An Roinn Sláinte
Department of Health

A Department of Health Research Paper 2024

Changing Behaviour: Reducing Unnecessary Antibiotic Prescribing. A Systematic Review and Meta-analysis.

Dr. Robert Murphy*, Dr. Elayne Ahern, Aaron Deegan*, Kimberely Hogan*, Ailish Kelly*, John Reidy*, Dr. Grace McMahon**, Prof. Orla Muldoon****

*Strategic Research & Evaluation Unit, Research, Development, & Health Analytics Division, Department of Health.

**Department of Psychology, University of Limerick

August 2024

IGEES
Seirbhís Eacnamaíoch agus Luachála Rialtas na hÉireann
Irish Government Economic and Evaluation Service

Table of Contents

Citation

Murphy, R., Ahern, E., Deegan, A., Hogan, K., Kelly, A., Reidy, J., McMahon, G & Muldoon, O. (2024). Changing Behaviour: Reducing Unnecessary Antibiotic Prescribing. A Systematic Review and Meta-analysis.

Acknowledgements

We thank Viktoria Pavlakova, Alison O'Dwyer and William Kavanagh from the Department of Psychology, University of Limerick for their contribution to the meta-analysis.

Executive Summary

Background

Antimicrobial resistance (AMR) is when a microbe (bacteria, viruses, parasites, or fungi) changes over time to become more or fully resistant to medicines (called antimicrobials) which previously could treat it. AMR leads to higher medical costs, increased mortality, and lower economic output. AMR is classified by the World Health Organization (WHO) as 1 of the top 10 threats to public health. AMR poses a significant threat to our health system through reduced treatment options for infections by resistant pathogens, while also imposing a large financial burden on the state. In recent years AMR has increased at an accelerated rate globally and it is forecast to continue to increase. A driver of AMR is the unnecessary use of antimicrobials, e.g., prescribing and using antibiotics for infections that are not bacterial.

Ireland's current policy response to AMR is outlined in Ireland's Second One Health National Action Plan on Antimicrobial Resistance 2021-2025 (iNAP2). Action 5-05 of iNAP2 includes the action to "Review the evidence base for behavioural change initiatives to promote optimal antimicrobial prescribing and reduce antimicrobial consumption". This study delivers on that action. This study provides the highest level of evidence (a systematic review of randomised trials - RCTs) on whether interventions which seek to reduce unnecessary use of antibiotics in the community have the intended effect on prescribing, dispensing or consumption.

Key Findings

This review identifies seven intervention categories that have been tested in the peer reviewed literature through RCTs in the community. Namely, education, communication training, point of care (POC) testing, decision support tools (other than POC testing), delayed prescribing, audit and feedback, and multiple component interventions (which involved a combination of two or more of the latter). There was a high share of interventions with multiple components. For example, educational interventions were often combined with one or more other interventions such as communication training and audit and feedback interventions. Most of the studies tested whether interventions changed the behaviours of prescribing followed by consumption. Some studies also measured whether prescriptions were dispensed or not after the interventions.

Our meta-analysis produced a pooled weighted average estimate of the effect of interventions on a particular outcome. An estimate is produced for each of the outcome measures used in the primary studies, namely prescribing, consumption and dispensing.

The meta-analysis shows that behaviour change interventions reduced antimicrobial prescribing by 21% relative to control. This finding of intervention effectiveness holds across geography (Europe vs. North America), publication year (studies published up to and including 2010, relative to the subsequent decade), and intervention target group (practitioner and patient versus practitioner alone). The finding also holds after allowing for possible risk of bias and indeed after undertaking sensitivity analyses.

Our meta-analysis (weighted average effect size) also found that behaviour change interventions reduced antimicrobial consumption by 53% relative to control. While the total number of studies are smaller than for prescribing (5 compared to 22), this finding of effectiveness still holds across checks. Our finding holds across geography, publication year, and intervention target group (practitioner and patient versus patient alone), and it also holds after risk of bias assessment (it was not possible to undertake sensitivity analyses due to the smaller number of studies). Our meta-analysis suggests that behaviour change interventions did not significantly reduce the number of antimicrobial prescriptions dispensed relative to control. However, this latter finding is based on only two studies.

Undertaking a simple count of whether authors' of primary studies found reported interventions to be effective or not, supports the effectiveness of behaviour change interventions to reduce prescribing, consumption, or dispensing. Looking across all the 88 identified tests of interventions, approximately 2 out of 3 (58 out of 88) are reported to have significantly reduced antibiotic prescribing, consumption, or dispensing while approximately 1 out of 3 (30) are reported not to be effective.

We also produced meta-analysis estimates of effectiveness by type of intervention. Caution is needed when interpreting these as they are based on a relatively small number of studies. Overall, the available evidence supports the effectiveness of education; communication training; point of care (POC) testing, and POC testing combined with communication training; decision support tools (DST) other than POC testing, and DST combined with education; and delayed prescribing. There is conflicting evidence between the meta-analysis estimates of no effect and the narrative analysis of authors' conclusions on effectiveness for the interventions of audit and feedback combined with education.

Conclusions

Overall Conclusion

Based on the highest level of evidence (a systematic review of randomised trials - RCTs) this study shows that interventions can reduce unnecessary prescribing and use of antibiotics in the community and therefore, there is a **policy rationale**:

a. to **support the use** of interventions for which the evidence supports their effect, and

b. to **explore and encourage refinements** to improve interventions for which evidence is less clear but there is potential.

Conclusions by Intervention Type and Reporting of Findings[1]

1. **Education interventions** and **communication training** both aim to increase capability and are both shown to reduce unnecessary prescribing for use in the community, so it is important to review the extent to which education and communication training in the initial education and continuing professional development of general practitioners (GPs) in Ireland:
    a. Covers the **topics** included in the effective interventions identified by this review.
    b. Avails of the **range of pedagogy and delivery mechanisms** used in the effective interventions identified in this review.
    c. Draws on evidence from the wider behavioural science literature on what are the most relevant underlying psychological mechanisms to target in education interventions and communication training and how best to frame such interventions.

2. **Point of care testing** is shown to reduce unnecessary prescribing for use in the community, therefore it is important to:
    a. Review the **promotion** of POC testing in the initial education and continuing professional development of general practitioners (GPs) in Ireland.
    b. Determine the **extent of use** of POC testing in general practice in Ireland.

---

[1] When reading this section, it is important to note that while the meta-analysis indicates whether certain interventions work or not based on available evidence, the researchers apply these results to form aspects of these conclusions.

c. Examine potential **barriers** to the use of POC testing, which could be financial (cost of tests, additional time) and non-financial (awareness, perceptions), and **ways to increase** use of POC testing by GPs. In doing so, it will be important to draw on the wider behavioural science literature on barriers and drivers to the use of POC testing.

3. **Decision support tools** (other than POC testing) used for prescribing in the community are shown to be effective, although even when recommended for use their take-up can sometimes be limited. Therefore, for DSTs it would be useful to:
   a. Identify if DST are recommended to general practitioners (GPs) in Ireland and if so to **gauge the extent of current use**.
   b. Where DST have been recommended it would be beneficial to **undertake a "sludge audit"** to identify frictions reducing use and ways to improve design (drawing on the wider behavioural science literature) to support greater use of DST.

4. **Delayed prescribing** use by general practitioners (GPs) and other prescribers for use in the community is shown to reduce unnecessary consumption, so it is important to:
   a. Review the **promotion** of delayed prescribing in the initial education and continuing professional development of general practitioners (GPs) in Ireland.
   b. Determine the **extent of use** of delayed prescribing in general practice in Ireland, distinguishing between the use of delayed script filling or delayed script collection.
   c. Examine **potential barriers** to the use of delayed prescribing, whether delayed script filling or delayed script collection is more effective, and **ways to increase** the use of delayed prescribing by GPs (taking into account evidence from the wider behavioural science literature).

5. **Audit and feedback** to professionals who prescribe for antibiotic use in the community has mixed evidence on effectiveness. The content and presentation of information provided in audit and feedback interventions are particularly important. Audit and feedback is currently provided in Ireland in letter format to GPs on prescribing for patients

with medical cards by the HSE Antimicrobial Resistance and Infection Control (AMRIC). Given the findings from this review it would be useful[2]:

a. For the AMRIC to **consider working on a collaborative project with the Better Letter Initiative** (BLI)^ to design and test A&F correspondence for GPs aimed to reduce unnecessary prescribing considering the existing A&F correspondence used in Ireland, correspondence reported to be effective in this review, and the BLI approach (which involves incorporating findings from the wider behavioural science literature and typically involves testing of re-design material).
b. For GPs not covered by the existing audit and feedback mechanism above, possibly 2 out of every 10 GPs^^, it is important to engage with the ICGP and HSE to **develop ongoing mechanisms to** (i) collect information on prescribing by these GPs, and (ii) audit and provide feedback to these GPs on their prescribing practices.

Re ^ and ^^, please see the Main Report for more detailed information.

6. **Reporting of information in primary research studies.** Approximately half the relevant studies identified for this review did not report sufficient statistical detail to facilitate inclusion in the meta-analysis. Therefore, it is recommended that future primary studies transparently **report details of the participant numbers that were sampled alongside relevant frequency statistics** (e.g., risk events, total events) to allow for efficient pooling of all available studies and facilitate future meta-analysis.

[2] This conclusion is relevant to any profession engaged in prescribing of antibiotics for use in the community.

1. Introduction

1.1 Background

Antimicrobial resistance (AMR) is when a microbe (bacteria, viruses, parasites, or fungi) change over time to become more or fully resistant to medicines, called antimicrobials, which previously could treat it. Antimicrobials include antibiotics, which kill or inhibit the growth of bacteria. Resistance to antimicrobials leads to:

- Higher medical costs to treat complications caused by resistant infections.
- Prolonged stays in hospital to treat resistant infections.
- Increased mortality due to resistant infections.
- Lower economic output due to reduced workforce participation and productivity.

AMR is classified by the World Health Organization (WHO) as 1 of the top 10 threats to public health. In recent years AMR has increased at an accelerated rate globally and it is forecast to continue to increase. One of the drivers of AMR is the overuse (hereafter referred to as unnecessary use) of antimicrobials. This happens when there is prescription and consumption of antibiotics for infections that are *not* bacterial or of anti-virials for infections that are *not* viral.

1.2 Purpose of this Study

Ireland's current policy response to AMR is outlined in Ireland's Second One Health National Action Plan on Antimicrobial Resistance 2021-2025 (iNAP2). Action 5-05 of iNAP2 includes the action to "Review the evidence base for behavioural change initiatives to promote optimal antimicrobial prescribing and reduce antimicrobial consumption". This study delivers on that action.

This study provides the highest level of evidence (a systematic review of randomised trials - RCTs) on whether interventions which seek to reduce unnecessary use of antibiotics in the community have the intended effect of reducing antibiotic prescribing, dispensing or consumption. RCTs provide the basis to draw reliable conclusions on cause-effect relationship between an intervention and the behaviour of interest as RCTs compare the outcome for a group that received an intervention to the outcome to a control group that did not receive an intervention and the allocation to either group was by chance (i.e., when correctly implemented the only difference between the groups is the intervention).

We identified studies and extracted information from them in a way that minimises bias. We used predefined terms to search five peer reviewed databases and reference searched eight previous systematic reviews. All RCTs that tested whether an intervention reduced antibiotic prescribing, dispensing or consumption were included provided they were undertaken in an OECD country and published in English. We extracted the conclusions of study authors' on the effectiveness of interventions. In addition, we produced a meta-analysis or weighted mean effect estimate across studies by statistically combining results from multiple studies. This study differs from previous systematic reviews as it focuses on unnecessary use in the community and therefore includes interventions that are focused on the practitioner, the patient or both.

2. Methods

2.1 Search Strategy

A systematic search for peer reviewed literature was undertaken of PubMed, EMBASE, MEDLINE, PsycINFO and the Cochrane Central Register of Control Trials (CENTRAL) in August 2022 using the search string below. In addition, the five Cochrane systematic reviews were identified through a primary search of CENTRAL and their references were searched: Arnold et al. (2005), O'Sullivan et al. (2016), Ryan et al. (2014), Spurling et al. (2017), and Tonkin-Crine et al. (2017). From this reference search, four further systematic reviews were identified, and their references were searched: Boonacker et al., (2010), Castelino et al. (2009), de Bont et al. (2015), and Sumant et al. (2008). A final systematic review (Raban et al. (2023) was identified during the search and the 20 studies included in this review were assessed for eligibility to include.

