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Reducing antibiotic prescribing for children with respiratory tract infections in primary care:

a systematic review

Abstract

Background
Respiratory tract infections (RTIs) in children are common and often result in antibiotic prescription despite their typically self-limiting course.

Aim
To assess the effectiveness of primary care based interventions to reduce antibiotic prescribing for children with RTIs.

Design and setting
Systematic review.

Method
MEDLINE®, Embase, CINAHL®, PsycINFO, and the Cochrane library were searched for randomised, cluster randomised, and non-randomised studies testing educational and/or behavioural interventions to change antibiotic prescribing for children (<18 years) with RTIs. Main outcomes included change in proportion of total antibiotic prescribing or change in 'appropriate' prescribing for RTIs. Narrative analysis of included studies was used to identify components of effective interventions.

Results
Of 6301 references identified through database searching, 17 studies were included. Interventions that combined parent education with clinician behaviour change decreased antibiotic prescribing rates by between 6–21%; structuring the parent–clinician interaction during the consultation may further increase the effectiveness of these interventions. Automatic computerised prescribing prompts increased prescribing appropriateness, while passive information, in the form of waiting room educational materials, yielded no benefit.

Conclusion
Conflicting evidence from the included studies found that interventions directed towards parents and/or clinicians can reduce rates of antibiotic prescribing. The most effective interventions target both parents and clinicians during consultations, provide automatic prescribing prompts, and promote clinician leadership in the intervention design.

Keywords
anti-bacterial agents, children, prescriptions, primary health care, respiratory tract infections.

INTRODUCTION

Respiratory tract infections (RTIs) in children are common and costly conditions for families, healthcare providers, and health systems.[1] Clinicians frequently prescribe antibiotics for RTIs,[2] despite the fact that most are self-limiting and use of antibiotics for most RTIs is of uncertain value.[3] Overuse of antibiotics is associated with development of antimicrobial resistance,[4] increased care-seeking behaviour,[5] and adverse effects.[6] Perhaps the greatest threat to public health comes from the continuing emergence of antimicrobial resistance. This leads to increased use of second/third generation antibiotics, costlier treatment, and further bacterial resistance.

Efforts to reduce antibiotic prescribing have been ongoing for decades,[7] and have included a wide range of strategies and campaigns targeted at patients, clinicians, practices, and whole populations. To some extent these efforts have been successful, leading to reductions in the UK of 24%, from 572 antibiotic prescriptions per 1000 child-years in 1996 to 435 prescriptions per 1000 child-years in 2000.[8] However, US data indicates that while overall antibiotic prescription rates decreased during the 1990s, prescribing rates of broad spectrum antibiotics for children with RTIs actually increased.[9] Prescribing rates for non-specific RTIs in the UK have increased by 10% since 2002.[8] This upward trend is concerning in light of evidence-based practice recommendations that propose a 'wait and see' approach for the majority of RTIs.

A recent review of interventions to modify parental help-seeking behaviour for RTIs in children found that interventions that engaged children in addition to parents and provided specific symptom guidance were effective at influencing consulting behaviour.[10] However, strategies are also needed to help clinicians determine which children are most in need of antibiotics,[11] and reduce inappropriate antibiotic prescribing.[12,13] Given the importance of the parent–clinician interaction in guiding antibiotic use, this study aimed to systematically review the effectiveness of educational or behavioural interventions directed to parents, clinicians, or both, to reduce antibiotic prescribing for children with RTIs in primary care.

METHODS

MEDLINE®/PubMed, CINAHL®, Embase, PsycINFO and the Cochrane Library

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How this fits in

Prescribing rates of antibiotics for RTI in children have declined, but are still high and largely unnecessary. Reducing unnecessary prescriptions is a priority in order to reduce inappropriate antibiotic use in primary care. Based on a systematic review of 17 studies it was found that the most effective interventions target both parents and clinicians during consultation, provide automatic prescribing prompts, and promote clinician leadership in the intervention design. These can produce significant reductions in antibiotic prescribing for children with RTIs.

(from inception through June 2012) were searched using terms for RTIs, children, parents, education, antibiotic prescription, and consultation (Table 1). One author screened titles and abstracts based on predefined inclusion criteria to identify relevant studies and reviewed reference lists and related citations of selected studies to identify additional references. Two authors reviewed the full-text of selected studies to determine inclusion. Disagreements were settled through discussions with a third author.

Controlled studies were included that used a randomised, cluster randomised, non-randomised or one-group pre- and post- test design to assess the effectiveness of educational or behavioural interventions to change clinicians' antibiotic prescribing for acute RTIs in children (birth to 18 years) in primary care settings (family practice, emergency, or paediatric primary care). Outcomes of interest were change in proportion of antibiotic prescriptions issued for RTIs in children, or change in 'appropriate' antibiotic prescribing. Comparisons included no-treatment or alternate treatment controls. Studies were excluded if they were: from in-patient settings; evaluations of treatment guidelines, public health interventions, diagnostic tests; studies of children with chronic illnesses or serious comorbidities; or studies from countries not classified as high-income by the Organisation for Economic Co-operation and Development.

