription practice and to parents to increase their knowledge, beliefs, or attitudes towards improving antibiotic use. Educational interventions could be delivered individually or in groups of people, in single or multiple sessions, regardless of whether they included an action plan. We excluded reviews of studies focused on diagnostic procedures (e.g., rapid diagnosis tests), mass media without educational interventions or clinical decision support system interventions (including decision aids).

Phenomenon of interest

To address our first objective, we retrieved information about the effectiveness of educational interventions to improve antibiotic prescription in children with uncomplicated ARTIs. The effectiveness of these interventions is typically using outcomes such as antibiotic prescriptions rates, consultation rates, knowledge, attitudes and expectations, and satisfaction. For our second objective, we identified contextual factors that may influence the implementation of interventions aimed to optimise antibiotic prescription. Contextual factors were defined as a set of active and unique characteristics or circumstances surrounding the practice of antibiotic prescription. These factors may represent either barriers or facilitators to the educational interventions' implementation [24].

Setting and Language

Outpatient settings: PC centres and/or community pharmacies. We included reviews published in English or Spanish.

Stage 3: Study selection

Two previously calibrated reviewers independently selected references based on title and abstract, using Rayyan QCRI software (Rayyan QCRI) [25]. Subsequently, a pair of reviewers independently selected the reviews based on full texts. Disagreements were solved by consensus or with the help of a third reviewer. References were managed with EndNote.

Stage 4: Charting the data

We used a previously pilot-tested data charting (Additional File 1. III Charting Data and "Best Fit" Framework Synthesis Steps. IV Terms of Definition of the Scoping Review). Pairs of previously calibrated reviewers extracted relevant information from the included

reviews. Disagreements were solved by consensus or with the help of a third reviewer.

Stage 5: Collating, summarising and reporting the result
We used the “Best fit” framework synthesis approach, consisting on seven deductive steps, to collect, analyse and evaluate the information (Additional File 1. III Charting Data and “Best Fit” Framework Synthesis Steps. Table 1, and 2) [26].

We examined previous reviews of studies exploring factors influencing antibiotic prescription [27–29]. After careful consideration, we selected and adapted the Consolidated Framework for Implementation Research (CFIR) [30]. We developed a logic model, based on this framework, to explain how educational interventions can optimise antibiotic prescription. As part of the development process, we consulted experts (a qualitative researcher, a public health expert and a psychologist) and clinicians (a paediatrician and a nurse) to improve the model.

The logic model was constructed through an iterative process, as analysis was performed, with new themes emerging as the analysis proceeded (Fig. 1). This model consists of three main domains. (1) **Intervention characteristics**, the themes that emerged from this domain related to the type of intervention, the components, the target population, the mode of delivery and effectiveness

components. (2) **Contextual factors**: contains three subdomains being (a) Outer setting: Themes related factors outside the system such as public health policies or influence of other stakeholders; (b) Inner setting: Themes related to factor inside the system, such as HCP perceptions and attitudes; and (c) Characteristics of Parents: Themes related to sociodemographic characteristics as well as their perceptions. **3) Process-related factors** with subdomains: barriers and facilitators of antibiotics use and implementation considerations of the interventions. More details are in Additional File 1.

The findings from reviews assessing the characteristics and effectiveness of educational interventions were narratively synthesised using the components of the intervention characteristics of the logic model (e.g. target population). The following definitions were developed to classify the effectiveness of educational interventions:

- Measures that showed a positive outcome in terms of antibiotic use, the knowledge of population or HCPs, consultation rate, attitudes, expectation and satisfaction were classified as “more effective”.
- Measure that showed no improvement, or were unclear, or worsen about the use and prescription of antibiotics, the knowledge of the population or HCPs, consultation rate, attitudes and expectation satisfaction, were classified as “less effective”.

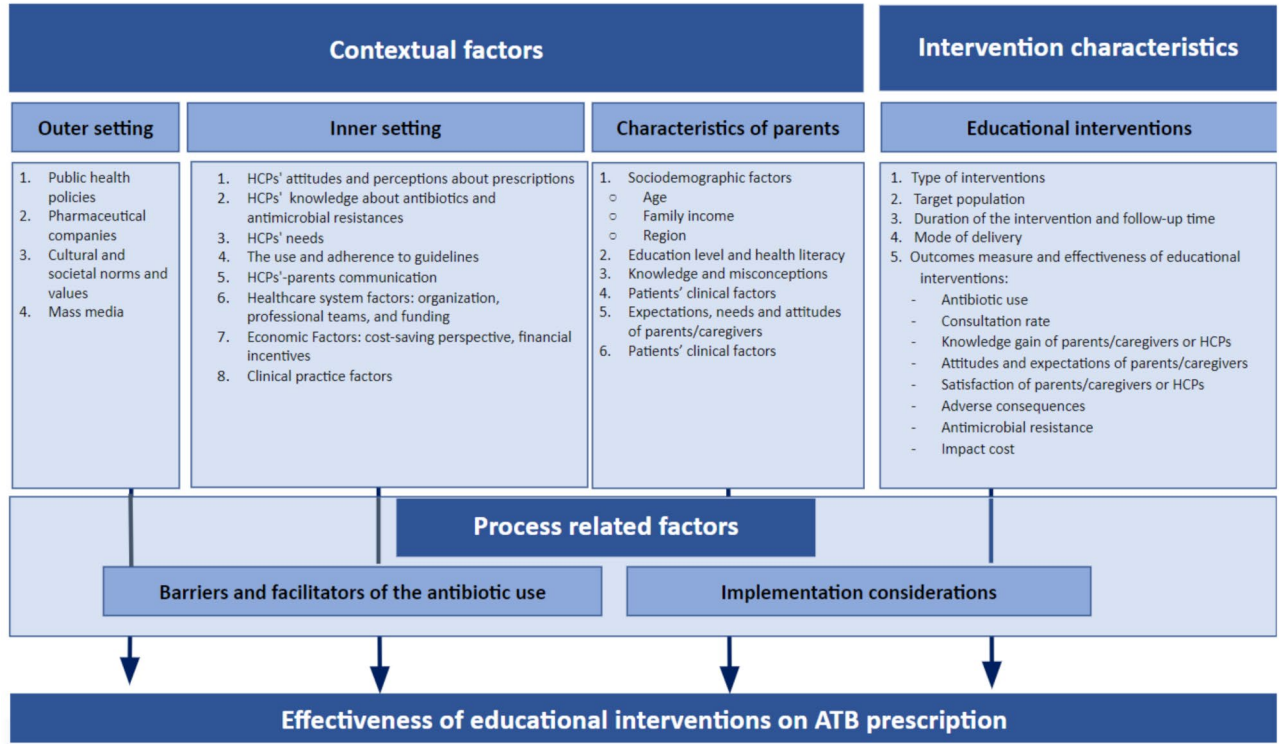


Fig. 1 Logic model illustrating the factors that influence the effectiveness of educational interventions to optimise antibiotic prescription in paediatric uncomplicated acute respiratory tract infections

When an educational intervention was implemented alongside a non-educational intervention, the included reviews did not differentiate the results by intervention type. Therefore, this scoping review reports the findings similarly. Additionally, the number of reviews categorised by type of educational intervention has been quantified.

The synthesis of qualitative findings related to contextual factors, derived from qualitative or narrative reviews included (1) line-by-line coding themes from results and discussion sections, (2) deductive classification of themes concerning the logic model, and (3) inductive identification of new themes (for findings not suitable to the logic model). Therefore, the logic model was iteratively refined. Finally, we developed descriptive and analytical themes within each subdomain. One reviewer (UEA) proposed the initial themes, and a second reviewer cross-checked and confirmed that they were based on other subdomains. Final themes were discussed with the review team

for final approval. We charted the data in a spreadsheet (Excel®) (Additional File 2).

Quality of included studies

We collected the instruments used in the included reviews to assess the quality of the individual studies. We report narratively the overall quality of the evidence as reported in the included reviews.

Results

Study selection

We included a total of 33 reviews, selected as described in the PRISMA flowchart (Fig. 2) [22]. Reasons for exclusion of reviews are available in Additional File 1. II Eligibility Criteria. Table 1, and 2.

Characteristics of included reviews

Among the reviews included, 11 (33.3%) addressed the effectiveness of educational interventions [18, 31–40],