2.2 Search Terms

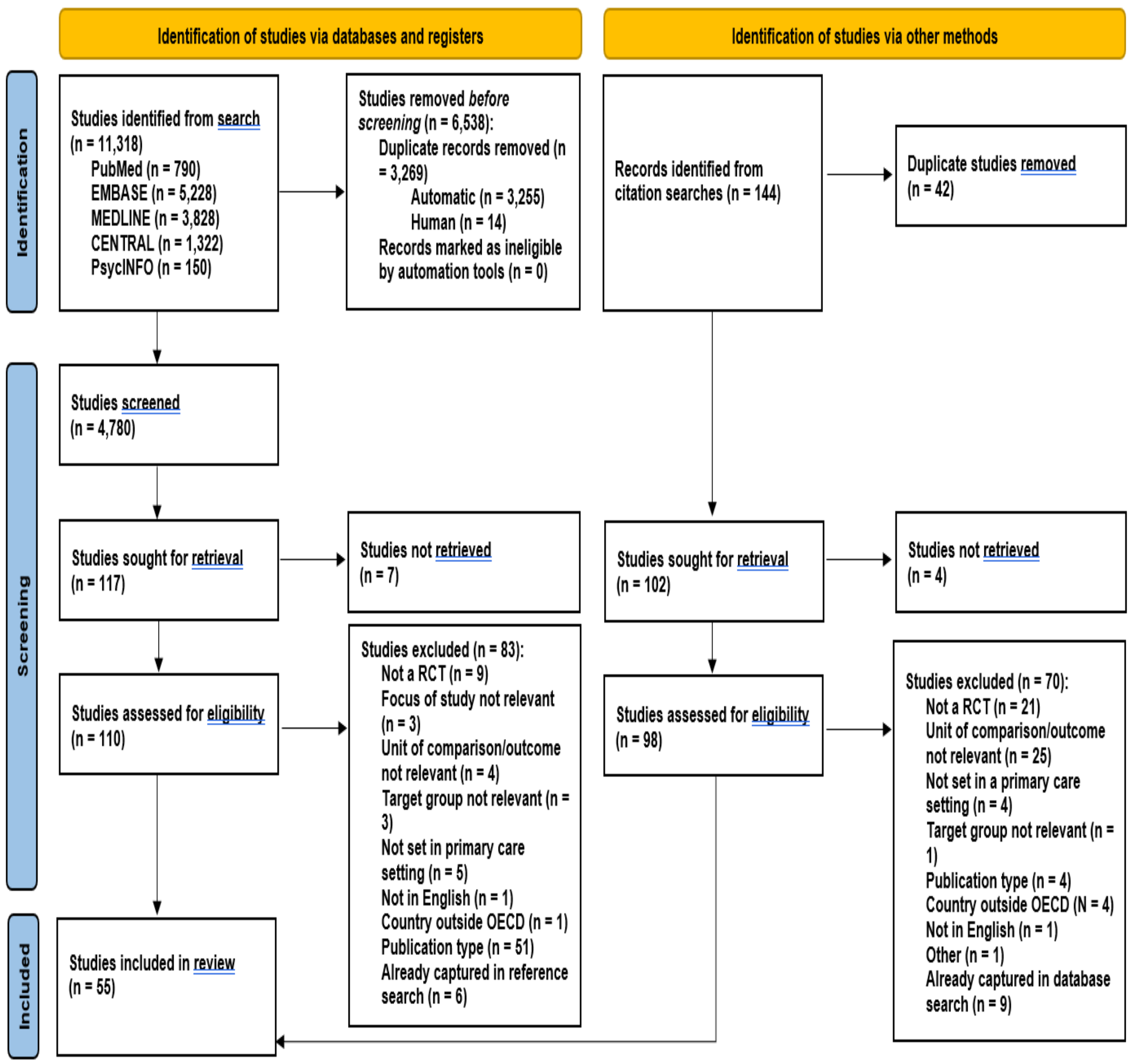
The search terms below were used:

(antibio OR antimicrob* OR antibact* OR antiviral OR AMR) AND (consum* OR use OR utilis* OR prescrib* OR prescrip*) AND (reduc* OR change* OR decreas* OR lower) AND (community OR "general population" OR "general practic*" OR "primary care" OR "ambulatory care") AND (RCT OR random* OR trial OR experiment* OR test*)*

2.3 Inclusion Criteria

Studies were included if they met the following criteria: (1) evaluated a behavioural change intervention that intended to influence behaviour in the community or within a primary or healthcare setting; (2) were not specific to patient type, medical condition or types of medications/ antimicrobials being used; (3) the target of the intervention was the patient/s or practitioner or a combination of both; (4) measures a form of antimicrobial consumption/use or antimicrobial prescription rates/patterns; (5) was a randomised control trial with a control group; (6) was conducted in an OECD country; (7) was published in English. The full texts of 98 articles were screened for eligibility. A total of 55 randomised control trials were included in the qualitative analysis, of those trials 29 could be included in the meta-analysis (see Fig. 1 – PRISMA Flow Diagram.)

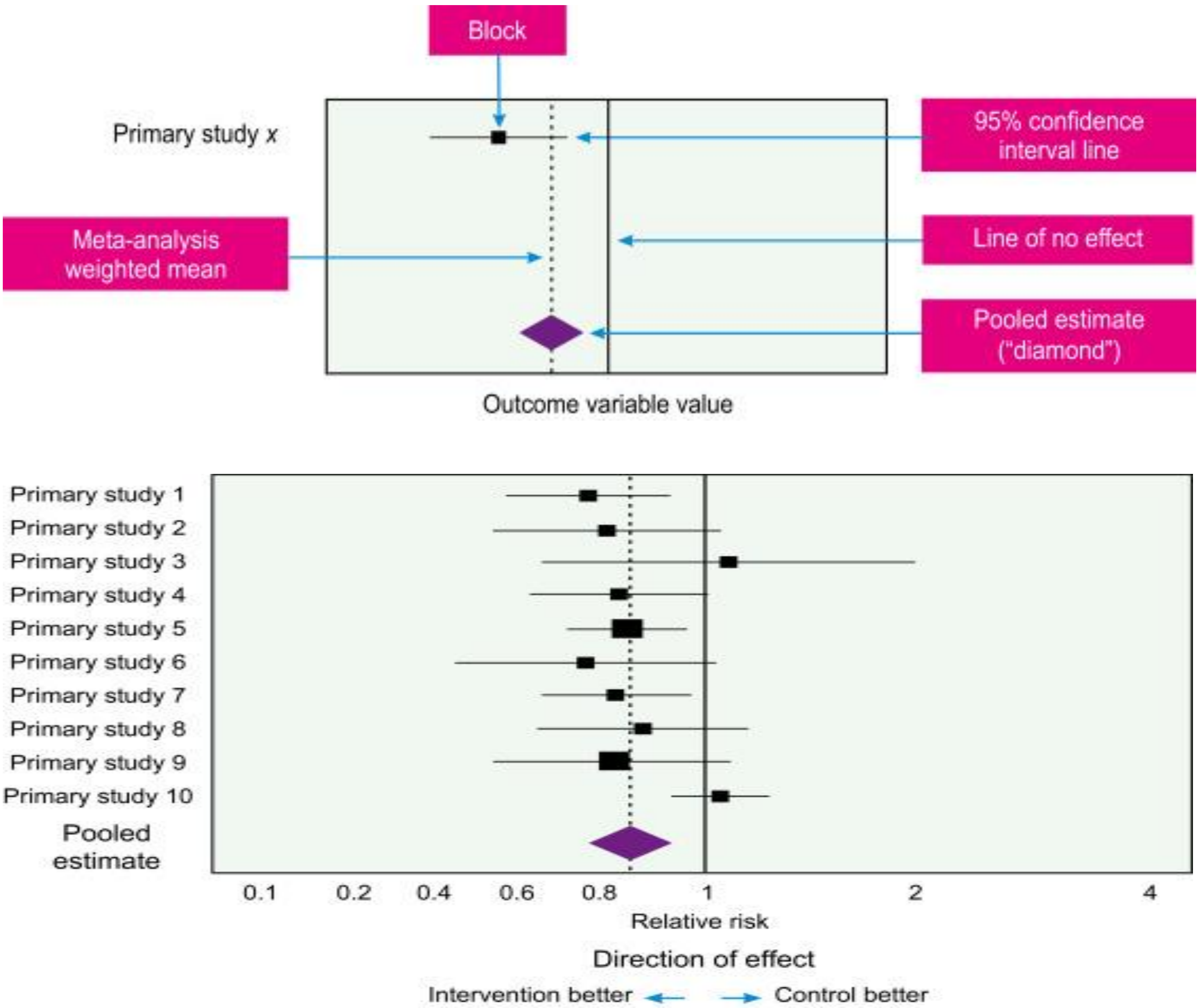
Figure 2.1: Outline of Search Strategy and Screening Profile



2.4. Statistical Methods for Estimating Effect Size

A meta-analysis combines results from multiple studies on the same topic. Results produced through meta-analysis are visually presented as a forest plot (Figure 2.2). Each study is represented by a block indicating the point effect estimate. The area of the block indicates the weight given to each study. The pooled estimates is presented as a diamond at the bottom of the plot. This represents the weighted mean effect across all individual studies included in the meta-analysis.

Figure 2.2: Explanation of Forrest Plots



When only percentage rates were reported in a given study, the absolute risk was calculated using the relevant subsample size of the intervention or control group, respectively (e.g., Legare et al., 2011, 2012). Studies that did not report the respective subsample sizes were not synthesised as the appropriate study inverse-variance weighting could not be determined (e.g., per 1000 patients; Butler et al., 2012; D'Hulster et al., 2022; Gold et al., 2021; McNulty et al., 2018).

Each study contributed only one effect estimate per meta-analysed outcome to ensure independence on effect estimates. In instances where multi-arm trials reported on the efficacy of several behaviour change interventions (e.g., Briel et al., 2006; de la Poza Abad et al., 2016; Gonzales et al., 2013; Hoye et al., 2013; Hurliman et al., 2014; Little et al., 2013; Mainous et al., 2000; Meeker et al., 2016), the number or risk and total events were summed across the intervention arms into a single intervention group and then compared to the control, in accordance with recommendations (Higgins et al., 2023). Additional details on the statistical methods used are provided in Appendix A.

Subgroup analyses were conducted to determine the influence of categorical moderator variables when a minimum of 2 studies were available per subsample. Pre-specified subgroups included publication year (up to 2010, 2011 on); continent (e.g., Europe, North America); intervention target (practitioner, practitioner and patient), and intervention typology (e.g., audit and feedback, education, communication training, point-of-care testing, decision support tool). For the subgroup analysis by intervention typology, multi-arm trials could contribute one effect estimate to the respective subgroup.

In addition, subgroup analysis using the risk of bias assessment of individual studies was undertaken on intervention effect for prescribing and consumption outcomes, and a sensitivity analysis was additionally undertaken for findings for the prescribing outcomes. These are discussed in Chapter 4 and the overall findings remain consistent following these robustness checks.

As only 29 of the 55 eligible studies could be included in the meta-analysis due to a lack of appropriate statistical reporting, this review also includes a narrative analysis so that these studies are not entirely excluded from our analysis. The narrative analysis refers to the collection of conclusions on effectiveness from all studies (those included and not included in the meta-analysis). It involves undertaking a simple count of whether the authors of each study concluded if an intervention was effective or not.

2.5 Outcome Measures

The main outcomes measured in the studies reported in this paper are antimicrobial prescribing, consumption, and dispensing. More detail is provided in the below table, which list all the defined measures from the included studies.