Two reviewers used an extraction form developed for a previous systematic review[10] to independently extract data for study design, setting, patient population, intervention, comparison, outcome(s), and assessment method. Disagreements were resolved by discussion with a third author. Reviewers were not blinded to any aspect of the studies. Data from a French language study were extracted following translation.

Two reviewers independently assessed study quality using a framework adapted from the Cochrane handbook.[14] Randomised or cluster randomised trials were assessed based on randomisation, blinding, description of intervention, exposure to intervention, and generalisability. Non-randomised controlled trials were assessed on the basis of comparability of groups, intervention description, exposure to intervention, and generalisability. One-group designs were assessed based on intervention description, exposure to intervention, and generalisability. A judgement of 'low', 'high', or 'unclear' was made regarding the risk of bias for each criterion; based on this, each study was then given an overall judgement of 'low', 'moderate', or 'high' risk of bias (Table 2). Overall quality assessments were used to interpret the findings.

Mean differences were calculated with 95% confidence intervals (CI) for changes in mean numbers of prescriptions, and odds ratios (OR) with 95% CI for changes in prescribing rates, using Yates's correction and Fisher's exact test where an expected cell was below five (EpiInfo version 3.4.3). Where raw data were unavailable, proportional or mean differences were presented. Considerable statistical and clinical heterogeneity prevented pooling of outcomes; therefore results of each study are presented individually and interpreted using narrative analysis.

RESULTS

Of the 6301 references returned in the search, 17 studies met inclusion criteria (Figure 1).[15–31] One study[21] included three different interventions (targeting parents, clinicians, or both) for a total of 19 interventions among the 17 studies. Thirteen studies involved 228 practices or clinics (four studies[15,18,21,31] did not report number of included practices). The studies varied in design, paediatric population, and length of follow-up (Table 1). The majority of studies used a randomised design (n = 12), with the remaining studies using pre- and post-test (n = 3) or non-randomised designs (n = 2). Most were conducted in the US (n = 10), followed by Israel (n = 3), Europe (n = 3), and Australia (n = 1). The interventions were delivered in family practice or paediatric care settings, except for one set in an after-hours clinic.[23] The majority of interventions (n = 10) were directed toward clinicians and parents.[15–24] Six interventions were

Table 1. Characteristics of included studies

Interventions targeting clinicians and parents

Study	Design	Setting	Participants	Children	Intervention	Comparison	Length of follow-up	Outcome	Method of assessing outcome
Cohen[15] 2000 France	RCT	PCC	Generalists *n* = 703 Paediatricians *n* = 413 Parents	<10 yr with nasopharyngitis, (mean 2.5 yr)	Written educational material for clinicians and parents on natural history, symptomatic treatment, reasons to re-consult, and lack of need for AB for acute uncomplicated rhinopharyngitis	No intervention	7 days receiving ABx	Proportion	Medical records I = 1957 C = 1807
Doyne[16] 2004 US	CRCT	11 PCC or FQHC	Community paediatric practices I = 6 C = 6 Parents	Not described	Clinician academic detailing on appropriate AB use (5 sessions); clinician focus groups (identified reasons for prescribing); parent focus groups (identified expectations around ABx). Clinicians received prescribing guidelines plus patient education materials (CDC poster, pamphlet, handouts) to give to parents (on illness prevention, when to consult, what to expect at consultation, effect of AB on outcomes, resistance, and AB treatment recommendations)	Receipt of locally developed guidelines (once) plus practice-specific feedback (twice)	12 mo	ABx filled per consultation	Medical records and health information provider data
Finkelstein[17] 2001 US	CRCT	12 PCC	Clinicians I = 86 C = 71 Parents	3 mo <72 mo I = 7050 C = 6410	Clinicians given group education (2 sessions) on problem of AB resistance and accurate diagnosis of AOM and written materials (6 evidence-based summaries and prescribing feedback from previous year); parents were mailed educational pamphlet with letter signed by paediatricians	Unclear (study reports that control group received no feedback)	12 mo	ABx per person–year for children	Pharmacy data
Francis[18] 2006 US	P/P	HMO	Paediatricians *n* = 153 Parents	With AOM	Clinicians attended lectures on appropriate use of AB for AOM (financial incentive for attendance); newsletters, program website, and academic AOM. Patients received educational handouts that explained treatment recommendations	(Historical data prior to intervention)	14 mo	Exceptions to care pathway per 1000 episodes of care	Claims data
Francis[19] 2009 UK	CRCT	61 PCC	Practices *n* = 61 Parents Clinicians	6 mo–14 yr with RTI lasting < 7 day I = 274 (mean 5.1 yr) C = 284 (mean 5.3 yr)	8-page interactive book given to parents and used during consultation with clinician to foster discussion of parental concerns, expectations, and to explain symptom course, treatment, and need for re-consultation. Booklet included information normal duration and effectiveness of AB for common RTIs, interpretation of symptoms, self-care advice, negative aspects of AB use, and reasons to re-consult	Usual care	2 wks	ABx/ index consultation	Phone interview
Juzych[20] 2005 US	NRCT	4 PCC	Paediatricians I = 9 C = 6 Pharmacists Nurses Parents	Not described	Group education (1 half day session) on antimicrobial resistance, appropriate treatment and diagnosis for bronchitis, AOM, pharyngitis, and non-specific URI. Participants received guideline handouts, literature on AB resistance and patient handouts	No intervention	12 mo	ABx per index consultation	Pharmacy claims data
Mainous[21] 2000 US	RCT	PCC	Clinicians I1 = 53 I2 = 49 I3 = 52 C = 62 Parents	<18 yr Medicaid enrollees	I1: Patient education pamphlet on AB use I2: Clinician feedback (prescribing profile on (URI, bronchitis, pharyngitis, with number of episodes, number of ABx, proportion of ABx, total cost of episode, proportionate cost of ABx) mailed with letter explaining that prescribing was being evaluated I3: Clinician feedback; and patient education	No intervention	5 mo	ABx per URI episode of care	Medicaid data