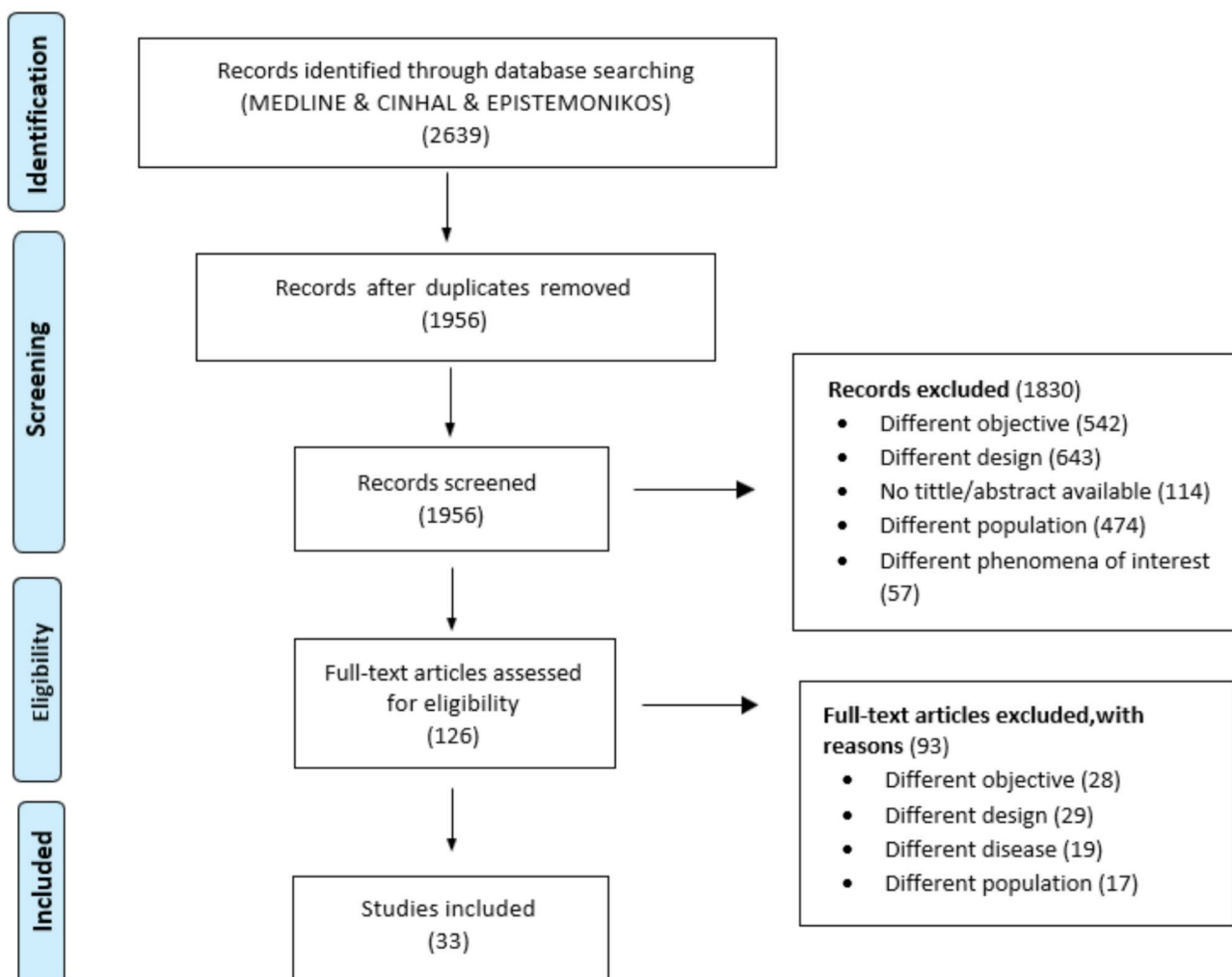


Fig. 2 Flowchart of the study screening process

Table 1 Effectiveness reviews' main characteristics

Author, Year, Country	Review Type	Objective	Number of studies including educational intervention ¹	Type of primary study design of the reviews	Country or region of primary studies	Setting	Target Population	Quality assessment of the included studies	Number of participants
Vodicka 2013 UK [31]	Systematic review	To review the effectiveness of educational or behavioural interventions	15	Randomised and non-randomised evidence	USA, Israel, Europe and Australia	PC ² , emergency department, health organisation	Parents, paediatricians, family doctors, nurses, community pharmacist	Moderate	Clinicians: 6 to 1116, Parents: 7 to 449, Children: 326 to 13,460
O'Sullivan 2016 Australia [40]	Systematic review, Qualitative evidence synthesis	To evaluate the effectiveness of written information	2	Randomised evidence	UK and USA	PC ²	Parents, children, family doctors	Low or moderate	PC doctors: 269; Clinicians: 61; Children: 558
Boonacker 2010 The Netherlands [32]	Systematic review	To analyse the effectiveness of interventions and to analyse the costs associated with these interventions.	8	Randomised and non-randomised evidence	Not reported	PC ² , emergency department	Paediatricians, family doctors, nurses, primary care pharmacists	Low	Clinicians: 6 to 175, Children: 324 to 13,460
Hu 2016 Canada [18]	Systematic review	To analyse the effectiveness of different intervention approaches and the factors that influence on the effectiveness.	12	Randomised and non-randomised evidence	USA, Israel, Norway, UK, Iran and Canada	PC ² , hospital	Parents and health professionals without specification	Moderate	Clinicians: 27 to 578, Patients: 81 to 97,699
Lee 2015 Korea [33]	Systematic review	To assess the relevance of educating, and to evaluate the effectiveness of interventions and their main aspects.	28	Randomised evidence	Not reported	PC ² , hospitals	Parents, children, clinicians, nurses, community pharmacists	Not reported	Not reported
An-drews 2011 USA [34]	Systematic review	To identify interventions that can be applied to the multi-component interaction between parents and doctors	20	Randomised and non-randomised evidence	USA, UK and Israel	PC ² , emergency department and day care	Parents, children	Not reported	Parents and children: 20 to 2916
McDonagh 2018 USA [35]	Systematic review	To compare effectiveness strategies with other strategies or standard care.	65	Randomised and non-randomised evidence	USA and Europe	PC ² , emergency department and hospitals	Parents, paediatricians, health professionals without specification, children	Moderate	Clinicians: 101,443; Patients or parents: 7,452,357
Neo 2020 USA [36]	Literature or narrative review	To assess factors associated with the successful implementation of interventions. To offer strategies that enable healthcare administrators, clinicians, and researchers to make informed choices.	15	Randomised and non-randomised evidence	Not reported	PC ² and hospitals	Parents, health professionals without specification	Not reported	Not reported
Huttner 2010 Switzerland [37]	Systematic review, Literature or narrative review	To update the evidence about the characteristics and outcomes of large-scale public campaigns in high-income countries that aim to improve the use of antibiotics.	22	Randomised evidence	Not reported	PC ²	Parents, children, paediatricians, family doctors, health professionals without specification and community pharmacists	Not reported	Not reported

Table 1 (continued)

Author, Year, Country	Review Type	Objective	Number of studies including educational intervention ¹	Type of primary study design of the reviews	Country or region of primary studies	Setting	Target Population	Quality assessment of the included studies	Number of participants
Wang 2015 France [38]	Literature or narrative review	To identify measures implemented in France and abroad for antibiotic stewardship in general practice.	24	Randomised and non-randomised evidence	Not reported	PC ² , hospitals, community pharmacies	Parents, family doctors, community pharmacists	Not reported	Not reported
Korppi 2022 Finland [39]	Minireview	To summarise the data on the implementation of antibiotic stewardship programs and their impact.	5	Randomised and non-randomised evidence	USA	PC ²	Parents, physicians, pharmacist	Not reported	Not reported

¹ In most cases, the number of studies including educational interventions are the same as the total number of included studies (i.e. Vodicka's review contains 17 studies, and 17 studies include educational interventions). However, in other reviews such as Andrews et al., McDonagh et al., and Wang et al., the number of studies containing educational interventions is lower (Andrew's review contains 23 studies in total and 20 studies including educational interventions). Ten out of the 11 included reviews contain primary studies that assess educational interventions as well as non-educational interventions (e.g. delayed prescription, audit and feedback). ² PC: Primary care

and 22 (66.7%) the contextual factors of antibiotic prescription [17, 27, 41–60]. Tables 1 and 2 show the main characteristics of the included reviews.

Country and setting

The most frequent countries of origin of the primary studies included in the reviews were USA (21/33; 63.6%) [17, 18, 27, 31, 34, 35, 39, 40, 42–44, 48–50, 52, 53, 55–59], UK (17/33; 51.5%) [17, 18, 34, 40, 42–44, 46, 50–58], European countries (13/33; 39.4%) [17, 18, 27, 31, 35, 43, 48, 50–52, 55, 58, 59] and Canada (8/33; 24.3%) [18, 43, 46, 48, 50, 52, 55, 58]. Less frequently the reviews included studies from Asia (12/33; 36.4%) [17, 18, 27, 45–48, 52, 55, 58, 59], Africa (5/33; 15.1%) [17, 44, 45, 51, 55, 58], and South America (2/33; 6.0%) [17, 51]. More details of the distribution of primary studies by country of origin are available in Additional File 3. Figure I. Distribution of primary studies by country of origin.

Almost all primary studies were conducted in the PC setting, although some reviews included few primary studies conducted in emergency departments (7/33; 21.2%) [31, 32, 34, 35, 53, 54, 57], hospitals (13/33; 39.3%) [33, 36, 38, 41, 43, 45, 47, 48, 50, 53, 57–59], and community pharmacies (5/33; 15.1%) [38, 46, 48, 54, 57].

Sociodemographic and clinical information

The number of participants in each primary study and across reviews varied widely (6–485,632 participants). From the 11 reviews assessing effectiveness, eight reviews (72.7%) did not report the sex of participants, while in 3/11 (27.3%) it was reported. About the age from the 11 reviews, four (36.4%) included adults (parents or HCPs), one included adults and children (9.1%) and the remaining 6 (54.4%) did not specify the age group. Eighteen reviews studied both upper and lower ARTIs (18/33; 54.5%) [18, 27, 31, 33–35, 37, 39, 41, 43, 48, 49, 52–54, 57, 59, 60] and 15 reviews included only upper ARTIs (15/33; 45.4%) [17, 32, 36, 38, 40, 42, 44–47, 50, 51, 55, 56, 58].

Quality of included studies

Most of the reviews evaluated the quality of included studies (21/33, 63.3%). The most common tool for assessing the quality of the studies was the Cochrane Risk of Bias Tool [61] (6/33;18.2%) [18, 31, 32, 34, 40, 43], followed by the Critical Appraisal Skills Programme tool [62] (5/33;15.1%) [17, 42, 50, 52, 56], and by the Drug Effectiveness Review Project [63] (1/11;3.0%) [35]. One review evaluated the certainty of evidence with GRADE [40, 64].

The majority of the reviews considered the quality of the studies to be low to moderate. The detected methodological limitations referred to the study design and implementation of the intervention, including contamination between groups [40], lack of randomization [18,

Table 2 Main characteristics of the reviews assessing contextual

Authors, Year, Country [reference]	Review Type	Objective	Num-ber of included studies	Type of pri-mary study design in the reviews	Country or region of primary studies	Settings	Target population	Quality as-sessment of the included studies	Number of participants
King2018 USA [60]	Literature or narra-tive review	To synthesise the causes of inappropriate antibiotic prescription and potential antibiotic stewardship interventions in outpatient settings. To provide an overview of the consequences and epidemiology of outpatient antibiotic prescription.	Not reported	Randomised and non-randomised evidence	Not reported	Not reported	Parents, physicians	Not reported	Not reported
Ray O'Connor 2017 Ireland ([41])	Literature or narra-tive review	To identify primary care providers' deci-sions factors when prescribing	139	Randomised and non-randomised evidence	Not reported	PC ¹ , hospitals	Family doctors, nurse practitioners, maternal child health nurses, pharmacists	Not reported	Not reported
Bosley 2017 UK [42]	Systematic review	To explore the influences of parental attitudes to antibiotic prescription	20	Randomised and non-randomised evidence	Asia, Middle East, UK, USA, South America	PC ¹	Parents, children and physician	Low	Parents: 10 to 5312
Kyaw 2018 Singapore [43]	Systematic review	To assess the effectiveness of digital technology to deliver education on antibiotic management	8	Randomised evidence	USA, UK, Canada, China, Netherlands, Wales, Belgium, Spain, Poland	PC ¹ , hospitals	Parents, physician	Low	PC practices: up to 655, Primary care physicians: up to 1392, Patients: 485,632. Participants: 12 to 479
Ness2016 UK [44]	Mixed methods research synthesis	To identify antimicrobial prescription behaviour in all clinical settings.	7	Non-randomised evidence	USA, South Africa and UK	PC ¹ , other clinical settings	Nurses	Not reported	Nurses: 36 to 509
Papoutsis 2017 UK [58]	Mixed methods (realistic review)	To understand how interventions change behaviours of doctors in training on antimicrobial prescription and the effects of these interventions.	131	Non-randomised evidence	USA, UK, Canada, Australia, France, Sweden, Nigeria, Turkey, Spain, Switzerland, and Peru, Brazil, Netherlands, Belgium, India, Egypt, Singapore, Ireland Korea, Israel, Thailand, Mexico	PC ¹ , hospitals	Physicians in training	Not reported	Not reported

Table 2 (continued)