Table 2.1: Main Outcomes Measured

Consumption
▪ Number of patients who consumed/used the antibiotics as prescribed expressed as a percentage of the total number of all patients in the group ▪ Rate of collected/filled prescriptions ▪ Rates of antibiotic courses dispensed per person-year in experimental and control practices ▪ Patients who reported using antibiotics at some stage during the illness ▪ Patients who took the antibiotics in the following two weeks ▪ Where parents had administered the antibiotic to their child as prescribed up to 7 days after consultation ▪ Percentage of patients who self-reported antibiotic use ▪ Number of antibiotic prescriptions per 100 patient-years and the rates of antibiotic drugs purchased by the populations
Prescribing
▪ Total numbers of oral antibiotic items dispensed for all causes per 1000 practice patients in the year after the intervention, adjusted for the previous year's dispensing ▪ Prescribing Rate per 100 Person-Years in order of study periods ▪ Change in the mean number of PIP per patient ▪ Average rate of antibiotic prescriptions per acute cough by GP

- Antimicrobial Prescriptions for ARIs Among Intervention and Control Clinics Adjusted for Clinician Clustering as a percentage of total visits to GP
- Rate of prescribed antibiotics reported by physicians – n (%)
- Number of antibiotics prescribed for acute otitis media as given by the change in mean outcome (before vs after)
- Antibiotic prescribing for all indications, Mean rate per 100 encounters
- Prescription of an antibiotic at the time of the clinical encounter, as recorded on the clinical encounter form
- Prescription for antibiotic medication given to patient in the initial consultation
- Median prescribing rates per 100 Medicare services provided during studied period
- Prescriptions of antibiotics given by number of prescriptions per 1000 patients per month.
- The proportion of practice encounters for acute symptoms of the respiratory tract for which antibiotics were prescribed.
- Total antibiotic prescriptions per 100 encounters for total indicators
- The percentage change of adolescents and adults prescribed antibiotics for uncomplicated acute bronchitis during the PDS intervention
- The percentage change of adolescents and adults prescribed antibiotics for uncomplicated acute bronchitis during the CDS intervention

2.6 Strengths and Limitations

A first strength of this paper is the use of meta-analysis. Meta-analysis gives a less biased analysis of evidence than a narrative analysis as it is less subject to author interpretation. A second strength is the systematic search for studies that was undertaken. A systematic search for peer reviewed literature was undertaken to identify papers for inclusion after application of explicit inclusion criteria. The studies reported in this paper are all randomised control trials (RCTs), the gold standard for this kind of behavioural research. RCTs provide an accurate way of investigating cause-effect relationships between behavioural interventions and outcomes.

A limitation of this paper is that not all studies included in it met the eligibility criteria to be included in the meta-analysis due to the lack of full data reporting. As reported earlier, only 29 of the 55 eligible studies could be included in the meta-analysis. So that these studies are not entirely excluded from this study we also undertake a narrative analysis. However, this introduces a further limitation associated with reporting the results of these studies not included in the meta-analysis. Reporting a simple narrative or count analysis does not account for differences in the relative sizes of the studies and may give equal weights to studies to lower powered studies. Another limitation is that meta-analysis tells you whether certain interventions work or not, however it is up to the researcher to apply these results.

2.7 Quality Assurance

In preparing this report, the authors followed the Irish Government Economic and Evaluation Service (IGEES) quality assurance process on:

- The analysis format (structure)
- Clarity (quality of writing)
- Accuracy (reliability of data)
- Robustness methodological rigour
- Consistency (between evidence and conclusions)

The report was circulated for review to the following internal and external reviewers:

- Colleagues in the Strategic Research & Evaluation Unit, Department of Health
- Members of the Clinical Effectiveness, Antimicrobial Resistance & Surveillance Unit, Department of Health
- Members of the HSE National Antimicrobial Resistance and Infection Control (AMRIC) Team
- Professor Miroslav Sirota, Department of Psychology, University of Essex.

3. Description of Interventions

The primary studies examined did not report using a common typology of intervention types. Nevertheless, it was possible to identify seven intervention categories based on the descriptions of interventions provided in the primary studies. Namely, education, communication training, point of care (POC) testing, decision support tools (other than POC testing), delayed prescribing, audit and feedback, and multiple component interventions (which involved a combination of two or more of the latter).

Education interventions involved informing practitioners of unnecessary antimicrobial use, and equipping practitioners with best practice guidelines: consulting skills, diagnostics and treatments for specific conditions, and recommended prescribing practices. Within the studies these were delivered through seminars, reading material, or posters. [2]

Communication training interventions aimed to improve practitioners' ability to collect information on patient's concerns and expectations, exchanging information on symptoms, advising on natural disease course and treatment, agreement of and agreeing a management plan, and providing guidance about when to reconsult.

Point of care (POC) testing refers to clinical tests carried out by General Practitioners at consultations that provide results in a few minutes. The tests examined in the studies included C-reactive protein (CRP) blood tests for lower respiratory tract infections and Rapid Antigen Detection (RADT) to identify infection at back of throat.

1 Interventions are categorized according to active ingredients, in most cases compared against a control where no intervention, but in some cases normal practice might have involved an intervention to the control and then categorised according to additional interventions e.g., Sondergaard et al, 2003.

2 In some case Education interventions may have also included an element of communication training, e.g., Kronman et al, 2020.

Decision support tools (other than POC testing) refer to computerised tools which aim to support diagnostic or therapeutic decision making. In the studies this could have included providing best practice prompts relating to diagnostic and treatments, information, and tools to assist in assessing a patient's chance of having certain acute conditions (e.g., pneumonia), practitioner inputted free text justifications for prescribing antibiotics that are recorded on patients health electronic record, and suggestions for alternative non-antibiotic forms of treatment.

Delayed prescribing refers to the practice of a general practitioner (GP) providing a prescription with structured advice to avoid filling the prescriptions for a number of days to first see if symptoms will resolve independently of antibiotic use.

Audit and feedback interventions provide information to an individual practitioner on his/her prescribing practices compared to professional standards or peer performance. For example, a letter might be sent to practitioners who are amongst the highest prescribers, highlighting their high prescribing patterns relative to their peers.

Multiple interventions are interventions with 2 or more intervention elements. For example, audit and feedback combined with education and POC testing combined with communication training.

Table 3.1: Distribution of Interventions by Category

Intervention Category	**Meta-Analysis**		**Narrative Analysis**	
	Interventions	**Percentage**	**Interventions**	**Percentage**
Education	6	11%	17	19%
Communication Training	2	4%	3	3%
Point of Care Testing (POC)	3	6%	5	6%
POC Testing and Communication Training	2	4%	3	3%
Decision Support Tools (other than POC)	11	21%	11	13%
DST and Education	3	6%	6	7%
Delayed Prescribing	3	6%	4	5%
Audit & Feedback	4	8%	11	13%
Audit & Feedback and Education	7	13%	14	16%
Audit & Feedback and Decision Support Tool	6	11%	6	7%
Other	6	11%	8	9%
Total	53	100%	88	100%

A summary of each intervention for each study is provided in Appendix B.

4. Overall Effect of Behaviour Change Interventions

It was possible to produce meta-analysis estimates across the three outcome measures of prescribing, consumption, and dispensing. The results indicate that a behavioural change intervention:

- reduced antimicrobial **prescribing** by 21% relative to control. (RR = 0.79, 95% CI [0.72, 0.87], Z = 4.60, $p < .001$),
- reduced antimicrobial **consumption** by 53%, relative to control (RR = 0.47, 95% CI [0.35, 0.62], Z = 5.20, $p < .001$).
- did not significantly reduce the number of antimicrobial prescriptions **dispensed** (based on only 2 synthesised studies only), relative to control (RR = 0.88, 95% CI [0.63, 1.23], Z = 0.74, $p = .46$). Detailed estimates are shown in Figure 3.1.

There was substantial heterogeneity among the included studies for prescribing, T, χ^2 (21) = 87.37, p < .001, $\tau^2 = 0.04$, $I^2 = 76\%$, and consumption, χ^2 (4) = 14.93, p < .01, $\tau^2 = 0.07$, $I^2 = 73\%$. This warranted further subgroup analyses. This additional analysis suggests the interventions are effective across geography (Europe vs. North America), publication year (studies published up to and including 2010, relative to the subsequent decade), and intervention target group (practitioner and patient versus practitioner alone). Detailed results from the subgroup analysis are provided in Appendix C.

Of the 29 studies included in the meta-analysis, the vast majority (22 or 75%) measured prescribing, while a smaller number measured consumption (5 studies) or 2 dispensing (2 studies). It was possible to undertake an analysis by risk of study bias for the studies that measured prescribing and consumption, and it was also possible to undertake a sensitivity analysis for the studies that measured prescribing.

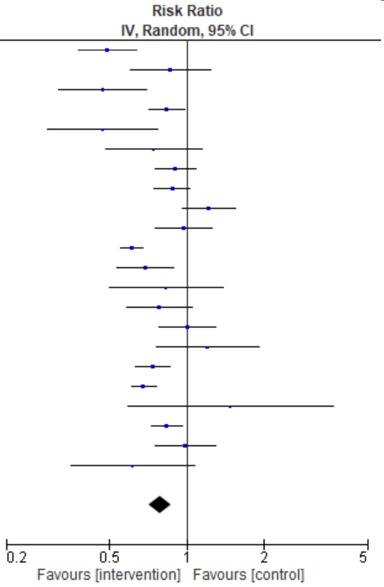
Subgroup analysis using the risk of bias assessment of individual studies suggested that the intervention effect on prescribing rates and consumption holds after taking account of risk of bias (details are in Appendix D). Results from the sensitivity analyses indicated that all findings for the prescription outcome remained consistent (see Appendix E for details).

Figure 4-1: Overall Intervention Effect by Outcome Measure

Prescribed[1]

Study or Subgroup	Intervention Events	Intervention Total	Control Events	Control Total	Weight	Risk Ratio IV, Random, 95% CI
Altiner et al. (2007)_CT+ED	51	175	116	196	4.9%	0.49 [0.38, 0.64]
Bourgeois et al. (2010)_DST	59	148	23	50	3.7%	0.87 [0.60, 1.24]
Cals et al. (2009)_merged	28	90	23	35	3.5%	0.47 [0.32, 0.70]
Ferrat et al. (2016)_ED	201	1434	359	2147	6.1%	0.84 [0.71, 0.98]
Francis et al. (2009)_CT+ED	17	87	38	92	2.6%	0.47 [0.29, 0.77]
Gerber et al. (2013)_A&F+ED	29	153	37	145	3.1%	0.74 [0.48, 1.14]
Gjelstad et al. (2013)_A&F+ED	151	474	166	472	5.9%	0.91 [0.76, 1.08]
Gonzales et al. (2013)_merged (DST print, comp.)	292	450	48	65	6.1%	0.88 [0.75, 1.03]
Hurlimann et al. (2014)_A&F+ED (merged)	91	180	64	154	5.2%	1.22 [0.96, 1.54]
Linder et al. (2010)_A&F	56	121	69	145	4.9%	0.97 [0.75, 1.26]
Little et al. (2013)_merged	642	1800	269	462	6.8%	0.61 [0.55, 0.68]
Llor et al. (2011)_POC	48	109	65	102	4.9%	0.69 [0.53, 0.89]
Mainous et al. (2000)_merged	21	46	11	20	2.5%	0.83 [0.50, 1.38]
McIsaac & Goel (1998)_DST	51	184	75	212	4.4%	0.78 [0.58, 1.05]
McIsaac et al. (2002)_DST	85	302	88	315	5.0%	1.01 [0.78, 1.30]
McIsaac et al. (2021)_A&F+DST+ED	20	42	21	53	2.9%	1.20 [0.76, 1.90]
Meeker et al. (2014)_ED	162	449	246	505	6.2%	0.74 [0.64, 0.86]
Meeker et al. (2016)_merged	1449	8880	300	1252	6.7%	0.68 [0.61, 0.76]
Persell et al. (2016)_merged	41	754	5	136	1.0%	1.48 [0.60, 3.68]
Regev-Yochay et al. (2011)_A&F+CT+ED	180	374	224	390	6.4%	0.84 [0.73, 0.96]
Vervloet et al. (2015)_A&F+CT+DST	32	51	52	82	4.8%	0.99 [0.76, 1.29]
Welschen et al. (2004)_A&F+ED	15	65	22	59	2.3%	0.62 [0.36, 1.08]
Total (95% CI)		**16368**		**7089**	**100.0%**	**0.79 [0.72, 0.87]**
Total events	3721		2321			