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Table 1 continued. Characteristics of included studies

Interventions targeting clinicians and parents

Study	Design	Setting	Participants	Children	Intervention	Comparison	Length of follow-up	Outcome	Method of assessing outcome
Regev -Yochay[22] 2011 Israel	CRCT	50 PCPC	Clinicians I = 26 C = 24 Parents	<18 yr registered at HMO practices I = 46 043 ± 3050 children per year (mean age: 5.6 (SD 0.02) yr C = 46 602 ± 1628 children per year (mean age: 5.9 (SD 0.02) yr	Multifaceted intervention involving five (I) group clinicians serving as 'local leaders', three workshops, focus groups, and seminars. Workshops took place at the beginning of years 1, 2, and 3 and focused on reasons for non-judicious prescribing and interventions to address this; parent–clinician communication; and prescribing feedback. Following workshops, participants joined focus groups to (1) develop local diagnostic and prescribing guidelines; (2) run seminar on AOM diagnosis and assess access to other diagnostic tools; (3) disseminate current research abstracts related to antibiotic resistance to clinicians; (4) disseminate educational posters, handouts, colouring books to parents and children in clinic; (5) run a simulation seminar on parent-clinician communication. (Most intervention activity took place during year 1).	No intervention	1 yr	Change in annual ABx per 100 patient years; ABx rates for penicillin, macrolide, and cephalosporin	HMO pharmacy data
Smabrekke[23] 2002 Norway	NRCT	2 ECS	Clinicians Nurses Parents	1–15 yr I = 210 C = 125	Doctors and nurses attended an evidence-based session on AOM care, received guidelines on appropriate diagnosis, AB treatment, and delayed prescribing. Pamphlets on limited benefits of AB, AB resistance, self-limiting nature, and symptomatic treatment of AOM were available in waiting rooms for parents; same information was given to parents during telephone contact	No educational activities	4 mo	ABx per child with AOM	Pharmacy data
Wilson[24] 2003 Australia	RCT	54 PCC	Clinicians I = 24 C = 30 Parents	<2 yr with acute respiratory infection, *n* = 502	Clinicians participated in workshops and parents in focus groups to develop treatment guideline for acute respiratory infection. Clinicians received guidelines, prescribing feedback (1 session) Parent material included handouts, prescription pads, and poster with information on RTI symptoms, symptomatic treatment, course, and explanation that AB is not necessary.	No intervention during months clinician 0–15; group education (1 session) on local guidline plus patient education (handout, prescription pads, posters)	24 mo	ABx per 100 Medicare services	Australia Health Insurance Commission data
Interventions targeting clinicians only									
Bauchner[25] 2006 US	CRCT	12 PCPC	Paediatric practices I = 6 C = 6	3 mo – 3 yr (mean 1.41 yr) with acute otitis media, I = 1382 C = 1146	Clinician given group education (2 sessions, information on CDC treatment recommendations and appropriate diagnosis of AOM), chart reminders to classify child as high or low risk, newsletters with feedback on local prescribing and adherence to AB treatment recommendations	Clinician group education (2 sessions, focus on AOM diagnosis and pneumococcal conjugate vaccine)	29 mo	ABx in adherence to guideline per all ABx	Medical records
Bourgeois[26] 2010 US	CRCT	12 PCC	Clinicians I = 112 C = 34	<18 yr with acute respiratory infection, I = 9409 (mean 7.6 yr) C = 2907 (mean 6.6 yr)	CDSS for acute respiratory infection: clinicians record symptoms, receive management options based on symptoms, over-the-counter treatment, watchful waiting guidelines, and additional diagnostic testing and patient handouts to print out. Clinicians were sent email reminders to use CDSS.	No intervention (not described)	7 mo	ABx per consultation	Electronic health record