Authors, Year, Country [reference]	Review Type	Objective	Num-ber of included studies	Type of pri-mary study design in the reviews	Country or region of primary studies	Settings	Target population	Quality as-sessment of the included studies	Number of participants
Md Rezal 2015 Sweden UK [45]	Systematic review	To review the knowledge, perceptions and behaviour of clinicians regarding antibiotic prescription.	19	Randomised and non-randomised evidence	Developed Countries and Bangladesh, DR Congo, India, Lesotho, Peru, Sudan and Trinidad and Tobago	PC ¹ , hospitals	Family doctors	Low	Clinicians: 12 to 695
Saha 2019 Australia [46]	Scoping review or mapping review (Qualitative evidence synthesis)	To identify surveys and tools to be used in stewardship monitoring and to measure and report the knowledge, perceptions and practices of clinicians.	10	Non-randomised evidence	Australia, UK, Malaysia, Ethiopia, Qatar, Pakistan, Canada	PC ¹ , community pharmacies	Community pharmacist	Low, moderate and high	Clinicians: up to 1530
Shaikhhan 2018 UK [47]	Systematic review	To evaluate the knowledge, attitude and practice regarding antimicrobial use	3	Non-randomised evidence	Qatar	PC ¹ , hospitals and other healthcare settings.	Parents	Moderate	Parents: up to 1111 participants
McCullough 2016 Australia [48]	Systematic review	To identify public's knowledge and beliefs about antibiotic resistance	54	Randomised and non-randomised evidence	Europe, Asia, USA, Canada	PC ¹ , hospitals, Community pharmacies and emergency department	Public	Not reported	Public: up to 55,225
Byler 2016 USA [49]	Literature or narrative review; Systematic review	To provide evidence on the use of shared decision making to promote appropriate use of antibiotics	12	Randomised and non-randomised evidence	USA, German, Switzerland, Canada, UK and Netherlands	PC ¹ , college students	Physicians in training	Not reported	Clinicians: up to 506, Students: up to 1262, Adults: up to 2750
Cantero-Arévalo 2016 Denmark [17]	Systematic review	To describe parents' knowledge and attitudes towards doctors, antibiotic use, and their behaviour when their children suffer from an ARTI	43	Non-randomised evidence	UK, USA, Wales, Poland, Norway, Spain, Vietnam, Iceland, Equator, Hong Kong, Jordan, Peru, China, Cyprus, Greece, Saudi-Arabia, Mongolia, Sweden, Trinidad-Tobago, Korea, Israel, France, Belgium, Italy, Turkey, UK, USA, Netherlands, Italy, Australia and Finland	PC ¹	Parents	Not reported	Parents: 35 to 1000
Cabral 2014 UK [59]	Systematic review, Meta-ethnography	To synthesise the evidence on communication and decision making	13	Non-randomised evidence		PC ¹	Parents, paediatricians, nurses	Low and high	Clinicians: 38, Parents: 533

Table 2 (continued)

Authors, Year, Country [reference]	Review Type	Objective	Num-ber of included studies	Type of pri-mary study design in the reviews	Country or region of primary studies	Settings	Target population	Quality as-sessment of the included studies	Number of participants
Teixeira Rodrigues 2013 Portugal [50]	Systematic review, Qualitative evidence synthesis	To explore clinicians' perceptions about factors influencing antibiotic prescription	35	Non-randomised evidence	Peru, Belgium, UK, Iceland, Canada, Thailand, Germany, Netherlands, India, Italy, China, Sweden, Spain and USA	PC ¹ , hospitals	Physicians	Not reported	Not reported
Silverberg 2017 Canada [51]	Scoping review or mapping review	To understand the teaching strategies employed in educating students on antimicrobial stewardship, and to determine their implementation, evaluation and effectiveness.	48	Non-randomised evidence	North America, UK, France, Sweden, Ireland, South Africa, Brazil, Australia, India, Nepal, Thailand, Malaysia, Bangladesh, China and Japan	Not reported	Family doctors	Not reported	Not reported
Tonkin-Crine 2011 UK [52]	Systematic review, Meta-ethnography	To examine clinicians' attitudes, perceptions and experiences of antibiotic prescription and interventions aimed at a more prudent prescription for ARTIs	12	Non-randomised evidence	UK, Belgium, France, Poland, Spain, UK, Norway, The Netherlands, New Zealand, Iceland, USA	PC ¹	Family Doctors	Not reported	Not reported
McKay 2016 Canada [53]	Systematic review	To identify and evaluate the characteristics of patients, clinicians and the environment associated with antibiotic use	28	Non-randomised evidence	USA, The Netherlands, Canada, Germany, UK and Belgium	PC ¹ , hospitals and emergency department	Parents, paediatricians, another physician	Not reported	Children: 273 to 4870 (Clinicians: not reported)
Lucas 2015 UK [27]	Systematic review, Qualitative evidence synthesis	To review the literature on the influence of views, beliefs, and attitudes of parents, children, and clinicians on antibiotic prescribing decisions	15	Non-randomised evidence	USA, France, Iceland, Norway, New Zealand, France, Poland, Spain, and Belgium	PC ¹ and hospitals	Parents, paediatricians, another physician	Not reported	Clinicians: up to 207, Parents: up to 101
Borek 2020 UK [54]	Rapid Reviews	To identify ways to optimise antimicrobial stewardship interventions by analysing behavioural content.	30	Randomised and non-randomised evidence	UK	PC ¹ , emergency care, community pharmacy	Family doctors, emergency care physicians, community pharmacist	Not reported	Not reported
Yau 2021 Australia [55]	Narrative review	To describe the appropriateness of antimicrobial prescription, to identify risk factors associated with AMS prescription, to assess the effectiveness of AMS interventions, to look for the correlation between AMR with antibiotic prescription and/or the volume of antibiotic use.	51	Randomised and non-randomised evidence	Niger, Australia, Alaska, Canada, USA, New Zealand, China, Pakistan, India, Kenya, Germany, Wales, Spain, Ireland, Saudi Arabia, Finland, Laos, UK	PC ¹ (rural)	Parents, physicians	Not reported	Not reported

Table 2 (continued)

Authors, Year, Country [reference]	Review Type	Objective	Number of included studies	Type of primary study design in the reviews	Country or region of primary studies	Settings	Target population	Quality assessment of the included studies	Number of participants
Rose 2021 UK [56]	Qualitative literature review	To explore family doctors' views and opinions, to determine the driver's influencing over-prescription and to determine how antibiotic prescription can be improved.	17	Non-randomised evidence	India, Spain, USA, UK, Sweden, Iceland	PC ¹	Family doctors	Not reported	Not reported
Chater 2020 UK [57]	Systematic review	To identify the evidence regarding the influences of non-medical prescribers on antimicrobial prescription behaviour.	8	Randomised and non-randomised evidence	UK, USA	PC ¹ , emergency care, hospital community pharmacy	Physicians, non-medical prescribers (nurses, pharmacists, paramedics, physiotherapists)	Moderate	Not reported

¹ PC: Primary care

[34], short assessment period [39], limited external validity (e.g. exclusion of low-income settings or severe cases) [31, 34, 37, 39, 40], poor reporting of surrogate outcomes such as knowledge or satisfaction [31, 35, 37, 40], diagnostic criteria (due to the lack of explicit diagnostic criteria and change in diagnostic labelling by participating physicians) [31, 34, 40], and variability in the terminology used for antibiotic use [35, 36].

Reviews assessing educational interventions: characteristics and effectiveness

Intervention characteristics

Type of intervention

The 11 reviews included a total of 182 interventions with at least one educational component out of 213 interventions identified overall. There were six types of educational interventions as shown in Table 3. Although the objective was related to the educational interventions, 31 interventions out of 213 (6.9%) were implemented in combination with non-educational components. The types of non-educational interventions were: (1) audit and feedback [18, 31, 33, 35–40], (2) decision-making tools for professionals [18, 31–33, 35, 37, 38], (3) delayed antibiotic prescription [18, 33, 35, 37, 38], (4) guidelines [18, 35–39], (5) point-of-care testing [35], and (6) financial intervention [38].

Target population, duration of intervention and follow-up time

In most studies, the target population included both, parents/caregivers and HCPs (7/11; 63.6%) [18, 31, 33, 35, 37, 39, 40]. Parents/caregivers were the unique target population in one review (1/11; 9.0%) [34], and HCPs in three reviews (3/11; 27.3%) [32, 36, 38]. Figure 3 shows educational interventions addressed to HCPs, parents/caregivers or both in the included reviews.

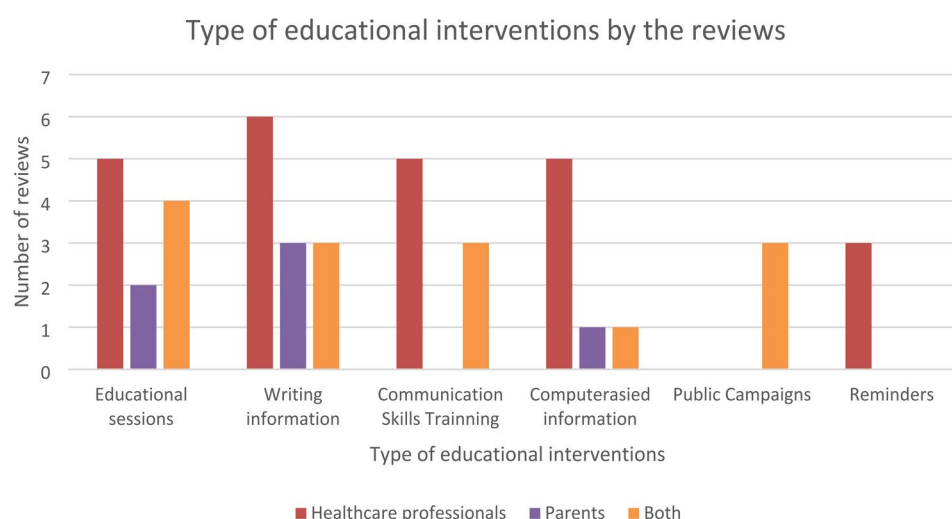
Seven reviews reported the duration of the intervention (7/11; 63.6%) [18, 31, 32, 35–37, 40], showing a wide variability, ranging from less than one hour to ten years. Nine reviews reported the follow-up time (9/11; 81.8%) [18, 31, 32, 34–37, 39, 40], varying from less than one month to 36 months.

Mode of delivery of the interventions

From the 11 effectiveness reviews assessing effectiveness, 51 interventions specified the mode of delivery. Of these 39.2% (20/51) of the interventions were conducted online, 33.3% (17/51) face-to-face, and 19.6% (10/51) used a mixed approach combining both face-to-face and online methods. The remaining four interventions did not explicitly state the delivery mode. Educational sessions were mainly mixed or face-to-face, communication skills training was mainly face-to-face, and public campaigns and computerised information were only online.