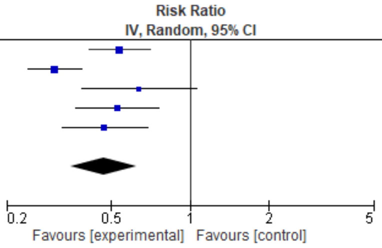
Heterogeneity: $Tau^2 = 0.04$; $Chi^2 = 87.37$, df = 21 (P < 0.00001); $I^2 = 76\%$
Test for overall effect: Z = 4.60 (P < 0.00001)



Consumed

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio IV, Random, 95% CI
Arroll et al. (2002)_DSF	32	67	55	62	22.8%	0.54 [0.41, 0.70]
de la Poza Abad et al. (2016)_merged (DSC, DSF)	55	198	92	101	23.9%	0.30 [0.24, 0.38]
Legare et al. (2011)_DST+ED	16	50	21	42	15.0%	0.64 [0.39, 1.06]
Legare et al. (2012)_DST+ED	28	102	52	100	19.3%	0.53 [0.37, 0.76]
Pshetizky et al. (2003)_ED	18	44	32	37	19.0%	0.47 [0.32, 0.69]
Total (95% CI)		**461**		**342**	**100.0%**	**0.47 [0.35, 0.62]**
Total events	149		252			

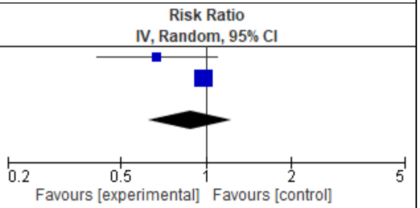
Heterogeneity: $Tau^2 = 0.07$; $Chi^2 = 14.93$, df = 4 (P = 0.005); $I^2 = 73\%$
Test for overall effect: Z = 5.20 (P < 0.00001)



Dispensed

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio IV, Random, 95% CI
Briel et al. (2006)_merged (ED, CT+ED	30	204	23	105	28.6%	0.67 [0.41, 1.10]
Hoye et al. (2013)_merged	398	439	444	481	71.4%	0.98 [0.94, 1.02]
Total (95% CI)		**643**		**586**	**100.0%**	**0.88 [0.63, 1.23]**
Total events	428		467			

Heterogeneity: $Tau^2 = 0.04$; $Chi^2 = 2.31$, df = 1 (P = 0.13); $I^2 = 57\%$
Test for overall effect: Z = 0.74 (P = 0.46)



1. Meeker et al. (2014, 2016) and Persell et al. (2016) report on antibiotic prescribing for visits with non-antibiotic-appropriate acute respiratory infection diagnoses. Gerber et al. (2013) reports on the proportion broad-spectrum (off-guideline) antibiotic prescribing for bacterial acute respiratory tract infections and antibiotics for viral acute respiratory tract infections per all prescriptions.

Undertaking a simple count of whether authors' reported interventions to be effective also supports the effectiveness of behaviour change interventions to reduce prescribing, consumption, or dispensing. Looking across all the 88 identified tests of interventions, approximately 2 out of 3 (58 out of 88) are reported to have significantly reduced antibiotic prescribing, consumption, or dispensing while approximately 1 out of 3 (30) are reported not to be effective.

The share of interventions reported to be effective was similar across the outcome measures of prescribing and consumption but a little higher for consumption (although the sample is small for the latter two). For prescribing it was 63% (43 out of 68) and for dispensing it was 67% (8 out of 12), while for consumption it was 88% (7 out of 8).

For each of the individual interventions tested the intervention type, target group, and conclusions of the primary authors on effectiveness are provided in Table 4.1. Appendix F provides a summary sentence from each paper on the effectiveness of each intervention tested.

None of the papers mentioned in this study reported substantial concerns in relation to unintended consequences or harms such as increased re-attendance or worsened symptoms.

Table 4.1: Intervention Type, Target Group and Effectiveness.

Studies	Intervention Category	Target Group	Primary Outcome Measure (11)			RR/ OR	95% C	Did it Work?
			Control	Intervention	Abs. Difference			
Altiner et al, 2007	CT + ED	Practitioner (General Practice) + Patient	59.0%	29.0%	-30.0	OR: 0.38; *p* = 0.002	[0.26; 0.56]	Yes
Arroll et al, 2002	DP	Patient (presenting with the common cold)	89.0%	48.0%	-41.0	OR: 0.12	[0.05; 0.29]	Yes
Bourgeois et al, 2010	DST	Practitioner (Paediatrics)	46.0%	40.0%	-6.0	*p* = 0.844	[0.60; 1.24]	No
Breil et al, 2006	CT + ED	Practitioner (General Practice)	21.4%	13.5%	-7.9	Not given. Significance not reported relative to the control.		No
Breil et al, 2006	ED		21.4%	15.7%	-5.7			No
Butler et al, 2012	ED	Practitioner (General Practice)	68.0%	66.0%	-2.0		[0.06; 0.08]	Yes
Cals et al, 2009	POC	Practitioner (General Practice)	67.0%	39.0%	-28.0	*p* = 0.02		Yes
Cals et al, 2009	CT	Practitioner (General Practice)		33.0%	-34.0	*p* < 0.01		Yes
Cals et al, 2009	CT + POC			23.0%	-44.0	The two interventions showed no statistically significant interaction effect (p =0.78)		Yes
Chappell et al, 2021	A&F	Practitioner (General Practice)	17.9%	16.2%	-1.7	*p* < 0.001		Yes

Studies	**Intervention Category**	**Target Group**	**Primary Outcome Measure (11)**			**RR/ OR**	**95% C**	**Did it Work?**
			Control	**Intervention**	**Abs. Difference**			
Christakis et al, 2001	A&F	Practitioner (Paediatrics)	11.6%	11.3%	-0.34	$p < 0.01$		Yes
Curtis et al, 2021	A&F	Practitioner (General Practice)	11.6%	11.3%	-0.3	$p = 0.104$	[-0.7%; 0.1%]	No
Curtis et al, 2021	A&F		11.6%	11.1%	-0.5	$p = 0.046$	[-0.7%; 0.8%]	Yes
De la Poza Abad et al, 2016	DP	Patient	91.1%	23.0%	-68.1	Not given. Significance not reported relative to the control.		Yes
De la Poza Abad et al, 2016	DP	Patient	91.1%	32.6%	-58.5	Not given. Significance not reported relative to the control.		Yes
D'Hulster et al, 2022	CT + ED	Practitioner (General Practice) + Patient	NR	NR	-7%	PRR = 0.93	[0.90; 0.95]	Yes
Dowell et al, 2001	DP	Patient (<16 presenting with acute cough as the primary complaint)	39.0%	25.9%	-13.1	$p = 0.23$		Yes
Ferrat et al, 2016	ED	Practitioner (General Practice)	17.0%	14.0%	-3.0	OR: 0.84; $p < 0.001$	[0.81; 0.87]	Yes
Figueiras et al, 2020	DST + ED	Practitioner (Primary Care)	13.5	13.8	-0.3		95% CI: -5.3% to -3.2%	Yes

Studies	**Intervention Category**	**Target Group**	**Primary Outcome Measure (11)**			**RR/ OR**	**95% C**	**Did it Work?**
			Control	**Intervention**	**Abs. Difference**			
Finkelstein et al, 2001(1)	ED	Patient (Children > 3months and <3 years)	2.6	1.8	-0.8	RE = 16%; $p < 0.01$		Yes
Finkelstein et al, 2001(1)	ED	Patient (Children >3years and <6 years)	1.6	1.2	-0.4	RE = 12%; $p < 0.01$		Yes
Francis et al, 2009	CT + ED	Practitioner (General Practice) + Patient	40.8%	20.0%	-20.8	OR: 0.29	[0.14; 0.60]	Yes
Gerber et al, 2013	A&F + ED	Practitioner (General Practice)	25.0%	19.0%	-6.0	$p = 0.01$	[0.48; 1.14]	Yes
Gjelstad et al, 2013	A&F + ED	Practitioner (General Practice)	35.0%	31.8%	-3.2	OR: 0.72	[0.61; 0.84]	Yes
Gold et al, 2021(2)	A&F	Practitioner (General Practice)	NR	NR	−0.01	ARMA (1,1) showed no effect of the intervention	$p = 0.565$	No
Gold et al, 2022	A&F	Practitioner (General Practice)	NR	NR	NR	$p = 0.041$; z = 2.04		No
Gonzales et al, 2013	DST	Practitioner (Primary Care)	74.3%	68.3%	-6.0	$p = 0.003$		Yes
Gonzales et al, 2013	DST	Practitioner (Primary Care)	74.3%	60.7%	-13.6	$p = 0.01$		Yes
Hallsworth et al, 2016	A&F + ED	Practitioner (General Practice)	13.1%	12.7%	-0.4	IRR 0.97; $p < 0.001$	[0.96; 0.98]	Yes

Studies	Intervention Category	Target Group	Primary Outcome Measure (11)			RR/ OR	95% C	Did it Work?
			Control	Intervention	Abs. Difference			
Hallsworth et al, 2016	ED	Patient	13.4%	13.5%	0.1	IRR: 1.01; p = 0.105	[1.00; 1.02]	No
Hoffman et al, 2022	DST + ED	Practitioner (General Practice)	2.6%	2.9%	0.3	RR: 1.01	[0.89; 1.15]	No
Hoye et al, 2013	ED	Practitioner (General Practice)	92.4%	91.8%	-0.6	RR: 0.99	[0.96; 1.01]	Yes
Hoye et al, 2013	DST + ED		92.4%	90.2%	-2.2	RR: 0.96	[0.94; 0.98]	Yes
Hurlimann et al, 2014	A&F + ED	Practitioner (General Practice)	48.5%	56.7%	8.2	OR: 1.42; p = 0.01	[1.08; 1.89]	No
Hurlimann et al, 2014	A&F + ED		18.8%	35.1%	16.3	OR: 2.16; p = 0.01	[1.19; 3.91]	No
Hurlimann et al, 2014	A&F + ED		4.7%	4.8%	0.1	OR: 1.02; p = 0.96	[0.36; 2.88]	No
Ilett et al, 1999(4)	ED	Practitioner (General Practice)	9654	7262	-2392	Not given. Significance not reported relative to the control.		Yes
Kronman et al, 2020(5)	A&F + ED	Practitioner (General Practice)	NR	NR	-7%	aRR: 0.93	[0.90; 0.96]	Yes
Lagerlov et al, 2000(6)	A&F + ED	Practitioner (General Practice)	NR	NR	6.0%	p = 0.08		Yes
Le Corvoisier et al, 2013	ED	Practitioner (General Practice)	16.4%	12.3%	-4.1	p < 0.001	[2.75; 5.11]	Yes

Studies	Intervention Category	Target Group	Primary Outcome Measure (11)			RR/ OR	95% C	Did it Work?
			Control	Intervention	Abs. Difference			
Legare et al, 2011	DST + ED	Practitioner (General Practice) + Patient	49.0%	33.0%	-16.0	*p* = 0.08		Yes
Legare et al, 2012	DST + ED	Practitioner (Family Physicians) + Patient	52.0%	27.0%	-25.0	RR: 0.5	[0.3; 0.7]	Yes
Lemiengre et al, 2018	ED		22.0%	47.0%	25.0	OR: 1.95	[1.11; 3.42]	No
Lemiengre et al, 2018	ED + POC		22.0%	25.0%	3.0	OR: 1.21	[0.66; 2.22]	No
Linder et al, 2010	A&F	Practitioner	47.0%	47.0%	0.0	OR: 0.97	[0.7; 1.4]	No
Little et al, 2013	POC	Practitioner	58.4%	34.7%	-23.7	RR: 0.54; $p < 0.001$	[0.42; 0.69]	Yes
Little et al, 2013	CT			40.7%	-17.7	RR: 0.69; $p < 0.001$	[0.54; 0.87]	Yes
Little et al, 2013	CT + POC			31.5%	-26.9	RR: 0.38; $p < 0.001$	[0.25; 0.55]	Yes
Little et al, 2019	POC	Practitioner (General Practice)	51.0%	43.3%	-7.7	Not given. Significance not reported relative to the control.		Yes
Little et al, 2019	CT			39.9%	-11.1	Not given. Significance not reported relative to the control.		Yes