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Table 1 continued. Characteristics of included studies

Interventions targeting clinicians and parents

Study	Design	Setting	Participants	Children	Intervention	Comparison	Length of follow-up	Outcome	Method of assessing outcome
Christakis[27] 2001 US	CRCT	1 UPC	Resident and attending physicians, nurse practitioners I = 12 C = 16	Not described	CDSS for otitis media. Clinicians greeted with pop-up window when they wrote e-prescription; CDSS included evidence summary, link to more information, link to abstracts, and studies that informed summary	No intervention	7 mo	Change in proportion of ABx <10 days. Change in frequency of ABx	Unclear
Mainous[21] 2000 US	RCT	PCC	Clinicians I1 = 53 I2 = 49 I3 = 52 C = 62 Parents	<18 yr Medicaid enrollees	I1: Patient education pamphlet on AB use I2: Clinician feedback (prescribing profile on (URI, bronchitis, pharyngitis, with number of episodes, number of ABx, proportion of ABx, total cost of episode, proportionate cost of ABx) mailed with letter explaining that prescribing was being evaluated; and I3: Clinician feedback and patient education	No intervention	5 mo	ABx per URI	Medicaid data episode of care
Margolis[28] 1992 Israel	RCT	1 PCPC	Clinicians *n* = 6	<16 yr	Clinicians received at least one computerised care algorithm (gave treatment guidance and produced a record of consultation) for otitis media, pharyngitis, or URI	No care algorithm (clinician could receive algorithm for other condition)	5 wks	Records of incorrect use of ABx per all ABx	Medical records
Razon[29] 2005 Israel	P/P	5 PCC	Clinicians *n* = 27	3 mo–18 yr with acute otitis media, tonsillopharyngitis, sinusitis, or upper RTI	Clinicians attended a 1 day group educational session, on appropriate diagnosis and treatment of paediatric viral respiratory tract infection, acute otitis media, acute tonsillopharyngitis, and acute sinusitis (content based on CDC principles of judicious AB use)	(Historical data prior to intervention)	4 mo	ABx per diagnosis Appropriate ABx per diagnosis	Medical records
Interventions targeting parents only									
Ashe[30] 2006 US	P/P	3 PCC	Clinicians *n* = 7 (Intervention was targeted to parents)	6 mo–10 yr (mean 4.2 yr) with respiratory tract infection, *n* = 720	Waiting room poster, targeted to parents, with information on causes of common cold, symptomatic treatment, appropriate use of AB, and AB resistance	Historical data (prior to intervention)	1 mo	ABx per RTI consultation	Medical records
Mainous[21] 2000 US	RCT	PCC	Clinicians I1 = 53 I2 = 49 I3 = 52 C = 62 Parents	<18 yr Medicaid enrollees	I1: Patient education pamphlet on AB use I2: Clinician feedback (prescribing profile on (URI, bronchitis, pharyngitis, with number of episodes, number of ABx, proportion of ABx, total cost of episode, proportionate cost of ABx) mailed with letter explaining that prescribing was being evaluated I3: Clinician feedback and patient education	No intervention	5 mo	ABx per URI	Medicaid data episode of care
Taylor[31] 2005 US	RCT	PCPC	Parents I = 252 C = 247	<24 mo	Parents were given a 5-minute personalised videotape message featuring a paediatrician from the local clinic; pamphlet on judicious use of AB; and instruction to review material and discuss any questions with child's clinician (clinicians were blinded to parent groups). Pamphlet and questionnaire mailed to parents 6 wks and 6 mo after enrolment.	3 pamphlets on injury prevention (each focusing on different age group); instruction to review material and discuss questions with child's clinician. Pamphlets and questionnaire mailed to parents 6 wks and 6 mo after enrolment	12 mo	Number of consultations resulting in ABx	Medical records

AB = antibiotic. ABx = antibiotic prescription. AOM = acute otitis media. C = control. CDC = Centers for Disease Prevention. CDSS = computerised decision support. CRCT = cluster randomised controlled trial. ECS = emergency call service (urgent care after hours clinic). FQHC = federally qualified health center. HMO = health maintenance organisation. I = intervention. mo = months. NRCT = non-randomised controlled trial. P/P = one group pre/post test. PCC = primary care clinic. PCPC = primary care paediatric clinic. RCT = randomised controlled trial. RTI = respiratory tract infection. SD = Standard deviation. UPC = university paediatric clinic. URI = upper respiratory infection. wks = weeks. yr = years.