Table 3 Type of educational interventions included: description and number of reviews

Type of interventions' components	Description of the intervention components	Number of reviews that included each intervention component	References
Educational Sessions	Workshops, seminars, clinical meetings towards HCPs or parents with the aim of improving knowledge and attitude about the use of antibiotics.	6	[18, 32, 33, 35, 36, 40]
Written Information	Disseminate information through pamphlets, leaflets, any other physical format towards HCPs or parents with the aim of improving knowledge and attitude about the use of antibiotics.	10	[18, 31–35, 37, 38, 40]
Communication Skills Training	Training programs focus on the improvement of HCPs-patients communication.	9	[18, 31, 32, 34, 35, 37–40]
Computerised Information	Disseminate information through videos, apps, or other digital devices towards HCPs or parents with the aim of improving knowledge and attitude about the use of antibiotics.	11	[18, 31–40]
Public Campaigns	A combination of strategies of information toward the public or a or specific population of each disseminated on a large scale by mass media, in healthcare centres, schools, collage, ... which involved educational interventions (printed or online material, media (radio, TV), mass mailing, seminars, academic detailing) and non-educational ones (rapid test antigen and audit and feedback)	3	[35, 37, 38]
Reminders	Messages to update and remember information (e.g. knowledge or adequate practice) treat before in another intervention. The format could be pop-ups, mails,...	3	[31, 33, 36, 37]

**Fig. 3** Educational interventions addressed to HCPs, parents or both in the included reviews

Written information strategies were delivered face-to-face. Reminder strategies were disseminated online, face-to-face and mixed. More details in Additional File 3. Figure II. Mode of Delivery of the educational interventions.

Outcomes measure and effectiveness of educational interventions

Most of the educational interventions were reported as effective (136/182; 74.7%). Table 4 below summarises the findings of the reviews according to the effectiveness of educational interventions per outcome and the implementation factors identified.

Antibiotic use

Educational interventions showed a reduction in antibiotic use of 6–21% in absolute terms [31] and 9–52% [33]. McDonagh et al. conducted an effective clinical-based educational intervention for parents/caregivers in which the reduction of antibiotic use was 21.3% [35]. Targeting parents/caregivers along with HCPs (commonly physicians) appeared to be more effective than implementing interventions separately [18, 31, 35, 36, 39, 40]. Interventions targeting only parents/caregivers showed inconsistent results [34, 35].

Overall, combined interventions with different strategies appeared to be more effective than single interventions [32–36, 39]. Communication skills training appeared to be a very effective type of intervention [18,

Table 4 Summarise of the reviews' findings according to the effectiveness of educational interventions by outcomes and implementation factors

Antibiotic use	
More effective	Less effective
Combined	Individual
- Educational sessions combined with educational materials for physicians and/or parents [31, 32]. - Educational sessions (online by training video towards healthcare professionals for better management in children with ¹URTIs) in combination with risk factor checklist [32]. - Educational sessions combining a delayed or no antibiotic prescribing strategy [34]. - Educational sessions plus audit feedback [33, 39]. - Educational session for patients (written information), plus audit and feedback [35] - Clinical practice guidelines (collaborative development), combined with written or computerised information [32]. - Communication skills training plus point-care testing, including shared decision-making interventions [35]. - Public education campaigns plus clinician and patient or parent education interventions [35]. - Guidelines and leaflets [33].	- Educational sessions for parents (33–36). - Educational session for HCPs such meetings or academic detailing [32, 34, 36]. - Written information to parents of children with ²ARTIs given by physicians for example an eight-page booklet on acute URTIs given during a consultation or written interactive materials during the consultation. [40]. - Communications skills training [18, 33] - Public campaigns aimed at educating parents (33,35–38).
Consultation Rate	
More effective	Less effective
- Educational sessions clinical based for parents [35]. - Writing information (pamphlet-based) in upper ARTI [35]. - Educational sessions towards parents like informative, illustrated booklets prior to their child becoming ill, and specifically sore throat, cough, respiratory tract infection and otitis media [34]. - Written information for parents [31]. - Public campaigns for parents [35, 37, 38].	- Communication skill training versus point-of-care C-reactive Protein Testing or usual care [35]. - Writing information (interactive booklet during clinic visits versus computer kiosk in the waiting room [35] - Written information no significant effect on compared to usual care [40]
Knowledge	
More effective	Less effective
- Educational sessions and writing materials among physicians [32] - Educational sessions versus searching in Wikipedia [33] - Computerised information (with or without a pamphlet) among just urban parents [35]. - Computerised information (based on cartoon-animation videos and illustrations) among parents [34]. - Two public campaigns that improve knowledge (increase standard of appropriate use [37, 39]. - Communication skill training [33].	- Public campaigns which try to improve the knowledge between infections caused by viruses or bacteria do not show any change in knowledge or even increase the self-medication [33, 37].
Attitudes and Expectation	
More effective	Less effective

Table 4 (continued)

- Public campaign based on a television spot [37]. - Computerised and written information (videotapes, pamphlets and posters) aimed at parents [35]. - Public campaigns [35, 37]. - Share decision-making among parents [35].		- Writing information (newsletters in the cold and flu season over 3 years) [35]. - Shared decision making among physicians [35].
Satisfaction		
More effective		Less effective
- Educational sessions towards patient and clinician did not decrease satisfaction [35].		- Written information intervention towards parents [40].

More effective: those interventions that presented a positive result in relation to the use and prescription of antibiotics, the knowledge of population or HCPs, consultation rate, attitudes and expectation satisfaction. **Less effective:** those interventions that do not have improvement or worsen in relation to the use and prescription of antibiotics, the knowledge of population or HCPs, consultation rate, attitudes and expectation satisfaction, or even when it is no clear the result or no information is given about effectiveness. Implementation factors are the factors identified in the review that facilitate the implementation of the intervention in each context. ¹URTI: uncomplicated Respiratory Tract Infections. ²ARTI: acute respiratory tract infections. No information on cost-effectiveness, adverse effects or antibiotic resistance is included in this table. The information is scarce and is commented on in the text below

Table 5 Number of reviews assessing contextual factor that included each contextual factor

Constructs	Factor	Number of reviews	References	Constructs	Factor	Number of reviews	References
Charac- teristics of individuals	Age (Sociodemographic factors)	3	[42, 50, 51]	Inner setting	HCPs attitudes and perception about prescription	10	[27, 41, 44, 49–52, 56, 59, 60]
	Family income (Sociodemographic factors)	3	[53, 60, 65]		HCPs knowledge antibiotics and AMR	9	[27, 45, 46, 51, 55, 56]
	Region (Sociodemographic factors)	3	[17, 53, 60]		HCPs needs	3	[27, 41, 52]
	Education and Health Literacy	3	[42, 56, 57]		HCPs- parent communication	6	[17, 27, 42, 49, 59, 67]
	Knowledge and misconception	3	[17, 48, 49]		The use and adherence to guidelines	5	[45, 52, 57, 60]
	Expectations, needs and attitudes of parents/ caregivers	8	[17, 41, 42, 50, 51, 59]		Healthcare system factors	6	[17, 41, 43, 47, 50, 51, 56]
Outer setting	Patients' clinical factors	2	[41, 44, 66]	Outer setting	Economic factors	3	[50, 51, 56]
	Policy	2	[46, 50]		Clinical practice	2	[27, 44, 46]
	Pharmaceutical Industry	2	[27, 41, 45]				
	Social norms	2	[27, 41]				
	Mass media	1	[41]				

[33]. Public campaigns also showed a large effect according to four reviews [33, 35, 37, 38]. According to two other reviews by Mc Donagh et al. and Korppi et al. — one primarily evaluating educational strategies and the other focusing on public campaigns — no reduction in antibiotic use was observed [35, 39].

Consultation rates

Educational interventions showed variable results regarding consultation rates. Five reviews reported some educational interventions showing a reduction in consultation rates from 17 to 13% [32, 34, 35, 37, 38]. Interventions combining communication skills training and point-of-care testing had no impact on reconsultation visits [35]. One of these reviews observed that an intervention based on an interactive booklet about childhood respiratory tract infections delivered at the point of care did not lead to significant differences in the proportion of reconsulting and hospital admissions after two nights [34].

Knowledge gain of parents or caregivers and HCPs

Some educational interventions were described to improve knowledge of appropriate antibiotic use in the public [37], parents/caregivers [34], paediatricians [32] medical students [33]. However, two reviews found inconsistent results in terms of knowledge, showing unclear results or incomplete evaluation of effect [37, 39]. Results were reported narratively, except in one review that reported an improvement of paediatricians' knowledge by more than 20% in absolute terms [32].

One review showed an improvement in adherence to guidelines in the first episodes of acute otitis media after educational interventions [31]. However, another review did not observe such an improvement [35].

Attitudes and expectation of parents and caregivers

One review reported a study (based on a waiting room videotape message intervention) that showed an increase in the proportion of parents/caregivers with appropriate

Table 6 Barriers and facilitators of the appropriate prescription of antibiotics**Barriers of the appropriate use and prescription of antibiotics****Related to parents and children**

The urgency of parents to cure their child [17]

Some sociodemographic factors:

- Living in rural areas [17]
- The age of the children [17].
- And the young age of the parents (since they have less experience and knowledge about antibiotics) [49]

Knowledge

- Parental knowledge was sometimes seen as a facilitator or as a barrier [57]
- Other times the poor knowledge of parents about antibiotics was associated with self-medication [17]
- The increasing college age of parents could be a barrier according to others [49]

Related to HCP

- HCP's time-pressure [45].
- Previous studies and training (the knowledge acquired during university training and from supervisors during hospital training influences the subsequent clinical practice of the physicians) [50]

Related to communication HCPs-parents

- The use of complex terms and jargonistic language by HCPs (influenced a poor HCP-patient relationship) [42]
- The lack of medical examination and of specific clarifications (simply receiving an antibiotic prescription without further explanations) [17]

Related to the pharmaceutical industry

- Unavailability of the recommended antibiotic in some regions [45]
- Oversupply and near-expiry antibiotics in some PC centre [45]
- Economic benefits from prescribing certain antibiotics over others [45]

Related to the community pharmacists

- Lack of training to undertake Antimicrobial Stewardship Programs (e.g. lack of availability of Antimicrobial Stewardship Programs supports dispensing guidelines) [46]
- Lack of access to patients' records and laboratory data [46].
- Lack of systems that support interacting with physicians, physicians' non-receptive behaviours to community pharmacists' interventions on the choice of antibiotics [46]

Related to the design of the interventions

- Lack of long-term studies [51]

Facilitators of the appropriate use and prescription of antibiotics**Related to communication HCPs-parents**

- Listening to patients' demands in consultation, interpreting their expectations [42, 53]
- Providing adequate explanations on care [42, 53]
- Using simple terms [42, 53]
- Providing information and reassurance regarding the self-limiting nature of uncomplicated ARTIs [49]

Related to the community pharmacists

- Offering access to HCPs to internet-based and up-to-date information [45]
- Physicians acting as referent and facilitating a good clinical practice [58]
- Community pharmacists collaborating with physicians [46]
- Doing public awareness campaigns [46]
- Assessing drug interactions [46]
- Adverse drug reactions and allergies to prescribed antibiotics [46]
- Developing patients' clinical and laboratory reports [46]

Related to the context

- Understanding the context of the interventions (result in a meaningful and sustainable change implemented [52, 58])

Related to the design of the interventions

- The use of behavioural science-based interventions and considering psychosocial factors and frameworks (e.g. Theoretical Domains Framework) in their development [54, 60]

attitudes towards antibiotic use (OR=0.20 [0.10–0.39]) [34]. However, there were no changes in antibiotic prescribing rates at 6- and 12-months follow-up [34].

Satisfaction of parents/caregivers and HCPs

Three reviews assessed satisfaction; two did not identify neither a positive or negative effect on parental' or HCPs' satisfaction [35, 40]. Another review did not observe a

relation between parental satisfaction and a delayed prescribing or no prescribing intervention with watchful waiting [34].