Studies	Intervention Category	Target Group	Primary Outcome Measure (11)			RR/ OR	95% C	Did it Work?
			Control	Intervention	Abs. Difference			
Little et al, 2019	CT + POC			45.5%	-5.5	Not given. Significance not reported relative to the control.		Yes
Llor et al, 2011	POC	Practitioner (General Practice)	64.1%	43.8%	-20.3	$p < 0.001$	[0.53; 0.89]	Yes
Mainous et al, 2000	A&F	Practitioner (Primary Care) + Patient	53.0%	43.6%	-9.4	$p > 0.10$		No
Mainous et al, 2000	ED	Practitioner (Primary Care) + Patient	53.0%	44.5%	-8.5			No
Mainous et al, 2000	A&F + ED			49.7%	-3.3			No
McIsaac & Goel, 1998	DST	Practitioner (Family Physicians)	35.3%	27.8%	-7.5	0.44	[0.21; 0.92]	Yes
McIsaac et al, 2002	DST	Practitioner (Family Physicians)	28.1%	27.9%	-0.2	0.57	[0.27; 1.17]	No
McIsaac et al, 2021(7)	A&F + DST + ED	Practitioner (General Practice)	NR	NR	-22.0%	$p = 0.05$	[1; 2.98]	Yes
McNulty et al, 2018	ED	Practitioner (General Practice)	62.5%	59.8%	-2.7	$p = 0.06$	[-5.5%; 1%]	Yes
Meeker et al, 2014	ED	Patient (Outpatient Primary Care) + Patient	52.7%	33.7%	-19.0		[0.64; 0.86]	Yes

Studies	Intervention Category	Target Group	Primary Outcome Measure (11)			RR/ OR	95% C	Did it Work?
			Control	Intervention	Abs. Difference			
Meeker et al, 2016	DST	Practitioner (General Practice)	24%	16.4%	-7.6			Yes
Meeker et al, 2016	DST	Practitioner (General Practice)		30.2%	6.2		[14.7; 18.0]	No
Meeker et al, 2016	A&F			19.2%	-4.8		[17.3; 21.1]	Yes
Meeker et al, 2016	A&F + DST			15.2%	-8.8			Yes
Meeker et al, 2016	A&F + DST			6.9%	-17.1		[8.8; 11.2]	Yes
Meeker et al, 2016	DST			16.0%	-8.0			Yes
Meeker et al, 2016	A&F + DST			10.0%	-14			Yes
O'Connell et al, 1999	A&F + ED	Practitioner (General Practice)	77.6%	79.2%	1.6	No measurable impact on prescribing rates		No
Ostervall, 2017	ED	Patient	NR	NR	-12.6%	Not given. Significance not reported relative to the control.		Yes
Persell et al, 2016	DST	Practitioner (Primary Care)	3.4%	11.4%	8.0			No
Persell et al, 2016	DST			7.8%	4.4			No

Studies	Intervention Category	Target Group	Primary Outcome Measure (11)			RR/ OR	95% C	Did it Work?
			Control	Intervention	Abs. Difference			
Persell et al, 2016	A&F			11.8%	8.4	Not given. Significance not reported relative to the control.		No
Persell et al, 2016	DST (Accountable Justification) + DST (Alternatives)			2.1%	-1.3			No
Persell et al, 2016	A&F + DST (Alternatives)			3.9%	0.5			No
Persell et al, 2016	A&F + DST (Accountable Justification)			2.9%	-0.5			No
Persell et al, 2016	A&F +DST (Accountable Justification) + DST (Alternatives)	Practitioner (Primary Care)	3.4%	5.6%	2.2	Not given. Significance not reported relative to the control.		No
Pshetizky et al, 2003	ED	Patient (Parents of children ages >3m and <4 years)	86.5%	40.9%	-45.6	$p < 0.001$		Yes
Regev Yochay et al, 2011	ED + CT + AF	Practitioner (Paediatrics)	57.6%	48.2%	-9.4	RR: 0.765	[0.75; 0.78]	Yes
Samore et al, 2005	ED	Patient	74.9%	85.2%	10.3	$p = 0.3$	[-6.2; 8.5]	Yes

Studies	Intervention Category	Target Group	Primary Outcome Measure (11)			RR/ OR	95% C	Did it Work?
			Control	Intervention	Abs. Difference			
Samore et al, 2005	DST + ED	Practitioner (Family Physicians) + Patient		75.3%	0.4		[-13.2; -4.2]	Yes
Schwartz et al, 2021(8)	A&F + ED	Practitioner (Family Physicians)	881	849	-32	RR: 0.96	[0.92; 1.01]	Yes
Schwartz et al, 2021(8)	A&F + ED			851	-30	RR: 0.95	[0.91; 1.00]	Yes
Sondergaard et al, 2003(9)	A&F	Practitioner (General Practice)	34.0	34.6	0.6	No significant impact on GP prescribing patterns.		No
Taylor et al, 2005(10)	ED	Patient (Parent of child)	2.5	2.2	-0.3	*p* = 0.23		No
Vervloet et al, 2016	A&F + CT + DST	Practitioner (Family Physicians)	64.0%	62.2%	-1.8		[0.76; 1.29]	Yes
Welschen et al, 2004	A&F + ED	Practitioner (General Practice) + Patient	37.0%	23.0%	-14.1		[-4.0; 18.9]	Yes
Zwar et al, 1999	A&F + ED	Practitioner (General Practice Trainees)	31.7%	19.7%	-12	*p* = 0.002		Yes

Notes. A&F = Audit and Feedback; CT = Communication Training; DP = Delayed prescription; DP+E = Delayed prescription used in conjunction with an educational element; DST = Decision Support Tool; ED + CT = Educational plus communication training; ED = Educational; M = Multifaceted programme with 3 or more intervention elements; POC = Point of care testing and training for certain illnesses.
RR = Risk Ratio; OR = Odds Ratio; IRR = Incidence rate ratio; RE = Relative intervention effect; CI = Confidence interval.
(1) The rate of antibiotic courses dispensed per person-year; (2) Results displayed are from an autoregressive and moving average model of first order ARMA (1,1) correlation structure; (3) Adjusted Medication Appropriateness Index (MAI) scores per person; (4) Average no. prescriptions per

GP; (5) Results displayed as probability of antibiotic prescription; (6) Results reported as mean proportion of acceptably treated patients; (7) Results displayed as probability of antibiotic prescription after adjustment for characteristics associated with antibiotic prescriptions; (8) Total number of antibiotic prescriptions over 12 months postintervention.; (9) Prescriptions per 1000 patients per month; (10) Total no. of prescriptions for antibiotics per patient; (11) Percentage of antibiotics prescribed/consumed from all visits, unless stated otherwise, (12) Percentage points unless otherwise stated.

5. Effectiveness by Intervention Type

5.1 Overview of Effectiveness by Intervention Type

Caution is needed when interpreting the effectiveness by intervention type, as they are based on a relatively small number of studies. Overall, the available evidence supports the effectiveness of education; communication training; point of care (POC) testing, and POC testing combined with communication training; decision support tools (DST) other than POC, and DST combined with education; and delayed prescribing. There is conflicting evidence between the meta-analysis estimates of no effect and the narrative analysis of authors' conclusions on effectiveness for the interventions of audit and feedback combined with education.

The estimated effect by intervention category is shown in Figure 5.1. The statistical tests suggest that the reduction in prescribing by point of care testing interventions[3] and by interventions that combine point of care testing with education[4] are greater than (or more efficacious) than interventions of audit and feedback, audit and feedback combined with education, education, and decision support tools. The tests also suggest that the reduction in prescribing by communication training interventions are more efficacious than interventions of decision support tools[5]. The effect of delayed prescribing appears large in comparison to

---

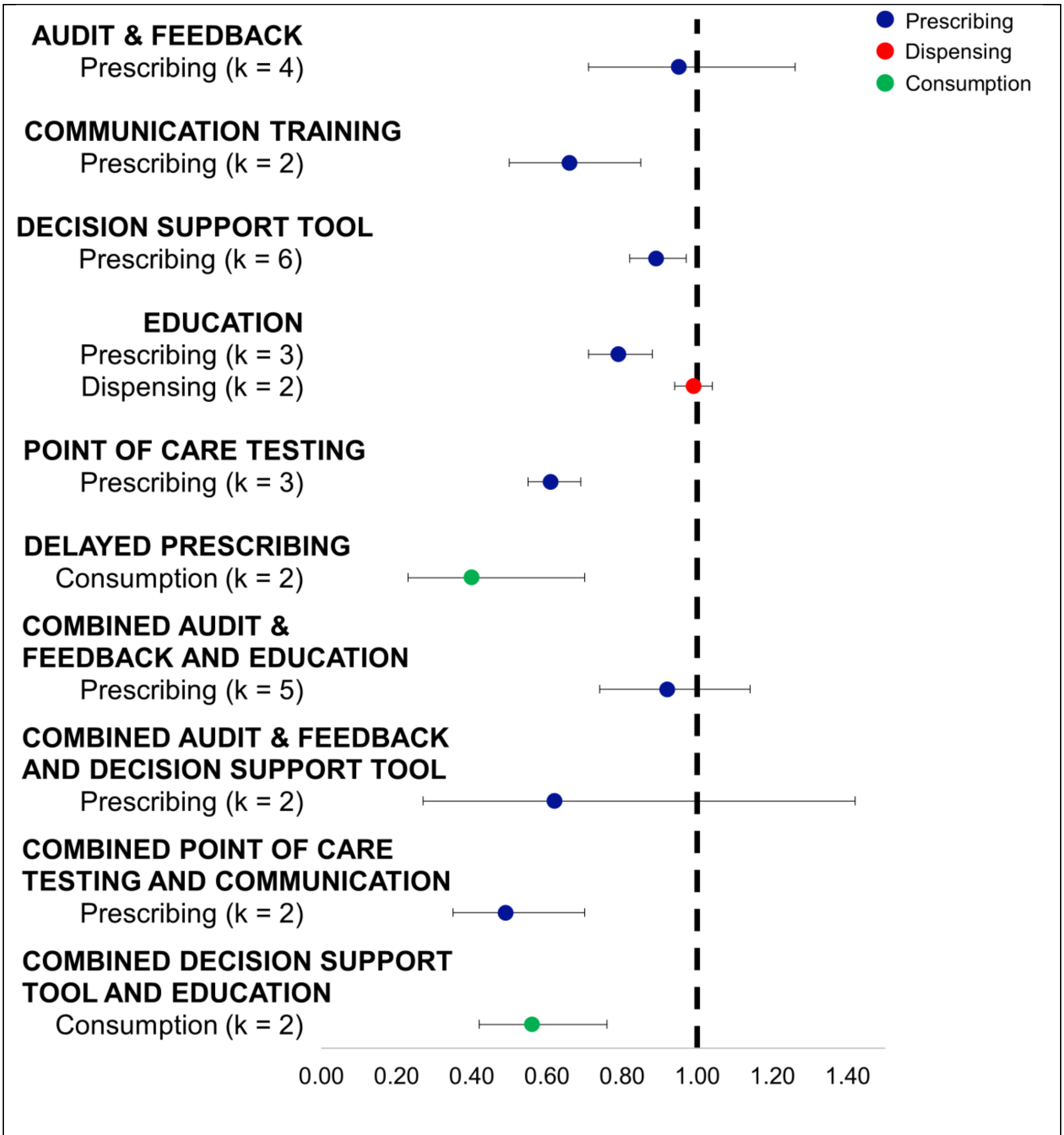
[3] Point of care testing (RR = 0.61, 95% CI[0.54, 0.68]) was significantly more efficacious at reducing antimicrobial prescribing than audit and feedback (RR = 0.96, 95% CI[0.71, 1.30]), $\chi 2$ (1) = 7.45, p = .006, I^2 = 86.6%, education (RR = 0.79, 95% CI[0.71, 0.88]), $\chi 2$ (1) = 9.64, p = .002, I^2 = 89.6%, audit and feedback + education, (RR = 0.92, 95% CI[0.74, 1.14]), $\chi 2$ (1) = 10.23, p = .001, I^2 = 90.2%, and decision support tools (RR = 0.89, 95% CI[0.82, 0.97]), $\chi 2$ (1) = 27.02, p < .001, I^2 = 96.3%.