Table 2. Effects of interventions targeting clinicians and parents to reduce antibiotic prescribing for respiratory tract infections in children

Study	Age	Outcome	Intervention	Control	OR [95% CI] or % difference	NNT	Mean difference	Significance	Risk of bias
Cohen[15] 2000	<10 yr	Proportion receiving ABx	523/1957 (26.7%)	670/1807 (37.1%)	0.62 [0.54 to 0.75]	10	–	<0.001	Moderate
Doyne[16] 2004[a,b]	NR	ABx filled/consultation	0.82 (0.71–0.95)	0.86 (0.77–0.95)	0.04	–	–	NS	High
Finkelstein[17] 2001[a,b]	3 to <36 mo	Change in ABx/person–year	–18.6%	–11.5%	7.1%	–	–	*<0.001*	Moderate
	36 to <72 mo		–15%	–9.8%	5.2%	–	–	*<0.001*	
Francis[18] 2006[c]	NR	Exceptions to care pathway	33.7%	41.2%	7.5%	13		<0.001	Moderate
Francis[19] 2009[a]	6 mo–14 yr	ABx/index consultation	50/256 (19.5%)	111/272 (40.8%)	0.35 [0.23 to 0.53]	5	–	<0.001	Minimum
Juzych[20] 2005[b,d]	NR	Change in ABx/consultation	–25.9%	–4.8%	21.1%	–	–	I: *<0.0001*[e] C: *0.35*[e]	Moderate
Mainous[21] 2000[b]	<18 yr	Mean change in proportion of consultations resulting in ABx	15.3%	22.5%	–	–	7.2%	*<0.05*	Moderate
Regev-Yochay[22] 2011[a]	<18 yr	ABx/100 patient–years (*n*)							Moderate
		Year 0, baseline	78.38 (43 677)	76.32 (44 453)	1.116 [0.91 to 1.36]	–	–	–	
		Year 1, baseline	65.57 (44 702)	70.95 (45 195)	0.914 [0.89 to 0.93]	–	–	–	
		Year 2, intervention	46.93 (42 495)	59.34 (45 918)	0.765 [0.75 to 0.78]	–	–	–	
		Year 3, intervention	48.18 (46 046)	57.58 (48 023)	0.809 [0.79 to 0.83]	–	–	–	
		Year 4, intervention	48.99 (49 341)	59.60 (48 323)	0.809 [0.79 to 0.83]	–	–	–	
		Year 5, follow-up	45.91 (49 998)	54.56 (47 701)	0.844 [0.82 to 0.86]	–	–	–	
Smabrekke[23] 2002[d]	1–15 yr	Patients receiving ABx of those consulting with acute otitis media	155/210 (73.8%)	114/124 (91.9%)	0.25 [0.11 to 0.53]	6	–	<0.001	Moderate
Wilson[24] 2003[b]	<2 yr	Mean change in ABx/ 100 Medicare services	–0.78 (+–1.3)	0.35 (+–1.7)	–	–	1.13	*0.03*	Moderate

[a]Cluster randomised controlled trial. [b]No absolute numbers given. [c]Pre- and post- design: intervention = post; control = pre. [d]Non-randomised controlled trial. [e]Within-group significance. ABx = antibiotic prescriptions. mo = month. NNT = Number needed to treat. NR = not reported. NS = not significant. yr = year. Italicised P-values were those reported in original study.

directed toward clinicians only;[21,25–29] three interventions targeted parents only.[21,30–31]

Effects of interventions targeting clinicians and parents

Eight of the 10 interventions which targeted both clinicians and parents reported significantly decreased prescribing rates,[15,17–20,22–24] with reductions ranging from 6–21% at follow-up from 1 week[15] to 2 years[24] (Table 2). The largest effect was observed in a study which used a combined parent–clinician 'interactive book' during the consultation, resulting in a lower prescribing rate of 19.5% (versus 40.8%, $P<0.001$) at 2 weeks.[19] One intervention, a combination of academic detailing and written parent education, showed no effect.[16] The remaining study by Mainous *et al* reported increased rates of antibiotic prescribing in both intervention (15.3%) and control groups (22.5%) during the 5-month study period.[21]

Most studies had a moderate risk of bias due to poor reporting of methods or uncertain participant exposure to the intervention.[16–18,20,21,23,24] The method of randomisation was not reported in either study where there was no intervention effect.[16,21] Indeed, Doyne *et al* noted that the lack of effect could in part be due to dissimilar prescribing rates between groups at baseline and to concurrent media campaigns.[16]