Adverse consequences

Potential adverse effects associated with reduced antibiotic use were scarcely evaluated. Three education-based interventions analysed in one review (clinical-based

educational intervention for parents of paediatric patients, public campaigns aimed at parents of young children, strategies combining clinician and patient or parent education intervention) reported no increase in adverse consequences (return office visits and potential complications) and no negative impact on complications [35]. Another review, revealed that campaigns did not have a response plan to manage unintended serious adverse effects associated with the reduction in antibiotic prescription [37].

Antimicrobial resistance

Regarding AMR, some campaigns were associated with a decrease in resistance at least for *Streptococcus pneumoniae* infections in a setting with high baseline antibiotic use and penicillin non-susceptible *Streptococcus pneumoniae* rates [37].

Impact on cost

National campaigns were associated with a reduction in antibiotic expenditure: a decrease in national antibiotic expenditure from NZ\$36 to NZ\$ 14.5 million in New Zealand (1996–2003), a reduction of €850 million in France (2002–2007), and €70 million in Belgium (2000–2006) [37]. However, no review assessed the cost-effectiveness of the campaigns or other types of interventions.

Excerpts from the review texts supporting these results are provided in Additional file 4.

Reviews assessing contextual factors

Contextual factors were analysed according to the constructs detailed in the logic model. Table 5 shows the number of reviews addressing contextual factors and the type of factor categorised in three of the domains of the logic model. We also created an interactive figure to facilitate the visualisation of these findings (Additional File 3. Figure III. Contextual factors related to antibiotic prescribing by the number of the reviews).

Population

The target population addressed in these reviews were parents or caregivers and HCPs (paediatricians, family doctors, nurses and community pharmacists). Parents/caregivers were the selected population in three reviews (3/22; 13.4%) [17, 47, 48] and HCPs in 12 reviews (12/22; 54.5%) [41, 44–46, 49, 51, 52, 54, 56–59]. Seven reviews addressed both parents and HCPs (7/22; 31.8%) [27, 42, 43, 50, 53, 55, 60].

Characteristics of parents and caregivers

Sociodemographic factors

We retrieved information related to age, region and income. Age directly influences antibiotic prescribing [50, 51], and according to Bosley et al., younger

parents/caregivers had less knowledge of antibiotic usage, because they had less parenting practice [42]. Geographic regions also influenced antibiotic prescribing, with no clear pattern of variability between regions [17, 53, 60]. One review showed a higher rate of antibiotic prescribing in rural areas than in urban areas [60]. However, another review found limited data comparing antibiotic prescribing by area to allow firm conclusions [53]. Income was described as an influential factor in antibiotic prescribing [50]. However, there was no unique pattern associated with each socioeconomic level. On the other hand, people with lower income were less likely to receive an antibiotic prescription than patients with private insurance [41, 44, 45]. Sometimes because physicians preferred not to overcharge patients with laboratory fees, they prescribed less [45]. Other times, because paying a consultation fee increased the likelihood of receiving a prescription for antibiotics [41]. On the other hand, patients from deprived socioeconomic areas tended to know and understand less about AMR and were more likely to receive antibiotics for uncomplicated ARTIs [41].

Education and health literacy of parents

Educational level influenced antibiotic prescribing [50], and an association has been observed between a lower educational level and inappropriate prescribing [42, 56]. Access to the internet and other sources of information could vary depending on the educational level, affecting knowledge about these drugs [42]. In addition, parents with a high educational level may perceive themselves as well-informed and feel more confident about appropriate antibiotic use, being more likely to self-medicate [42].

One review reported that parents/caregivers were aware of the importance of completing antibiotic treatment courses but were unfamiliar with the aetiology of infections and when to use antibiotics [42].

Knowledge and misconception

A higher socioeconomic position was associated with better knowledge about antibiotics, although greater knowledge did not always imply an appropriate use [17]. Overall, the public had an incomplete understanding and misperceptions about AMR [49]. Most parents had heard the term AMR and thought about the risk of being hospitalised or the need for prolonged courses of antibiotics, but they had low awareness and perceived a low personal risk of AMR [48]. They attributed the development of AMR to the actions of others, such as clinicians and other patients, and not necessarily to the overuse of antibiotics or not completing a treatment course [49]. Finally, it was not usual for parents to discuss AMR with their physicians [48].

Expectations, needs and attitudes of parents/caregivers

A common finding across reviews was that parents often expected an antibiotic prescription when attending a medical consultation, based on their previous experiences, concerns, and anxiety, sometimes resulting in an inappropriate prescribing practice [41, 42, 47, 50, 56]. Parents were afraid of not recognizing the symptoms of serious illnesses in their children, and this concern made them consult clinicians promptly to validate decision-making and to seek reassurance [42]. This sometimes led to self-medication [42, 51]. Parents often just wanted more information about the symptoms, the diagnosis or comment on previous experiences [59]. It has been shown that antibiotic prescription was more appropriate when the consultation was patient-centred [41]. Cantero-Arévalo et al. remarked that increasing parents' knowledge about the causes of ARTIs and the appropriate use of antibiotics can change their attitudes and behaviours [17].

Patients' clinical factors

The clinical uncertainty about some ARTIs had a large influence on the appropriate antibiotic prescribing [41, 50]. For example, a fever of less than three days duration or phlegm characteristics may urge clinicians to prescribe antibiotics even when there is no scientific evidence that these are necessary. Patients' conditions or individual factors such as allergy, comorbidity, pregnancy or other specific clinical conditions could also influence antibiotic prescribing [50]. The efficacy and tolerability of antibiotics were among the most influential factors in prescribing decisions [44].

Inner setting

Healthcare professionals' attitudes and perceptions about prescriptions

Attitudes of HCPs were considered the most important factor affecting antibiotic prescribing [50]. Overall, physicians' attitudes and feelings related to prescribing, such as fear or anxiety related to misprescribing, may lead to overprescribing [27, 50, 51, 56]. One review found no association between empathy or burnout and antibiotic prescribing for ARTIs in PC [41].

HCPs' perceptions influenced inadequate prescribing and there were several factors related

Clinic-related factors: (a) Perception of fear of complications from infections [27, 50, 60], (b) feeling uncertainty about ARTIs management [41, 52, 59], (c) Perception of the severity of the illness and abnormal results through the clinical examination [41], (d) Perception that overprescribing is not a problem [27].

Healthcare system-related factors: (a) Perception of lack of time and work overload [41, 60], (b) Feeling that

explaining to parents why antibiotics are unnecessary takes more time than writing [60].

Patient-physician related factors: (a) Parental pressure or implicit request for an antibiotic prescription [27, 41, 45, 49, 52, 59, 60], (b) Perception that parents need for a quick relief of children symptoms [45] (c) Perception that parents are questioning their diagnosis or therapeutic decision [41, 59] when parents are actually seeking for information or are concerned about some aspects of the treatment options [59], (d) Concern about the consequences of the patient-physician relationship, which implies prioritizing patients' satisfaction and expectations rather than selecting the most appropriate treatment [27, 41, 45, 50, 52, 56]. Texeira Rodriguez et al. also observed that fear of losing patients was directly related to antibiotic misprescribing, although complacency had little or no influence on antibiotic prescription [50].

According to Cabral et al., parental pressure was rare, but many times parental communication and behaviours were interpreted by physicians as pressure for antibiotic prescribing [59]. However, many clinicians who were conscious about overprescribing, anticipated pressure for antibiotic prescription and made an adequate prescription or gave recommendations justifying their prescription of non-antibiotic treatment [27, 44, 59]. When clinicians asked parents for feedback, this was seen as an opportunity to improve the patient-physician relationship [52].

Healthcare professionals' knowledge of antibiotics and antimicrobial resistance

Physicians believed that it was possible to reduce antibiotic use without putting their patients at risk to prevent the escalation of AMR, but they also believed that antibiotic use could reduce the occurrence of complications [45]. University education, postgraduate continuing education and work experience were identified as factors positively influencing physicians' knowledge and perception of AMR [41, 46, 50]. If physicians did not have direct experience with the consequences of antibiotic overuse, they did not change their practice even if it was incorrect and despite knowing the possible negative consequences [57].

Knowledge about AMR varied between regions and years of experience of the HCPs. Physicians who had a relaxed and complacent attitude toward AMR, were potentially causing increased antibiotic prescriptions [51, 56]. Physicians had a general idea about the problem of AMR and its consequences, but their knowledge regarding the prevalence of AMR in their local settings was limited [45].

Healthcare professionals' needs

There was little discussion of the needs of HCPs. Lucas et al. highlighted that physicians needed to quickly complete consultations and ensure that both parents and clinicians were satisfied after it [27]. Findings showed that physicians needed further guidance on how to answer patients' concerns without interpreting their questions as a demand for antibiotics [41]. Moreover, clinicians found it difficult to educate parents to understand that antibiotics were not necessary [27], stating that a more holistic approach should be performed when assessing patients' needs [52].

The use and adherence to guidelines

Guidelines use can be an influential factor in physicians' decision-making [50]. Non-physician prescribers found them useful [57]. However, the results remain inconclusive [45, 50, 52, 60]. The limited guideline recommendations for some conditions [60] and the low physicians' confidence in guidelines may contribute to inappropriate variations in antibiotic prescribing [45]. Pocket antibiotic guidelines were rated as the most useful source of information [45], and in some places (e.g. Spain) clinicians preferred guidelines adapted to the local context [52]. In addition, King et al.'s review found that physicians in the USA followed guidelines' recommendations for outpatient conditions, but there was sometimes low adherence in common conditions, such as acute otitis media, sinusitis or pharyngitis [60].

Healthcare professionals-parents communication

Communication was a key element influencing antibiotic prescribing [42, 49, 50, 59], some of the main factors influencing the HCP-parents interaction being:

Positive factors: (a) trustful and open communication, (b) easy access to clinician, (c) use of a range of communication methods (telephone, email, appointments) and, (d) addressing the need for antibiotics and the risks involved [17, 27, 42].

Negative Factors: (a) jargon and difficult vocabulary [42], (b) clinicians not spending enough time on explanations [42], and (c) limited conversations that do not leave time for parents to ask questions or report symptoms [59].

Physical examination may be important in giving the parents the chance to communicate and express their concerns and doubts [27, 49], providing them with information and reassurance [59]. Explanation of therapeutic decisions and other patient-centred strategies positively influenced patient satisfaction [17, 42].

Healthcare system factors: organization, professional teams, and funding

Several healthcare system related factors may favour inappropriate antibiotic prescribing, including direct patient access to antibiotics [41], HCPs' workload and pressure [41, 50, 51, 56], lack of diagnostic facilities, communication and organisational model, accreditation level of the practice setting and ownership of the practice location [50], roles and relationships of professional teams [46], and healthcare system funding [47].