[4] Point of care testing + communication training (RR = 0.49, 95% CI[0.35, 0.70]) was significantly more efficacious at reducing antimicrobial prescribing than audit and feedback (RR = 0.96, 95% CI[0.71, 1.30]), $\chi 2$ (1) = 7.69, p = .006, I^2 = 87%, education (RR = 0.79, 95% CI[0.71, 0.88]), $\chi 2$ (1) = 6.07, p = .01, I^2 = 83.5%, audit and feedback + education, (RR = 0.92, 95% CI[0.74, 1.14]), $\chi 2$ (1) = 8.47, p = .004, I^2 = 88.2%, and decision support tools (RR = 0.89, 95% CI[0.82, 0.97]), $\chi 2$ (1) = 10.13, p = .001, I^2 = 90.1%.

[5] Communication training (RR = 0.66, 95% CI[0.50, 0.85]) was significantly more efficacious at reducing antimicrobial prescribing than decision support tools (RR = 0.89, 95% CI[0.82, 0.97]), $\chi 2$ (1) = 4.79, p = .03, I^2 = 79.1%.

other interventions, however the outcome measure for other interventions is different so they are not comparable.

Figure 5-1: Estimated Effect by Intervention Category



Forest plot of intervention typology efficacy per outcome, where data is available from a minimum of 2 studies. The data point is indicative of the mean-weighted effect estimate (risk ratio), with the 95% confidence interval. Dashed black line is representative of a risk ratio of 1. k = number of studies.

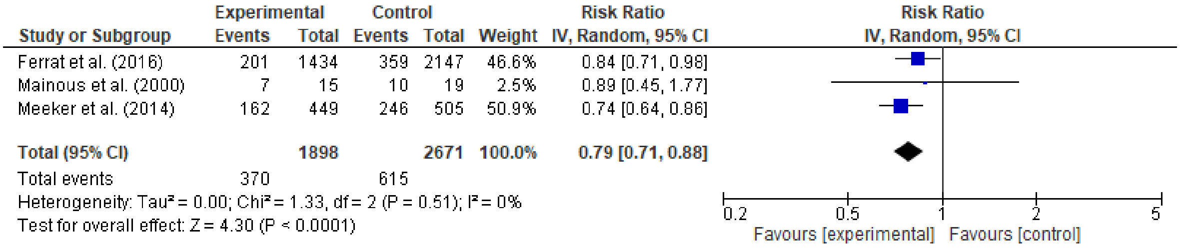
5.2 Detail on Effectiveness by Intervention Type

As noted above, caution is needed when interpreting the effectiveness by intervention type, as they are based on a relatively small number of studies. This section provides the evidence based on the meta-analysis and narrative analysis by intervention type.

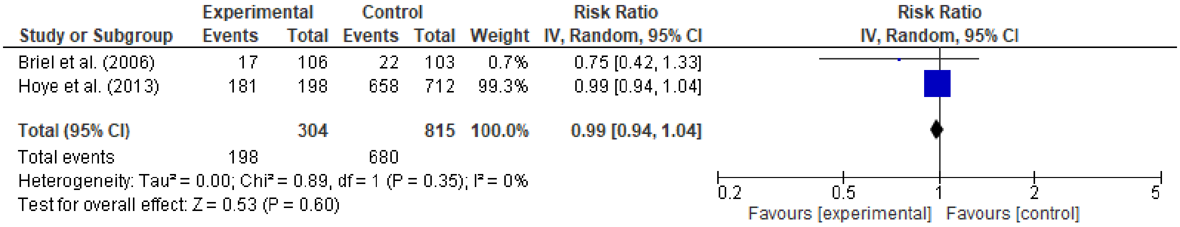
On balance, the evidence appears to support the effectiveness of **education interventions**. Regarding prescribing, a reduction is suggested by both the meta-analysis (reduced *prescribing* by 21%, RR = 0.79, 95% CI [0.71, 0.88], $p < .001$) and the narrative analysis (67% of interventions were reported to be effective, 6 out of 9). There is conflicting evidence for the *dispensing* outcome between the meta-analysis (no effect found, only 2 studies, RR = 0.99, 95% CI [0.94, 1.04], $p = .60$) and the narrative analysis (71% of interventions were reported to be effective, 5 out of 7). While on the *consumption* outcome, the 1 intervention targeting consumption reports it to be effective.

Figure 5-2: Estimated Effect of Education Interventions

Prescribed



Dispensed



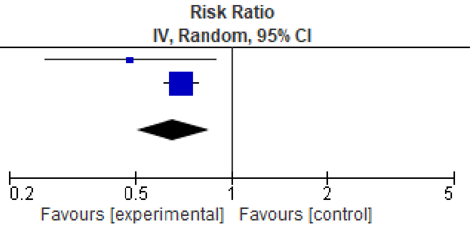
The evidence points to **communication training** reducing unnecessary antibiotic prescribing. This is supported by the meta-analysis (reduced prescribing by 34%, RR = 0.66, 95% CI [0.50, 0.85], $p < .001$, 2 studies) and the narrative analysis (all 3 interventions were reported to be effective).

Figure 5-3: Estimated Effect of Communication Interventions

Prescribed

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio IV, Random, 95% CI
Cals et al. (2009)	8	25	24	36	15.5%	0.48 [0.26, 0.89]
Little et al. (2013)	251	618	268	459	84.5%	0.70 [0.62, 0.79]
Total (95% CI)		**643**		**495**	**100.0%**	**0.66 [0.50, 0.85]**
Total events	259		292			

Heterogeneity: Tau² = 0.02; Chi² = 1.34, df = 1 (P = 0.25); I² = 25%
Test for overall effect: Z = 3.13 (P = 0.002)



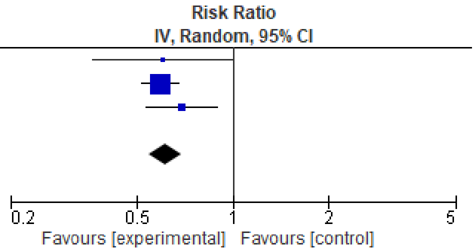
The evidence points to **point of care (POC) testing** reducing unnecessary antibiotic prescribing. This is supported by the meta-analysis (reduced prescribing by 39%, RR = 0.61, 95% CI [0.55, 0.69], $p < .001$) and the narrative analysis (80% of interventions reported to be effective, 4 out of 5).

Figure 5-4: Estimated Effect of Point of Care Testing Interventions

Prescribed

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio IV, Random, 95% CI
Cals et al. (2009)	12	30	22	33	5.4%	0.60 [0.36, 0.99]
Little et al. (2013)	202	583	279	478	74.3%	0.59 [0.52, 0.68]
Llor et al. (2011)	48	109	65	102	20.4%	0.69 [0.53, 0.89]
Total (95% CI)		**722**		**613**	**100.0%**	**0.61 [0.55, 0.69]**
Total events	262		366			

Heterogeneity: Tau² = 0.00; Chi² = 1.06, df = 2 (P = 0.59); I² = 0%
Test for overall effect: Z = 8.27 (P < 0.00001)



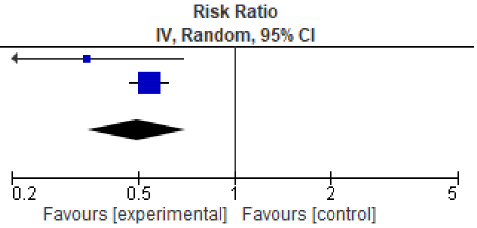
POC testing combined with communication training is also found to reduce unnecessary antibiotic prescribing. This is supported by the meta-analysis (reduced prescribing by 51%, RR = 0.49, 95% CI [0.35, 0.70], $p < .001$, 2 studies) and the narrative analysis (all 3 interventions reported to be effective).

Figure 5-5: Estimated Effect of POC Testing and Communication Training Interventions

Prescribed

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio IV, Random, 95% CI
Cals et al. (2009)	7	31	21	32	20.2%	0.34 [0.17, 0.69]
Little et al. (2013)	200	634	277	475	79.8%	0.54 [0.47, 0.62]
Total (95% CI)		**665**		**507**	**100.0%**	**0.49 [0.35, 0.70]**
Total events	207		298			

Heterogeneity: Tau² = 0.04; Chi² = 1.55, df = 1 (P = 0.21); I² = 36%
Test for overall effect: Z = 3.89 (P = 0.0001)



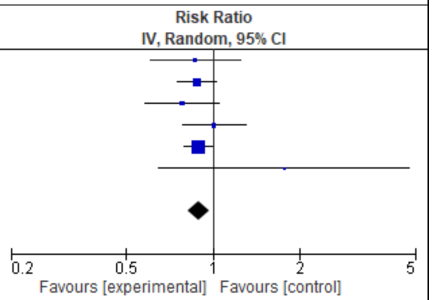
Decision support tools (other than POC testing) are shown to reduce antibiotic prescribing by 11% (RR = 0.89, 95% CI [0.82, 0.97], *p* = .006) and all interventions found were included in the meta-analysis (of the 11 interventions tested in these studies, 5 are reported to be effective).

Figure 5-6: Estimated Effect of Decision Support Tools (other than POC)

Prescribed

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio IV, Random, 95% CI
Bourgeois et al. (2010)_DST	59	148	23	50	5.1%	0.87 [0.60, 1.24]
Gonzales et al. (2013)_DST (merged)	292	450	48	65	25.7%	0.88 [0.75, 1.03]
McIsaac & Goel (1998)_DST	51	184	75	212	7.5%	0.78 [0.58, 1.05]
McIsaac et al. (2002)_DST	85	302	88	315	10.3%	1.01 [0.78, 1.30]
Meeker et al. (2016)_DST (merged)	860	4029	311	1299	50.8%	0.89 [0.80, 1.00]
Persell et al. (2016)_DST (merged)	14	216	5	136	0.7%	1.76 [0.65, 4.78]
Total (95% CI)		**5329**		**2077**	**100.0%**	**0.89 [0.82, 0.97]**
Total events	1361		550			

Heterogeneity: Tau² = 0.00; Chi² = 3.48, df = 5 (P = 0.63); I² = 0%
Test for overall effect: Z = 2.72 (P = 0.006)



Regarding merged estimates the combinations are: Gonzales two conditions (print, computerised), Meeker three conditions (alternatives, accountable justification, combined alternatives and accountable justification), Persell three conditions (alternatives, accountable justification, combined alternatives and accountable justification).

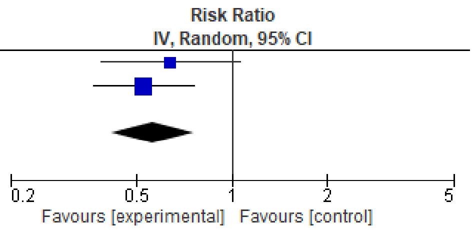
Decision support tools combined with education is shown to be an effective intervention, the meta-analysis suggests a reduction in consumption (44%, only 2 studies, RR = 0.56 95% CI [0.42, 0.76], *p* < .001) as does the narrative analysis (5 of 6 interventions reported to be effective at reducing prescribing / consumption/dispensing).