Three studies reported adverse events

Figure 1. Flow of included studies

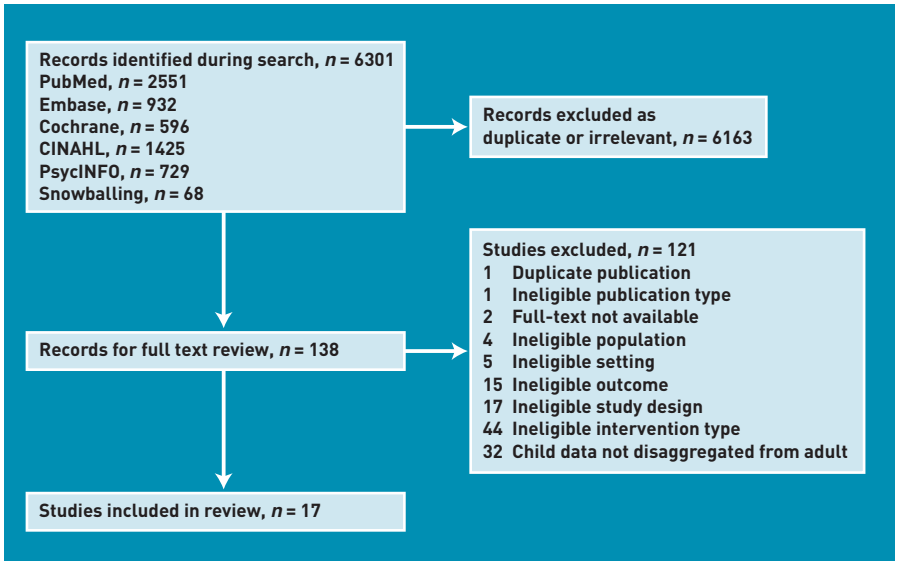

Table 3. Effects of interventions targeting clinicians to reduce antibiotic prescribing for respiratory tract infections in children

Study	Age	Outcome	Intervention	Control	OR [95% CI] or difference	NNT	Mean difference	Significance	Risk of bias
Bauchner[25] 2006[a]	3 mo–3 yr	ABx in adherence to guideline/total ABx							Moderate
		First episode of acute otitis media	1073/1373 (78.2%)	795/1126 (70.6%)	1.49 [1.24 to 1.79]	13	–	*0.42*[d]	
		Second episode of acute otitis media	316/505 (62.6%)	248/414 (60%)	1.12 [0.85 to 1.47]	37	–	*0.84*[d]	
Bourgeois[26] 2010[b]	<18 yr	ABx/RTI consultation	5929/14934 (39.7%)	2303/5007 (46%)	6.3%	–	–	*0. 844*[d]	Moderate
Christakis[27] 2001[a,c]	NR	Change in mean proportion of ABx <10 day duration	44.43%	10.48%	33.95%	–	–	*<0.01*	Moderate
		Change in frequency of ABx	4.33%	16.81%	12.48%	–	–	*0.095*	
Mainous[21] 2000[c]	<18 yr	Mean change in proportion of consultations resulting in ABx	15.2%	22.5%	–	–	7.3%	*NS*	Moderate
Margolis[28] 1992[c]	<16 yr	Incorrect AB orders/all AB orders					–		Moderate
		Otitis media	12%	46%	34%	–	–	*<0.001*	
		Pharyngitis	18%	47%	29%	–	–	*<0.01*	
		Upper respiratory infection	44%	64%	20%	–	–	*NS*	
Razon[29] 2005[b]	3 mo–18 yr	Appropriate ABx/consultations							Moderate
		Acute otitis media	1784/2114 (84.4%)	1290/1727 (74.7%)	1.83 [1.56 to 2.16]	10	–	*<0.001*	
		Pharyngitis/tonsillitis	711/1434 (49.6%)	654/1610 (40.6%)	1.44 [0.73 to 1.78]	11	–	*<0.001*	
		Sinusitis	108/186 (58.1%)	91/166 (54.8%)	1.14 [0.73 to 1.78]	31	–	*0.61*	
		ABx/ consultations							
		Acute otitis media	1848/2114 (87.4%)	1606/1727 (92.9%)	0.52 [0.42 to 0.66]	18	–	*<0.001*	
		Pharyngitis/ tonsillitis	1196/1434 (83.4%)	1348/1610 (83.7%)	0.98 [0.80 to 1.19]	309	–	*0.85*	
		Sinusitis	160/186 (86%)	143/166 (86.1%)	0.99 [0.52 to 1.89]	813	–	*0.90*	
		Upper respiratory infection	97/846 (11.5%)	119/861 (13.8%)	0.81 [0.60 to 1.09]	43	–	*0.16*	