Reviews reported an insufficient time to inform patients and discuss treatment alternatives, which was directly related to patient overload and organisational pressures, leading physicians to inappropriate prescribing [41, 50, 51, 56]. Additionally, the lack of structure and organisation to facilitate the work between physicians and other HCPs [46, 57], and the poor willingness of physicians to receive advice from pharmacists did not favour the coordination [46]. Pharmacists and informal HCPs (those who serve multiple functions in the healthcare delivery and include drug sellers, traditional birth attendants, and village doctors [67] may also be influential, particularly in regions where there is relatively unrestricted access to antimicrobials [55]. Community pharmacists considered AMR very important, and they were willing to collaborate to address Antimicrobial Stewardship Programs, but they believed their functions were undefined and stakeholders and policymakers should consider them as they provide an active role in patient safety [46].

In addition, some health services such as working in of hours units [41] and the private sector [45, 47] may influence inappropriate prescription, the latter having a high prevalence and overuse of broad-spectrum antimicrobials [45, 47]. Finally, the PC setting was found to be one of the most significant contributors to prudent prescribing [43].

Clinical practice factors

HCPs considered some clinical practice factors as positive for appropriate prescribing: (a) pharmacists evaluating clinical safety parameters before dispensing antibiotics (e.g. drug-drug interactions, allergies and previous adverse drug reactions) [46], (b) monitoring the symptoms and waiting before starting antibiotics, or initiating broad-spectrum antibiotics while waiting for results to adapt the treatment [44], and (c) offering self-care treatment or over-the-counter therapy for an infection when antibiotics were not necessary [46].

Economic Factors: cost-saving perspective, financial incentives

Only three reviews detailed economic factors (cost-saving perspective or financial incentives) [50, 51, 56].

A cost-saving perspective influenced physicians' prescribing behaviour as professionals were concerned about the cost to the system and to patients [50, 56]. Additionally, economic incentives promoted antibiotic overprescribing [50, 51].

Outer setting

Contextual factors framed in outer settings have been the least studied according to our findings. Overall, public health policies helped to address antibiotic misuse [50]. Pharmaceutical companies influence physicians' prescriptions and could sometimes be one of the major drivers of inappropriate prescription [27, 45] by influencing antimicrobial selection in the USA and Spain according to Md Reza et al. [45]. In some cultures, prescribing "just in case" or because of the perception of external pressure from educators, employers, parents [27], or daycare providers [41] is deeply rooted. Bosley et al. investigated cultural factors influencing parental attitudes toward antibiotic use, that some parents preferred managing their child's illness at home, using alternative treatments and remedies [42]. Additionally, two other reviews highlighted that heterogeneity in cultural contexts, healthcare systems, antibiotic consumption patterns, and resistance levels, makes the identification of the most effective interventions complex. Daycare centres sometimes pose an external pushing factor that encourages parents to consult a PC physician and seek antibiotics, overriding parents' own beliefs and perceptions about when it is appropriate to consult and use antibiotics [41]. Although there was little information about it, some authors considered that repeated national TV advertising campaigns reduced antibiotic prescription in uncomplicated ARTIs, especially when they targeted both HCPs and the public [41].

Process related factors

Implementation considerations of the educational interventions

The reviews highlighted several factors that may facilitate the implementation of educational interventions, to optimise antibiotic prescription. Some of the facilitating factors related to the target population identified in the reviews were conducting educational sessions in small groups [33], integrating patients, families or the public when developing the intervention [36], and improving engagement of parents/caregivers and children in the process of care before children's illness [34]. Other factors included providing written information focused on a specific symptom [34], open access learning sites with concise information [33], using more than one component (such as audit and feedback, academic detailing or education) [36], and educational follow-up elements like dissemination of information, followed by regular audits

and repeated personalised feedback [39]. The involvement of different HCPs, such as pharmacists and physicians in public campaigns was also mentioned [33, 38]. It was also suggested that public campaign messages should be clear and simple and, if possible, positively framed [37].

Reviews have also identified some barriers to implementing educational programs or rational antibiotic prescribing. These factors included physicians being hesitant to implement Antibiotic Stewardship Programs or to change their prescribing habits [38, 39]. Additionally, the reviews assessed did not identify any research incorporating long-term evaluations.

Barriers and facilitators of appropriate antibiotic use

Seven reviews out of 22 contextual factor reviews (31.8%) reported barriers and facilitators for appropriate antibiotic prescribing. Overall, barriers were related to parents and children, HCPs, communication between HCPs and parents, the pharmaceutical industry and community pharmacy. According to facilitators, we identified some related to communication HCPs-parents, community pharmacists, context, and design of the interventions. It can be highlighted that providing information and reassurance regarding the self-limiting nature of uncomplicated ARTIs facilitates the adequate use of antibiotics [49]. In contrast, the use of complex and jargonised terms by HCP to be understood by parents [42]; or the lack of access to patients' records by community pharmacists complicate the appropriate use [46]. More details appear in Table 6.

Excerpts from the review texts supporting these results are provided in Additional file 5 I Outer Setting. II Characteristics of Individuals. III Inner Setting.

Discussion

Main findings

This scoping review of reviews identified and characterised educational interventions, including implementation considerations, addressing inappropriate antibiotic prescription in paediatric uncomplicated ARTIs in PC. We also identified contextual factors for optimising antibiotic prescription, including barriers and facilitators.

Reviews highlighted interventions' characteristics that contribute to the optimisation of antibiotic prescription of antibiotics including target population (two population targets rather than one, for example, HCPs and parents/caregivers) and mode of delivery (face to face or online), type of interventions (communication skills training, public campaigns and educational interventions including workshops, clinical meetings, and seminars) and combinations of interventions. Computerised interventions (e.g. video and apps) have been much less

studied, although they appear to be promising. Written information interventions showed variable results.

Other outcomes, such as consultation rate, knowledge, attitudes and expectations have been less well studied. Consultation rate was reduced by interventions including public campaigns, educational sessions and written materials for parents. Educational sessions, public campaigns and computerised interventions that target both children and their parents had a positive impact on improving their knowledge. We found scarce evidence about attitudes and expectations, but public campaigns, and computerised and written information interventions appeared to be beneficial. There is limited information on patients' outcomes (e.g. symptoms, complications and satisfaction), resource use and cost. Most of the reviews did not report on economic data. Only three reviews addressed this issue but found no information on cost-effectiveness evaluations in the included studies.

Regarding contextual factors, those regarding characteristics of parents and caregivers, including sociodemographic factors (e.g. economic factors), educational level and knowledge, influenced antibiotic prescribing, but the results were variable. In addition, it is unclear if previous experiences and concerns (e.g. about symptoms), influence parents' expectations of receiving antibiotics. Parents do not always request antibiotic, but rather seek reassurance and information on the children's situation. Consequently, it is important for HCPs to listen actively to parents' concerns, and to be able to communicate clearly the diagnosis and the most appropriate course of action.

In relation to inner setting factors, they were the most frequently reported, especially HCPs' attitudes and perceptions, such as fear or anxiety, which contributed to overprescribing. HCPs' knowledge about antibiotics and AMR were also common, varying depending on the region and experience. Prescribers balanced the risk of complications or uncertainty and AMR, but, in general, there was a lack of knowledge about the local prevalence of AMR rates. HCPs-patient communication influenced physicians' attitudes towards antibiotic prescribing (e.g. perceived pressure from parents). Other factors related to healthcare systems, such as lack of time, organizational pressures and patient overload were also identified. Several outer setting factors that may affect antibiotic prescription practice were also identified such as mass media, the pharmaceutical industry putting pressure on the choice of antimicrobials, and the social norm of prescribing "just in case". However, there is a significant gap in the literature regarding the influence of cultural differences on decision-making processes among physicians and parents, which warrants in-depth analysis in future research.

Many of the barrier factors were also identified as inner setting. However, it can be underlined for example the lack of medical examination and specific clarifications and the lack of support from interacting pharmacist and physicians. As facilitators for a better development of interventions, it is recommended to work in small groups, address specific symptoms rather than general, know whether professionals in that setting are hesitant to change, develop clear and accessible information for the target population, as well as consider the participants, by facilitating engagement.

Our results in the context of previous results

The results of our scoping review corroborate the findings from previous evidence synthesis efforts. Previous reviews analysed ARTIs in adults [68, 69], paediatric infections not restricted to ARTIs [70], or another type of respiratory infection in adults [71]. This evidence also highlighted the importance of multifaceted interventions that combine more than one intervention's component [52, 71], address more than one target population and the use of delivery mode [71]. Our findings, as well as Germeni et al. and Arnold et al., also remark that the interventions are context-sensitive and thus, acceptability and barriers to implementation of the interventions in the community and the context should be considered [69, 71]. According to our findings and Donà et al.'s review, paediatric Antimicrobial Stewardship Programs reduce antibiotic prescribing, and also the healthcare costs and AMR, according to this author [70].

Limitations and strengths

Our review has some limitations. Applying a logic model can generate bias in data selection, since we focused on previously specified categories. As an effort to counteract these limitations, the definitions of the categories in the logic model have been established after a literature review, adapted from other frameworks, and refined after dialogue with field experts, as well as after the analysing of the content of the included reviews. Moreover, the data extraction and synthesis were conducted independently by pairs of reviewers. Also, as recommended by the "best fit" framework synthesis methodology, we collected and identified other factors that emerged in the analysis. Other limitations are that only reviews published in English or Spanish were included, and the limitations inherent in the scoping reviews, including the lack of formal assessment of the methodological limitations and main findings of the included reviews, or a more in-depth analysis. Finally, regarding the methodological aspects, the heterogeneity in the design of the studies and the outcome measures limited the findings in terms of synthesis and comparison [72]. The "antibiotic use" outcome was expressed in different ways throughout the

reviews, potentially limiting the ability to synthesise the findings [34]. Another limitation of this scoping review is that, rather than independently assessing the relative effectiveness and certainty of the evidence, it relies on the conclusions drawn by the included reviews. As such, the findings should be interpreted as indicative rather than conclusive in guiding decision-making. It should be highlighted that a reduction in antibiotic prescriptions may not necessarily reflect an improvement of the quality of prescribing practice [37]. For instance, the use of broad-spectrum antibiotics could have also increased [37]. Our review has also some strengths. To our knowledge, this is the first scoping review of reviews focused on the effectiveness of educational interventions, which also assesses factors affecting antibiotic prescribing practices, and the application of this logic model could prove helpful for similar evaluations. We have also identified knowledge gaps in the development, implementation, and evaluation process of the identified interventions.

Implications for practice and research

We identified a set of educational interventions and contextual factors that can guide policymakers, HCPs, and researchers in the design of educational interventions tailored to optimise antibiotic prescribing in paediatric uncomplicated ARTIs in PC. To address the barriers to the implementation of the interventions, probably one of the main limitations, governmental plans and Antimicrobial Stewardship Programs should consider parents' and HCPs' needs, the difficulties and previous experience in each context, and include a patient-centred holistic approach, including PC centres and community pharmacies, linked to hospitals and the public. At the organisational level of healthcare, some factors may facilitate implementation, such as (1) HCPs' team-building (sharing protocols and plans to support the clinical decision systems), and (2) implementing feasible interventions in each context, addressing HCPs' prescribing-related factors (promoting continuous training, offering guidelines and context-specific sources of information, facilitating local data on antibiotic prescription rates and on AMR prevalence). The use of electronic systems that allow a systematic collection of information to understand the practice is mandatory, both for daily practice and for future studies. Finally, more studies in this area should receive governmental and private funding [34]. Our findings have also informed the design of the OptimAP project, including the development of two educational interventions [23].