Figure 5-7: Estimated Effect of DST (other than POC) and Education

Consumed

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio IV, Random, 95% CI
Legare et al. (2011)	16	50	21	42	34.6%	0.64 [0.39, 1.06]
Legare et al. (2012)	28	102	52	100	65.4%	0.53 [0.37, 0.76]
Total (95% CI)		**152**		**142**	**100.0%**	**0.56 [0.42, 0.76]**
Total events	44		73			

Heterogeneity: Tau² = 0.00; Chi² = 0.37, df = 1 (P = 0.55); I² = 0%
Test for overall effect: Z = 3.78 (P = 0.0002)



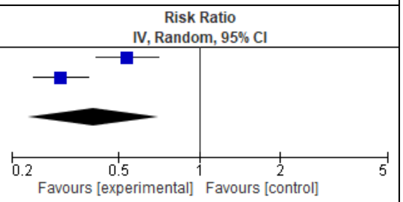
The evidence points to **delayed prescribing** reducing antibiotic consumption. This is the finding of the meta-analysis (reduced consumption by 60%, 2 studies, RR = 0.40, 95% CI [0.23, 0.70], *p* = .001) and the narrative analysis where all interventions (4 out of 4) are reported to be effective.

Figure 5-8: Estimated Effect of Delayed Prescribing

Consumed

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio IV, Random, 95% CI
Arroll et al. (2002)	32	67	55	62	49.3%	0.54 [0.41, 0.70]
de la Poza Abad et al. (2016)_merged (DSC, DSF)	55	198	92	101	50.7%	0.30 [0.24, 0.38]
Total (95% CI)		**265**		**163**	**100.0%**	**0.40 [0.23, 0.70]**
Total events	87		147			

Heterogeneity: Tau² = 0.15; Chi² = 9.95, df = 1 (P = 0.002); I² = 90%
Test for overall effect: Z = 3.19 (P = 0.001)



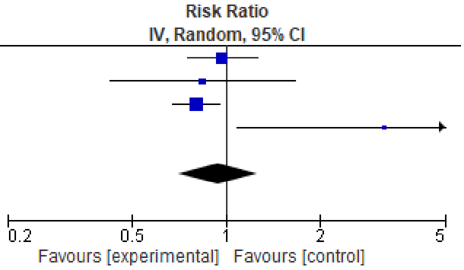
There is little evidence on the effectiveness of **audit and feedback** at reducing prescribing between meta-analysis (no effect found, RR = 0.95, 95% CI [0.71, 1.26], *p = .70) and the* narrative analysis, where 36% (or 4 of 11) of interventions are reported to be effective. Of those interventions not included in the meta-analysis, 43% (3 out of 7) are reported to be effective.

Figure 5-9: Estimated Effect of Audit & Feedback

Prescribed

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio IV, Random, 95% CI
Linder et al. (2010)	56	121	69	145	36.5%	0.97 [0.75, 1.26]
Mainous et al. (2000)	7	15	10	18	13.4%	0.84 [0.43, 1.66]
Meeker et al. (2016)	175	910	282	1177	43.8%	0.80 [0.68, 0.95]
Persell et al. (2016)	8	68	5	136	6.3%	3.20 [1.09, 9.41]
Total (95% CI)		**1114**		**1476**	**100.0%**	**0.95 [0.71, 1.26]**
Total events	246		366			

Heterogeneity: Tau² = 0.04; Chi² = 7.22, df = 3 (P = 0.07); I² = 58%
Test for overall effect: Z = 0.38 (P = 0.70)



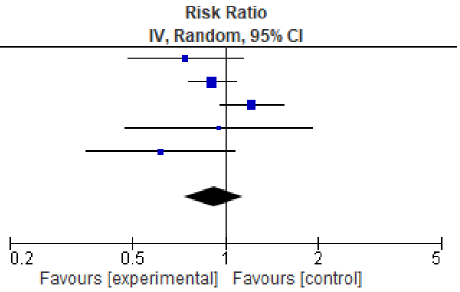
There is a conflicting pattern for **audit and feedback combined with education**, not showing an effect in the meta-analysis RR = 0.92, 95% CI [0.74, 1.14], *p* = .45*)* but support from the narrative analysis (64% or 9 of 14 interventions are reported to be effective). Of the 7 interventions not included in the meta-analysis, 86% (6 out of 7) are reported to be effective.

Figure 5-10: Estimated Effect of Audit & Feedback and Education

Prescribed

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio IV, Random, 95% CI
Gerber et al. (2013)	29	153	37	145	16.5%	0.74 [0.48, 1.14]
Gjelstad et al. (2013)	151	474	166	472	34.4%	0.91 [0.76, 1.08]
Hurliman et al. (2014)	91	180	64	154	29.4%	1.22 [0.96, 1.54]
Mainous et al. (2000)	6	12	11	21	8.1%	0.95 [0.48, 1.92]
Welschen et al. (2004)	15	65	22	59	11.6%	0.62 [0.36, 1.08]
Total (95% CI)		**884**		**851**	**100.0%**	**0.92 [0.74, 1.14]**
Total events	292		300			

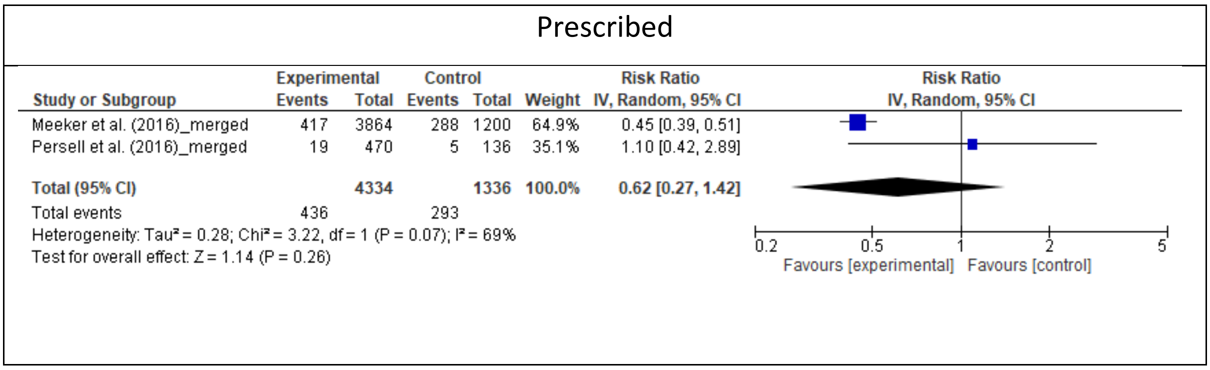
Heterogeneity: Tau² = 0.03; Chi² = 8.03, df = 4 (P = 0.09); I² = 50%
Test for overall effect: Z = 0.76 (P = 0.45)



Hurlimann had 3 separate subpopulations (UTI, RTI, COPD) so these are combined.

While **audit and feedback combined with a decision support tool** is not shown to be effective in the meta-analysis (RR = 0.62, 95% CI [0.27, 1.42], *p* = .26). There is some support from the narrative analysis, which reported 3 out of 6 interventions to be effective. All interventions in the narrative analysis are included in the meta-analysis.

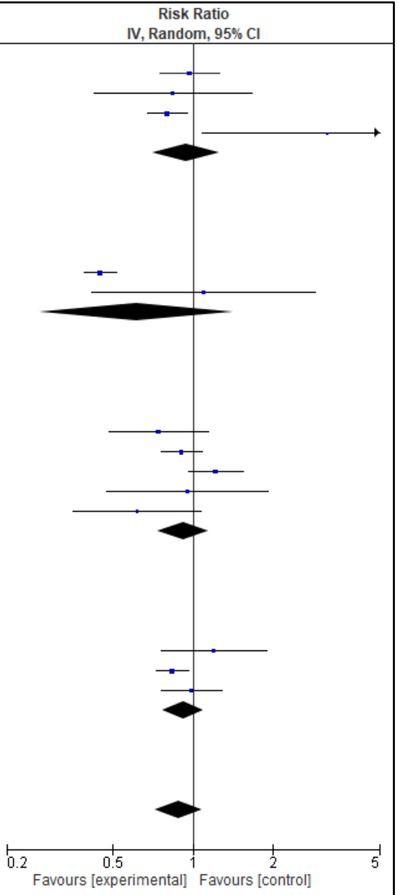
Figure 5-11: Estimated Effect of Audit & Feedback and Decision Support Tool (other than POC)



We have already seen that audit and feedback is not shown to significantly reduce antimicrobial prescribing. While there is mixed evidence for audit and feedback combined with education in the narrative analysis, neither audit and feedback combined with education or audit and feedback combined with a decision support tool is shown to significantly reduce prescribing in the meta-analysis. Similarly, we continue to see no significant reduction in prescribing when audit and feedback is combined 2 other interventions (RR = 0.92, 95% CI [0.77, 1.09], p = .87). Details are shown in Figure 5.12.

Figure 5-12: Subgroup Comparisons across all A&F subgroups

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio IV, Random, 95% CI
1.1.1 A&F Only						
Linder et al. (2010)	56	121	69	145	8.8%	0.97 [0.75, 1.26]
Mainous et al. (2000)	7	15	10	18	4.8%	0.84 [0.43, 1.66]
Meeker et al. (2016)	175	910	282	1177	9.5%	0.80 [0.68, 0.95]
Persell et al. (2016)	8	68	5	136	2.7%	3.20 [1.09, 9.41]
Subtotal (95% CI)		**1114**		**1476**	**25.8%**	**0.95 [0.71, 1.26]**
Total events	246		366			
Heterogeneity: Tau² = 0.04; Chi² = 7.22, df = 3 (P = 0.07); I² = 58%						
Test for overall effect: Z = 0.38 (P = 0.70)						
1.1.2 A&F+DST						
Meeker et al. (2016)_A&F+DST (merged)	417	3864	288	1200	9.8%	0.45 [0.39, 0.51]
Persell et al. (2016)_A&F+DST(account.just+altern)	19	470	5	136	3.1%	1.10 [0.42, 2.89]
Subtotal (95% CI)		**4334**		**1336**	**12.9%**	**0.62 [0.27, 1.42]**
Total events	436		293			
Heterogeneity: Tau² = 0.28; Chi² = 3.22, df = 1 (P = 0.07); I² = 69%						
Test for overall effect: Z = 1.14 (P = 0.26)						
1.1.3 A&F+ED						
Gerber et al. (2013)_A&F+ED	29	153	37	145	7.1%	0.74 [0.48, 1.14]
Gjelstad et al. (2013)_A&F+ED	151	474	166	472	9.5%	0.91 [0.76, 1.08]
Hurlimann et al. (2014)_A&F+ED (merged)	91	180	64	154	9.0%	1.22 [0.96, 1.54]
Mainous et al. (2000)_A&F+ED	6	12	11	21	4.7%	0.95 [0.48, 1.92]
Welschen et al. (2004)_A&F+ED	15	65	22	59	5.9%	0.62 [0.36, 1.08]
Subtotal (95% CI)		**884**		**851**	**36.1%**	**0.92 [0.74, 1.14]**
Total events	292		300			
Heterogeneity: Tau² = 0.03; Chi² = 8.03, df = 4 (P = 0.09); I² = 50%						
Test for overall effect: Z = 0.76 (P = 0.45)						
1.1.4 A&F+2 strategies						
McIsaac et al. (2021)_A&F+DST+ED	20	42	21	53	6.8%	1.20 [0.76, 1.90]
Regev-Yochay et al. (2011)_A&F+CT+ED	180	374	224	390	9.8%	0.84 [0.73, 0.96]
Vervloet et al. (2015)_A&F+CT+DST	32	51	52	82	8.7%	0.99 [0.76, 1.29]
Subtotal (95% CI)		**467**		**525**	**25.2%**	**0.92 [0.77, 1.09]**
Total events	232		297			
Heterogeneity: Tau² = 0.01; Chi² = 2.99, df = 2 (P = 0.22); I² = 33%						
Test for overall effect: Z = 0.94 (P = 0.35)						
Total (95% CI)		**6799**		**4188**	**100.0%**	**0.88 [0.72, 1.08]**
Total events	1206		1256			
Heterogeneity: Tau² = 0.11; Chi² = 98.19, df = 13 (P < 0.00001); I² = 87%						
Test for overall effect: Z = 1.19 (P = 0.24)						
Test for subgroup differences: Chi² = 0.92, df = 3 (P = 0.82), I² = 0%						



6. Conclusions

Overall Conclusion

Based on the highest level of evidence (a systematic review of randomised trials - RCTs) this study shows that interventions can reduce unnecessary prescribing and use of antibiotics in the community and therefore, there is a **policy rationale**:

a. to **support the use** of interventions for which the evidence supports their effect, and

b. to **explore and encourage refinements** to improve interventions for which evidence is less clear but there is potential.