[a]Cluster randomised controlled trial. [b]Pre/post design: intervention = post; control = pre. [c]No absolute numbers given. [d]Adjusted for cluster randomization. AB = antibiotic. ABx = antibiotic prescriptions. mo = month, NR = not reported. NS = not significant. RTI = respiratory tract infection. yr = year. Italicised P-values were those reported in original study.

or re-consultation rates, and reported no difference in rates of mastoiditis[23] or re-consultations.[19,20] Cohen *et al* found no significant difference in symptom duration between groups despite a significantly lower rate of antibiotic prescription (26.7% versus 37.1%, $P<0.001$) in the intervention group.[15]

Effects of interventions targeting clinicians only

Of the six interventions targeted only to clinicians, one[29] reported a significant reduction in antibiotic prescribing, and a further two[27,28] reported significant reductions in inappropriate prescribing (Table 3). The remaining three studies found either no significant reduction or an increase in antibiotic prescribing.[21,25,26]

Razon *et al* studied the effect of a 1-day educational seminar for clinicians and found significant reductions in antibiotic prescriptions per diagnosis at 4 months for acute otitis media (OR 0.52 [95% CI = 0.42 to 0.66]), but not for pharyngitis/tonsillitis,

Table 4. Effects of interventions targeting parents to reduce antibiotic prescribing for respiratory tract infections in children

Study	Age	Outcome	Intervention	Control	OR [95% CI] or difference	NNT	Mean difference	Significance	Risk of bias
Ashe[30] 2006[a]	6 mo–10 yr	ABx/RTI consultation	151/360 (41.9%)	175/360 (48.6%)	0.76 [0.56 to 1.04]	15	-	0.09	Low
Mainous[21] 2000[b]	<18 yr	Mean change in proportion of consultations resulting in ABx	12.6%	22.5%	-	-	9.9%	*<0.05*	Moderate
Taylor[31] 2005	<24 mo	Number of visits with ABx for OM[c]	1.7 ± 2.1	1.9 ± 2.4	-	-	0.2	*0.23*	Low
		Number of visits with ABx for OM or sinusitis[a]	1.9 ± 2.3	2.1 ± 2.5	-	-	0.2	*0.24*	

[a]Pre/post design: intervention = post; control = pre. [b]No absolute numbers given. [c]Per patient mean. ABx= antibiotic prescriptions. mo: month. NNT= Number needed to treat. OM=otitis media. OR= odds ratio. RTI= respiratory tract infection. yr= year. Italicised P-values were those reported in original study.

sinusitis or undefined upper respiratory infection.[29] Using a computer decision support system (CDSS) that automatically began each time a clinician wrote an antibiotic prescription, Christakis *et al* reported a 34% reduction in the frequency of inappropriate prescribing (prescriptions for >10 days); however, the prescribing rate increased overall during the 7-month follow-up, though to a lesser extent in the intervention group (4.3% versus 16.8%, non-significant).[27] Margolis *et al* found significant decreases in rates of 'incorrect' antibiotic prescribing for otitis media (34%) and pharyngitis (29%) but not upper respiratory infections among clinicians using a computerised algorithm, however, the study was stopped prematurely due to low participation.[28]

Prescribing feedback reports did not reduce prescribing, in fact rates increased by 15.2% at 5 months (versus 22.5% among controls).[21] Interventions in two other studies that did not find significant reductions in prescribing included an optional CDSS[26] (in contrast to the automatic system in the Christakis study), and prescribing feedback reports coupled with group education sessions.[25]

All studies in this group presented a moderate risk of bias due to unclear methods,[21,25,26,28] uncertain or low exposure to the intervention,[21,25,26,28] lack of detail in the intervention description,[21,28] or lack of control group.[29]

Effects of interventions targeting parents only

None of the interventions directed only at parents significantly reduced antibiotic prescribing (Table 4).[21,30–31] Ashe *et al* reported that a waiting room poster with information on judicious antibiotic use did not produce a significant difference in prescribing rates between intervention and control groups (41.9% versus 48.6%, $P = 0.09$).[30] Testing the effect of patient education pamphlets, Mainous *et al* observed an overall 12.6% increase in prescribing over 5 months, although this was lower than the increase seen in the control group (22.5%).[21] In the study by Taylor *et al*, parents viewed a brief videotape message and received a pamphlet 6 weeks and 6 months after initial randomisation (materials included education about the judicious use of antibiotics); at 12 months there was no significant difference in the number of RTI consultations resulting in antibiotic prescription between groups.[31] The studies by Ashe and Taylor had a low risk of bias, whereas the Mainous study had a moderate risk of bias due to unclear methods and intervention description. No study assessed extent of exposure to the intervention.