Further research is needed on (1) the design of the interventions based on complex interventions and on behavioural change frameworks; (2) participation of parents and children in the design of interventions; (3) context-specific barriers and facilitators of the

implementation; (4) economic implications; (5) evaluation of intermediate outcomes (e.g. consultation rate, knowledge, attitudes, or satisfaction); (6) assessment of intervention components (e.g. mode of delivery and the multifaced interventions); (7) contextual factors (especially outer settings and patients' characteristics); (8) long-term evaluations; and (9) facilitators and barriers.

Conclusions

Combining interventions (educational intervention plus another type), targeting both parents/caregivers and HCPs and considering their needs and the context, may improve antibiotic prescribing in children. Our findings can inform the design and evaluation of future interventions. More research is needed on contextual factors to guide policymaking and clinical practice.

Abbreviations

AMR	Antimicrobial resistance
ARTIs	Acute respiratory tract infections
HCPs	Healthcare professionals
PC	Primary care
URTIs	Upper Respiratory tract infections
RCT	Randomised clinical trial
CFIR	Consolidated Framework for Implementation Research

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12887-025-05688-4>.

Supplementary Material 1
Supplementary Material 2
Supplementary Material 3
Supplementary Material 4
Supplementary Material 5

Author contributions

Credit authorship contribution statement: UEA: Conceptualization, Methodology, Formal analysis, Data Curation, Investigation, Writing – original draft, Visualization, Project administration. ENDG: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Supervision, Visualization. PAC: Conceptualization, Methodology, Formal analysis, Writing – original draft, Supervision, Visualization, Funding acquisition. CR: Methodology, Investigation, Data Curation, Writing – review & editing. MLG: Methodology, Data Curation, Writing – review & editing. LL: Investigation, Data Curation, Visualization, Writing – review & editing, Supervision. LCS: Investigation, Data Curation, Visualization, Writing – review & editing. CMG: Investigation, Formal analysis, Writing – review & editing. AGM: Investigation, Formal analysis, Writing – review & editing. AB: Investigation, Data Curation, Writing – review & editing. IB: Conceptualization, Writing – review & editing. IS: Conceptualization, Writing – review & editing. The authors read and approved the final manuscript.

Funding

This work was supported by La Fundació la Marató de TV3 grant number 295/U/2018.

Data availability

Data is provided within the manuscript and supplementary information files, except narrative extracts taken from the reviews concerning inner setting, which can be ask to the authors for access.

Declarations

Ethics approval and consent to participate

Research ethics approval is not required for this scoping review. However, the results of this review were used to develop the interventions of a clinical trial (OptimAP project) that has been approved by the IDIAP Jordi Gol Clinical Research Ethic Committee (reference number 19/019-P). Besides, the Ethic Committees of each of the participating Autonomous Communities in Spain have also approved the project.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

¹Institut de Recerca Sant Pau (IR Sant Pau), Barcelona, Spain

²Primary Care Pharmacy, Debagoiena Integrated Health Organisation, Osakidetza Basque Health Service, Arrasate, Spain

³Centro Cochrane Iberoamericano, Institut de Recerca Sant Pau (IR Sant Pau), Barcelona, Spain

⁴Avedis Donabedian Research Institute, Barcelona, Spain

⁵Pharmacy and Services Sub-Directorate, Navarre Health Service, Pamplona, Navarre, Spain

⁶Navarra Institute for Health Research (IdiSNA), Pamplona, Navarre, Spain

⁷Unit of Innovation and Organization, Navarre Health Service, Pamplona, Navarre, Spain

⁸CIBER Epidemiología y Salud Pública (CIBERESP), Madrid, Spain

⁹Centro de Investigación en Epidemiología Clínica y Salud Pública (CISPEC), Facultad de Ciencias de la Salud Eugenio Espejo, Universidad UTE, Quito, Ecuador

¹⁰Servicio de Epidemiología y Salud Pública, Hospital de la Santa Creu i Sant Pau, Barcelona, Spain

¹¹Universitat Autònoma de Barcelona, Barcelona, Spain

¹²Quality, Process and Innovation Direction, Vall d'Hebron University Hospital, Vall d'Hebron Research Institute, Barcelona, Spain

¹³Health Services Research Group, Vall d'Hebron Institut de Recerca, Vall d'Hebron University Hospital, Barcelona, Spain

Received: 25 April 2024 / Accepted: 15 April 2025

Published online: 26 May 2025

References

- Jit M, Ng DHL, Luangasanatip N, Sandmann F, Atkins KE, Robotham JV, et al. Quantifying the economic cost of antibiotic resistance and the impact of related interventions: rapid methodological review, conceptual framework and recommendations for future studies. *BMC Med*. 2020;6:38.
- European Centre for Disease Prevention and Control. Point prevalence survey of healthcare associated infections and antimicrobial use in European acute care hospitals. Stockholm: ECDC; 2013.
- Cassini A, Högberg LD, Plachouras D, Quattrocchi A, Hoxha A, Simonsen GS, et al. Attributable deaths and disability-adjusted life-years caused by infections with antibiotic-resistant bacteria in the EU and the European economic area in 2015: a population-level modelling analysis. *Lancet Infect Dis*. 2019;19(1):56–66.
- O'Neill J. Tackling drug-resistant infections globally: final report and recommendations: the review on antimicrobial resistance. 2016.
- Murray CJ, Ikuta KS, Sharara F, Swetschinski L, Robles Aguilar G, Gray A, et al. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *Lancet*. 2022;399(10325):629–55.
- Interagency Coordination Group on Antimicrobial Resistance. No time to wait: Securing the future from drug-resistant infections. *Artforum Int*. 2019.
- Arroll B. Antibiotics for upper respiratory tract infections: an overview of Cochrane reviews. *Respir Med*. 2005;99(3):255–61.
- Venekamp RP, Sanders SL, Glasziou PP, Del Mar CB RMM. Antibiotics for acute otitis media in children. *Cochrane Database Syst Reviews*. 2015;(6):CD000219.
- Smith SM, Fahey T, Smucny JBLA. Antibiotics for acute bronchitis. Smith SM, editor. *Cochrane Database Syst Rev* [Internet]. 2017;6(6):CD000245. Available from: <https://doi.org/10.1002/14651858.CD000245.pub2>
- Fleming-Dutra KE, Hersh AL, Shapiro DJ, Bartoces M, Enns EA, File TM, et al. Prevalence of inappropriate antibiotic prescriptions among US ambulatory care visits, 2010–2011. *JAMA*. 2016;315(17):1864–73.
- Goossens H, Ferech M, Vander Stichele R, Elseviers M. Outpatient antibiotic use in Europe and association with resistance: a cross-national database study. *Lancet*. 2005;365(9459):579–87.
- Agencia Española de Medicamentos y Productos Sanitarios (AEMPS). Plan estratégico y de acción para reducir el riesgo de selección y diseminación de la resistencia a los antibióticos. 2014.
- Sartorius B, Gray AP, Davis Weaver N, Robles Aguilar G, Swetschinski LR, Ikuta KS, et al. The burden of bacterial antimicrobial resistance in the WHO African region in 2019: a cross-country systematic analysis. *Lancet Glob Health*. 2024;12(2):e201–16.
- Tonkin-Crine SKG, Tan PS, van Hecke O, Wang K, Roberts NW, McCullough A, et al. Clinician-targeted interventions to influence antibiotic prescribing behaviour for acute respiratory infections in primary care: an overview of systematic reviews. *Cochrane Database Syst Reviews*. 2017;2017(9):Cd012252.
- Gulliford MC, van Staa T, Dregan A, McDermott L, McCann G, Ashworth M, et al. Electronic health records for intervention research: A cluster randomized trial to reduce anti biotic prescribing in primary care (eCRT study). *Ann Fam Med*. 2014;12(4):344–51.
- Agencia Española de Medicamentos y Productos Sanitarios (AEMPS). Plan Nacional Resistencia Antibióticos. Objetivos de mejora prioritarios en Atención Primaria (Pediatria). Línea estratégica II: control. Madrid. 2017.
- Cantarero-Arévalo L, Hallas MP, Kaae S. Parental knowledge of antibiotic use in children with respiratory infections: a systematic review. *Int J Pharm Pract*. 2017;25(1):31–49.
- Hu Y, Walley J, Chou R, Tucker JD, Harwell JI, Wu X et al. Interventions to reduce childhood antibiotic prescribing for upper respiratory infections: Systematic review and meta-analysis. *J Epidemiol Community Health* (1978). 2016;70(12):1162–70.
- Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur AAE. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Med Res Methodol*. 2018;18(1):1–7.
- Alonso-Coello PCFYBAALBGRi, et al. A randomized cluster trial for the optimization of antibiotic prescription in acute uncomplicated respiratory tract infections in children: a protocol of the optimap study. [Internet] OSF; 2023.
- Aromataris EMZ. JBI Manual for Evidence Synthesis: Scoping reviews. 2020 [cited 2023 Jan 26]; Available from: <https://doi.org/10.46658/JBIMES-20-0101>
- Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med*. 2018;169(7):467–73.
- Elizondo-Alzola U, RC, LGM LL et al. Contextual factors and educational interventions for improving antibiotic prescription in children with acute respiratory infections: a protocol of a mixed methods scoping review. *Open Science Framework* [Internet]. 2021 [cited 2024 Jan 29]; Available from: <https://doi.org/10.17605/OSF.IO/96HTC>
- Pfadenhauer LM, Mozygemba K, Gerhardus A, Hofmann B, Booth A, Lysdahl KB, et al. Context and implementation: A concept analysis towards conceptual maturity. *Z Evid Fortbild Qual Gesundheitswes*. 2015;109(2):103–14.
- Z AE, I I, M FHH, Mourad Ouzzani KMO, Hammady H. Zbys Fedorowicz, and Ahmed Elmagarmid. Rayyan — a web and mobile app for systematic reviews. *Systematic Reviews* (2016) 5:210. <https://doi.org/10.1186/s13643-016-0384-4>. Abstracts of the 22nd Cochrane Colloquium. 2016.
- Carroll C, Booth A, Leaviss JRJ. Best fit framework synthesis: refining the method. *BMC Med Res Methodol*. 2013;13(1):37.
- Lucas PJ, Cabral C, Hay AD, Horwood J. A systematic review of parent and clinician views and perceptions that influence prescribing decisions in relation to acute childhood infections in primary care. *Scand J Prim Health Care*. 2015;33(1):11–20.
- Bradbury K, Steele M, Corbett T, Geraghty AWA, Krusche A, Heber E, Easton S, Cheetham-Blake T, Slodkowska-Barabas J, Müller AM, Smith K, Wilde LJ, Payne L, Singh K, Bacon R, Burford T, Summers K, Turner L, Richardson A, Watson E, Foster C, Little P, Yard YL. Developing a digital intervention for cancer survivors: an evidence-, theory- and person-based approach. *NPJ Digit Med*. 2019;2:85.
- Sargent L, McCullough A, Del Mar C, Lowe J. Using theory to explore facilitators and barriers to delayed prescribing in Australia: a qualitative study using the theoretical domains framework and the behaviour change wheel. *BMC Fam Pract*. 2017;18(1):20.

30. Management C, for C. CFIR Research Team. Consolidated Framework for Implementation Science Ann Arbor [Internet]. 2017 [cited 2017 May 3]. Available from: <http://www.cfirguide.org/>
31. Vodicka TA, Thompson M, Lucas P, Heneghan C, Blair PS, Buckley DI, et al. Reducing antibiotic prescribing for children with respiratory tract infections in primary care: A systematic review. *Br J Gen Pract*. 2013;63(612):e445–54.
32. Boonacker CWB, Hoes AW, Dikhoff MJ, Schilder AGM, Rovers MM. Interventions in health care professionals to improve treatment in children with upper respiratory tract infections. *Int J Pediatr Otorhinolaryngol*. 2010;74(10):1113–21.
33. Lee CRLKJLBSH. Educational effectiveness, target, and content for prudent antibiotic use. 2015;2015:214021. Available from: <http://www.hindawi.com/journals/biomed/>
34. Andrews T, Thompson M, Buckley DI, Heneghan C, Deyo R, Redmond N et al. Interventions to influence consulting and antibiotic use for acute respiratory tract infections in children: A systematic review and Meta-Analysis. *PLoS ONE*. 2012;7(1).
35. McDonagh MS, Peterson K, Winthrop K, Cantor A, Lazur BH, Buckley DI. Interventions to reduce inappropriate prescribing of antibiotics for acute respiratory tract infections: summary and update of a systematic review. *Journal of International Medical Research*. Volume 46. SAGE Publications Ltd; 2018. pp. 3337–57.
36. Neo JRJ, Niederdeppe J, Vleemeyer O, Lau B, Demetres M, Sadatsafavi H. Evidence-Based strategies in using persuasive interventions to optimize antimicrobial use in healthcare: a narrative review. *J Med Syst*. 2020;44(3).
37. Huttner B, Goossens H, Verheij T, Harbarth S. Characteristics and outcomes of public campaigns aimed at improving the use of antibiotics in outpatients in high-income countries. *Lancet Infect Dis* [Internet]. 2010;10(1):17–31. Available from: [https://doi.org/10.1016/S1473-3099\(09\)70305-6](https://doi.org/10.1016/S1473-3099(09)70305-6)
38. Wang S, Pulcini C, Rabaud C, Boivin JM, Birgé J. Inventory of antibiotic stewardship programs in general practice in France and abroad. *Med Mal Infect*. Volume 45. Elsevier Masson SAS; 2015. pp. 111–23.
39. Korppi M. Antibiotic stewardship programmes had a low impact on prescribing for acute respiratory tract infections in children. *International Journal of Paediatrics*. Volume 111. *Acta Paediatrica*; 2022. pp. 1500–6.
40. O'Sullivan JW, Harvey RT, Glasziou PP, McCullough A. Written information for patients (or parents of child patients) to reduce the use of antibiotics for acute upper respiratory tract infections in primary care. *Cochrane Database Syst Reviews*. 2016;2016:11.
41. O'Connor R, O'Doherty J, O'Regan A, Dunne C. Antibiotic use for acute respiratory tract infections (ARTI) in primary care; what factors affect prescribing and why is it important? A narrative review. *Irish Journal of Medical Science*. Volume 187. Springer London; 2018. pp. 969–86.
42. Bosley H, Henshall C, Appleton JV, Jackson D. A systematic review to explore influences on parental attitudes towards antibiotic prescribing in children. *Journal of Clinical Nursing*. Volume 27. Blackwell Publishing Ltd; 2018. pp. 892–905.
43. Kyaw BM, Car LT, van Galen LS, van Agtmael MA, Costelloe CE, Ajuebor O, et al. Health professions digital education on antibiotic management: systematic review and meta-analysis by the digital health education collaboration. *J Med Internet Res*. 2019;21(9):1–14.
44. Ness V, Price L, Currie K, Reilly J. Influences on independent nurse prescribers' antimicrobial prescribing behaviour: A systematic review. *J Clin Nurs*. 2016;25(9–10):1206–17.
45. Md Reza RS, Hassali MA, Alrasheedy AA, Saleem F, Md Yusof FA, Godman B. Physicians' knowledge, perceptions and behaviour towards antibiotic prescribing: A systematic review of the literature. *Expert Rev Anti Infect Ther*. 2015;13(5):665–80.
46. Saha SK, Hawes L, Mazza D. Improving antibiotic prescribing by general practitioners: A protocol for a systematic review of interventions involving pharmacists. Volume 8. *BMJ Open*: BMJ Publishing Group; 2018.
47. Shaikhan F, Rawaf S, Majeed A, Hassounah S. Knowledge, attitude, perception and practice regarding antimicrobial use in upper respiratory tract infections in Qatar: a systematic review. *J RSM Open*. 2018;9(9):205427041877497.
48. McCullough AR, Parekh S, Rathbone J, Del Mar CB, Hoffmann TC. A systematic review of the public's knowledge and beliefs about antibiotic resistance. *J Antimicrob Chemother*. 2016;71(1):27–33.
49. Blyer K, Hulton L. College students, shared decision making, and the appropriate use of antibiotics for respiratory tract infections: A systematic literature review. *J Am Coll Health*. 2016;64(4):334–41.
50. Teixeira Rodrigues A, Roque F, Falcão A, Figueiras A, Herdeiro MT. Understanding physician antibiotic prescribing behaviour: A systematic review of qualitative studies. *Int J Antimicrob Agents* [Internet]. 2013;41(3):203–12. Available from: <https://doi.org/10.1016/j.ijantimicag.2012.09.003>
51. Silverberg SL, Zannella VE, Countryman D, Ayala AP, Lenton E, Friesen F, et al. A review of antimicrobial stewardship training in medical education. *Int J Med Educ*. 2017;8:353–74.
52. Tonkin-Crine S, Yardley L, Little P. Antibiotic prescribing for acute respiratory tract infections in primary care: A systematic review and meta-ethnography. *J Antimicrob Chemother*. 2011;66(10):2215–23.
53. McKay R, Mah A, Law MR, McGrail K, Patrick DM. Systematic review of factors associated with antibiotic prescribing for respiratory tract infections. *Antimicrobial Agents and Chemotherapy*. Volume 60. American Society for Microbiology; 2016. pp. 4106–18.
54. Borek AJ, Wanat M, Atkins L, Sallis A, Ashiru-Oredope D, Beech E et al. Optimizing antimicrobial stewardship interventions in english primary care: A behavioural analysis of qualitative and intervention studies. *BMJ Open*. 2020;10(12).
55. Yau JW, Thor SM, Tsai D, Speare T, Rissel C. Antimicrobial stewardship in rural and remote primary health care: a narrative review. Volume 10. *Antimicrobial Resistance and Infection Control*. BioMed Central Ltd; 2021.
56. Rose J, Crosbie M, Stewart A. A qualitative literature review exploring the drivers influencing antibiotic over-prescribing by gps in primary care and recommendations to reduce unnecessary prescribing. *Perspectives in Public Health*. Volume 141. SAGE Publications Ltd; 2021. pp. 19–27.
57. Chater A, Family H, Lim R, Courtenay M. Influences on antibiotic prescribing by non-medical prescribers for respiratory tract infections: A systematic review using the theoretical domains framework. *Journal of Antimicrobial Chemotherapy*. Volume 75. Oxford University Press; 2020. pp. 3458–70.
58. Papoutsis C, Mattick K, Pearson M, Brennan N, Briscoe S, Wong G. Social and professional influences on antimicrobial prescribing for doctors-in-training: A realist review. *J Antimicrob Chemother*. 2017;72(9):2418–30.
59. Cabral C, Horwood J, Hay AD, Lucas PJ. How communication affects prescription decisions in consultations for acute illness in children: A systematic review and meta-ethnography. *BMC Fam Pract*. 2014;15(1).
60. King LM, Fleming-Dutra KE, Hicks LA. Advances in optimizing the prescription of antibiotics in outpatient settings. *BMJ*. 2018;363.
61. Haggins JGSR. *Cochrane handbook for systematic reviews of interventions* version 5.1.0. The Cochrane Collaboration. 2011. P5. *Cochrane Database of Systematic Reviews*. 2020;2020(2).
62. Long HAFDBJ, CASP-Qualitative-Checklist. -2018. *Research Methods in Medicine & Health Sciences* [Internet]. 2020 [cited 2023 Dec 19];1(1):31–42. Available from: <https://doi.org/10.1177/2632084320947559>
63. McDonagh MS, Jonas DE, Gartlehner G, Little A, Peterson K, Carson S, et al. Methods for the drug effectiveness review project. Volume 12. *BMC Medical Research Methodology*; 2012.
64. Brozek JL, Canelo-Aybar C, Akl EA, Bowen JM, Bucher J, Chiu WA et al. GRADE guidelines 30: the GRADE approach to assessing the certainty of modeled evidence—An overview in the context of health decision-making. *J Clin Epidemiol*. 2021;129.
65. Cantarero-Arévalo L, Hallas MP, Kaae S. Parental knowledge of antibiotic use in children with respiratory infections: a systematic review. *International journal of pharmacy practice*. Volume 25. Wiley-Blackwell Publishing Ltd; 2017. pp. 31–49.
66. Teixeira Rodrigues A, Roque F, Falcão A, Figueiras A, Herdeiro MT. Understanding physician antibiotic prescribing behaviour: A systematic review of qualitative studies. *International Journal of Antimicrobial Agents*. Volume 41. Elsevier B.V.; 2013. pp. 203–12.
67. Sudhinaraset M, Ingram M, Lofthouse HK, Montagu D. What is the role of informal healthcare providers in developing countries?? A systematic review. *PLoS ONE*. 2013;8(2).
68. Van Der Velden AW, Pijpers EJ, Kuyvenhoven MM, Tonkin-Crine SKG, Little P, Verheij TJM. Effectiveness of physician-targeted interventions to improve antibiotic use for respiratory tract infections. 62. *Br J Gen Pract*. 2012.
69. Germeni E, Frost J, Garside R, Rogers M, Valderas JM, Britten N. Antibiotic prescribing for acute respiratory tract infections in primary care: an updated and expanded meta-ethnography. *Br J Gen Pract*. 2018;68(674):e633–45.
70. Donà D, Barbieri E, Daverio M, Lundin R, Giaquinto C, Zaoutis T et al. Implementation and impact of pediatric antimicrobial stewardship programs: a systematic scoping review [Internet]. Vol. 9. *Antimicrobial Resistance and Infection Control*. 2020. Available from: <https://pubmed.ncbi.nlm.nih.gov/31911831/>
71. Arnold SR, Straus SE. Interventions to improve antibiotic prescribing practices in ambulatory care. *Cochrane Database Syst Reviews*. 2005;1(2):623–90.

72. Köchling A, Löffler C, Reinsch S, Hornung A, Böhmer F, Altiner A, et al. Reduction of antibiotic prescriptions for acute respiratory tract infections in primary care: A systematic review. *Implement Sci.* 2018;13(1):47.

Publisher's note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.