DISCUSSION

Summary

Conflicting evidence from the 17 studies found that interventions directed towards parents and/or clinicians can reduce rates of antibiotic prescribing for children with RTIs. The most effective interventions involved targeting both parents and clinicians during a consultation,[19] providing automatic computer prompts for evidence-based prescribing,[27] and promoting clinician leadership or participation in the design of treatment guidelines and/or peer education.[22,24] There was moderately strong evidence that interventions were more effective in reducing antibiotic prescribing when delivered to clinicians in collaboration with parents.[15,17–19,22–24] In contrast, based on limited evidence, passive strategies targeting only parents, such as waiting room posters or pamphlets, do not appear to alter prescribing rates significantly.[30–31] Moreover, interventions involving printed materials for parents varied in effect; those with actionable information (such as self-care advice and signs to re-consult)[18] were more effective in reducing rates of antibiotic prescription than materials with generic information on the appropriate use of antibiotics.[30] The findings suggest computer-based interventions are only successful when integrated into routine clinical processes (for example, writing prescriptions) and less so when clinicians must manually employ the application.

Strengths and limitations

Only published studies were included therefore unpublished studies of relevant interventions may have been missed. To address risk of publication bias multiple databases were searched, the search by language was not limited, and reference lists and related citations of included studies were also searched. The focus was on studies from high income countries, which may limit the generalisability of the findings to low/middle income settings. Overall methodological quality of the included studies was highly variable and generally moderate. Most studies did not report the extent of parent and/or clinician completion or participation in intervention activities; this risk of bias may further limit the robustness of conclusions that can be drawn from the reported findings. Studies which assess 'appropriate' prescribing

could be subject to changes in diagnostic labelling by participating clinicians, which would bias the results toward a positive intervention effect.[32] Also, diagnostic criteria for eligible RTIs were not clearly described, and it is unclear how generalisable the spectrum of illness was in study populations at enrolment. Only three studies reported complications or re-consultations; results from these studies did not indicate increased risk of adverse events related to decreased prescribing but would not have been adequately powered to identify effects on less common adverse outcomes (for example, hospital admission).[19,20,23]

Comparison with existing literature

Previous reviews have explored the effectiveness of interventions to change antibiotic prescribing behaviour of clinicians for various types of infection in adults and children.[13,33–35] These reviews and prior research similarly concluded that the most effective interventions involve clinicians and patients,[35–37] as well as the general public.[7,32] In a systematic review of antimicrobial control programmes in paediatric outpatient and hospital settings (of which four studies overlap with this review) Patel *et al* concluded that provider-targeted interventions which featured diagnosis-specific education were more likely to change prescribing for childhood infections.[34] Two systematic reviews (Arnold[33] and Ranji[35]) examined effectiveness of clinician and/or parent strategies to reduce antibiotic prescribing for adults and children for all conditions in outpatient settings. Although only a small number of the studies in this review overlapped with these (six out of 30 studies in Ranji; two out of 39 studies in Arnold), the findings broadly concur with their conclusions that effective interventions to reduce antibiotic prescribing involve multifaceted approaches targeting clinicians and patients, and that printed materials or audit and feedback had limited effect.

Finally, a systematic review[13] of interventions to change health professional's behaviour (including prescribing, referral, clinician knowledge, and guideline compliance) in management of children with upper RTIs in any type of setting identified 10 studies (six of which are also included in this review[20,23–25,27,28]). It concluded that computer interventions, educational sessions, collaboratively developed guidelines and training videos were effective in changing practice, and that multifaceted and computer interventions worked best. This review identified an additional 11 studies specific to antibiotic prescribing for children with RTI in primary care, and included interventions directed towards both clinicians and parents, which more realistically reflects actual practice. Only mixed evidence was found to support CDSS to change clinician behaviour (partly due to the inclusion of a newer study[26]) and noted that the more effective CDSS provided: recommendations rather than just assessments; and automatic decision support at the time and location of decision-making.[38] We found two studies including consultation skills training,[19,22] which has been shown to be effective in reducing antibiotic prescribing for adults.[39–40]

Implications for practice and research

For policymakers, the findings of this study suggest that more appropriate prescribing for RTIs in children may be achieved when interventions are designed in consultation with participants, incorporate changes into everyday prescribing processes, and address the needs of parents and clinicians. Passive approaches such as waiting room posters and written materials in isolation have limited effects. However, the cost-effectiveness of these interventions and effects on other health service outcomes such as repeat attendance or risk of complications need to be determined. In addition, clinicians and parents need evidence for the effectiveness of alternatives to antibiotic therapy for symptomatic relief of RTIs.[41] Qualitative research, involving parents and clinicians, of the reasons why some interventions are more effective than others could improve the understanding of effective interventions. Ongoing studies involving multi-component interventions, HAPPY AUDIT,[42] DECISION+,[43] and TARGET (http://targetstudy.org.uk/), will likely contribute new data to these research gaps.

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