Conclusions by Intervention Type and Reporting of Findings[6]

1. **Education interventions** and **communication training** both aim to increase capability and are both shown to reduce unnecessary prescribing, so it is important to review the extent to which education and communication training in the initial education and continuing professional development of general practitioners (GPs) in Ireland:

    a. Covers the **topics** included in the effective interventions identified by this review.

    b. Avails of the **range of pedagogy and delivery mechanisms** used in the effective interventions identified in this review.

    c. Draws on evidence from the wider behavioural science literature on what are the most relevant underlying psychological mechanisms to target in education interventions and communication training and how best to frame such interventions.

2. **Point of care testing** is shown to reduce unnecessary prescribing, therefore it is important to:

    a. Review the **promotion** of POC testing in the initial education and continuing professional development of general practitioners (GPs) in Ireland.

    b. Determine the **extent of use** of POC testing in general practice in Ireland.

    c. Examine potential **barriers** to the use of POC testing, which could be financial (cost of tests, additional time) and non-financial (awareness, perceptions), and **ways to**

[6] When reading this section, it is important to note that while the meta-analysis indicates whether certain interventions work or not based on available evidence, the researchers apply these results to form aspects of these conclusions.

increase use of POC testing by GPs. In doing so, it will be important to draw on the wider behavioural science literature on barriers and drivers to the use of POC testing.

3. **Decision support tools** (other than POC testing) are shown to be effective, although even when recommended for use their take-up can sometimes be limited. Therefore, for DSTs it would be useful to:
   a. Identify if DST are recommended to general practitioners (GPs) in Ireland and if so to **gauge the extent of the current use**.
   b. Where DST have been recommended it would be beneficial to **undertake a "sludge audit"** to identify frictions reducing use and ways to improve design (drawing on the wider behavioural science literature) to support greater use of DST.

4. **Delayed prescribing** is shown to reduce unnecessary consumption, so it is important to:
   a. Review the **promotion** of delayed prescribing in the initial education and continuing professional development of general practitioners (GPs) in Ireland.
   b. Determine the **extent of use** of delayed prescribing in general practice in Ireland, distinguishing between the use of delayed script filling or delayed script collection.
   c. Examine **potential barriers** to the use of delayed prescribing, whether delayed script filling or delayed script collection is more effective, and **ways to increase** the use of delayed prescribing by GPs (taking into account evidence from the wider behavioural science literature).

5. **Audit and feedback** has mixed evidence on effectiveness. The content and presentation of information provided in audit and feedback interventions are particularly important. Audit and feedback is currently provided in Ireland in letter format to GPs on prescribing for patients with medical cards by the HSE Antimicrobial Resistance and Infection Control (AMRIC). Given the findings from this review it would be useful[7]:
   a. For the AMRIC to **consider working on a collaborative project with the Better Letter Initiative** (BLI)^ to design and test A&F correspondence for GPs aimed to reduce

[7] This conclusion is relevant to any profession engaged in prescribing of antibiotics for use in the community.

unnecessary prescribing considering the existing A&F correspondence used in Ireland, correspondence reported to be effective in this review, and the BLI approach (which involves incorporating findings from the wider behavioural science literature and typically involves testing of re-design material).

b. For GPs not covered by the existing audit and feedback mechanism above, possibly 2 out of every 10 GPs^^, it is important to engage with the ICGP and HSE to **develop ongoing mechanisms to** (i) collect information on prescribing by these GPs, and (ii) audit and provide feedback to these GPs on their prescribing practices.

6. **Reporting of information in primary research studies.** Approximately half the relevant studies identified for this review did not report sufficient statistical detail to facilitate inclusion in the meta-analysis. Therefore, it is recommended that future primary studies transparently **report details of the participant numbers that were sampled alongside relevant frequency statistics** (e.g., risk events, total events) to allow for efficient pooling of all available studies and facilitate future meta-analysis.

---

^ The BLI is a series of quality improvement projects which involve simplifying the process and language along with the use of behavioural design elements in correspondence, and typically includes testing redesigns using RCTs. To date the BLI has involved projects to improve access to hospital care through the redesign of correspondence to increase patient engagement with hospital waiting list management and appointments. It is a collaboration between the Department of Health, the HSE, the NTPF and a Behavioural Science Advisory Group. The projects have been showcased nationally and internationally (WHO, OECD, United Nations).

https://www.gov.ie/en/collection/3c5bc8-health-research-and-statistics/#behavioural-insights-and-patient-public-engagement

^^ A rough estimate suggests that 23% of GPs may not be covered by prescribing audit and feedback. This is based on 733/3,233 where the numerator of 733 GPs not included in the current feedback mechanism is made up of an estimated 233 entirely private GPs and 500 GPs on a HSE Primary Care Reimbursement Scheme (PCRS) “list” but not included on the HSE’s Medical Card / GP Card "list" (e.g. such GPs might provide screening services but not general practice to MC/GPC holders). The denominator or total number of GPs is made up of this 733 GPs plus the 2,500 GPs on the HSE’s Medical Card / GP Card "list". This is an approximation is provided as indicative of overall scale.

References

Adams, G., Gulliford, M. C., Ukoumunne, O. C., Eldridge, S., Chinn, S., & Campbell, M. J. (2004). Patterns of intra-cluster correlation from primary care research to inform study design and analysis. *Journal of clinical epidemiology*, *57*(8), 785–794. https://doi.org/10.1016/j.jclinepi.2003.12.013.

Allard, J., Hébert, R., Rioux, M., Asselin, J., & Voyer, L. (2001). Efficacy of a clinical medication review on the number of potentially inappropriate prescriptions prescribed for community-dwelling elderly people. *CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne*, *164*(9), 1291–1296. http://www.ncbi.nlm.nih.gov/pmc/articles/pmc81019/.

Altiner, A., Brockmann, S., Sielk, M., Wilm, S., Wegscheider, K., & Abholz, H. H. (2007). Reducing antibiotic prescriptions for acute cough by motivating GPs to change their attitudes to communication and empowering patients: a cluster-randomized intervention study. *The Journal of antimicrobial chemotherapy*, *60*(3), 638–644. https://doi.org/10.1093/jac/dkm254.

Arnold, S. R., & Straus, S. E. (2005). Interventions to improve antibiotic prescribing practices in ambulatory care. The Cochrane database of systematic reviews, 2005(4), CD003539. DOI: https://doi.org/10.1002%2F14651858.CD003539.pub2.

Arroll, B., Kenealy, T., & Kerse, N. (2002). Do delayed prescriptions reduce the use of antibiotics for the common cold? A single-blind controlled trial. *The Journal of family practice*, *51*(4), 324–328. https://pubmed.ncbi.nlm.nih.gov/11978254/#:~:text=Conclusions%3A%20Delayed%20prescriptions%20are%20a,in%20a%20lower%20prescription%20rate.

Boonacker, C. W., Hoes, A. W., Dikhoff, M. J., Schilder, A. G., & Rovers, M. M. (2010). Interventions in health care professionals to improve treatment in children with upper respiratory tract infections. *International journal of pediatric otorhinolaryngology*, *74*(10), 1113–1121. https://doi.org/10.1016/j.ijporl.2010.07.008.

Bourgeois, F. C., Linder, J., Johnson, S. A., Co, J. P., Fiskio, J., & Ferris, T. G. (2010). Impact of a computerized template on antibiotic prescribing for acute respiratory infections in children and adolescents. *Clinical pediatrics*, *49*(10), 976–983. https://doi.org/10.1177/0009922810373649.

Briel, M., Langewitz, W., Tschudi, P., Young, J., Hugenschmidt, C., & Bucher, H. C. (2006). Communication training and antibiotic use in acute respiratory tract infections. A cluster randomised controlled trial in general practice. *Swiss medical weekly*, *136*(15-16), 241–247. https://doi.org/10.4414/smw.2006.11342.

Butler, C. C., Simpson, S. A., Dunstan, F., Rollnick, S., Cohen, D., Gillespie, D., Evans, M. R., Alam, M. F., Bekkers, M. J., Evans, J., Moore, L., Howe, R., Hayes, J., Hare, M., & Hood, K.

(2012). Effectiveness of multifaceted educational programme to reduce antibiotic dispensing in primary care: practice based randomised controlled trial. *BMJ (Clinical research ed.)*, *344*, d8173. https://doi.org/10.1136/bmj.d8173.

Cals, J. W., Butler, C. C., Hopstaken, R. M., Hood, K., & Dinant, G. J. (2009). Effect of point of care testing for C reactive protein and training in communication skills on antibiotic use in lower respiratory tract infections: cluster randomised trial. *BMJ (Clinical research ed.)*, *338*, b1374. https://doi.org/10.1136/bmj.b1374.

Castelino, T., Fiore, J. F., Jr, Niculiseanu, P., Landry, T., Augustin, B., & Feldman, L. S. (2016). The effect of early mobilization protocols on postoperative outcomes following abdominal and thoracic surgery: A systematic review. *Surgery*, *159*(4), 991–1003. https://doi.org/10.1016/j.surg.2015.11.029.

Chappell, N., Gerard, C., Gyani, A., Hamblin, R., Jansen, R. M., Lawrence, A., Mackay, J., Minko, N., Roberts, S., Shuker, C., Te Karu, L., & White, J. (2021). Using a randomised controlled trial to test the effectiveness of social norms feedback to reduce antibiotic prescribing without increasing inequities. *The New Zealand medical journal*, *134*(1544), 13–34. https://pubmed.ncbi.nlm.nih.gov/34695090/#:~:text=Conclusions%3A%20A%20targeted%20intervention%20using,but%20further%20investigation%20is%20needed.

Christakis, D. A., Zimmerman, F. J., Wright, J. A., Garrison, M. M., Rivara, F. P., & Davis, R. L. (2001). A randomized controlled trial of point-of-care evidence to improve the antibiotic prescribing practices for otitis media in children. *Pediatrics*, *107*(2), E15. https://doi.org/10.1542/peds.107.2.e15.

Coenen, S., Van Royen, P., Michiels, B., & Denekens, J. (2004). Optimizing antibiotic prescribing for acute cough in general practice: a cluster-randomized controlled trial. *The Journal of antimicrobial chemotherapy*, *54*(3), 661–672. https://doi.org/10.1093/jac/dkh374.

Curtis, H. J., Bacon, S., Croker, R., Walker, A. J., Perera, R., Hallsworth, M., Harper, H., Mahtani, K. R., Heneghan, C., & Goldacre, B. (2021). Evaluating the impact of a very low-cost intervention to increase practices' engagement with data and change prescribing behaviour: a randomized trial in English primary care. *Family practice*, *38*(4), 373–380. https://doi.org/10.1093/fampra/cmaa128.

de Bont, P. A., van den Berg, D. P., van der Vleugel, B. M., de Roos, C., de Jongh, A., van der Gaag, M., & van Minnen, A. (2015). Predictive validity of the Trauma Screening Questionnaire in detecting post-traumatic stress disorder in patients with psychotic disorders. *The British journal of psychiatry: the journal of mental science*, *206*(5), 408–416. https://doi.org/10.1192/bjp.bp.114.148486.

e la Poza Abad, M., Mas Dalmau, G., Moreno Bakedano, M., González González, A. I., Canellas Criado, Y., Hernández Anadón, S., Rotaeche del Campo, R., Torán Monserrat, P., Negrete Palma, A., Pera, G., Borrell Thió, E., Llor, C., Little, P., Alonso Coello, P., & Delayed

Antibiotic Prescription (DAP) Working Group (2013). Rationale, design and organization of the delayed antibiotic prescription (DAP) trial: a randomized controlled trial of the efficacy and safety of delayed antibiotic prescribing strategies in the non-complicated acute respiratory tract infections in general practice. *BMC family practice*, *14*, 63. https://doi.org/10.1186/1471-2296-14-63.

D'Hulster, L., Abrams, S., Bruyndonckx, R., Anthierens, S., Adriaenssens, N., Butler, C. C., Verheij, T., Goossens, H., Little, P., & Coenen, S. (2022). Nationwide implementation of online communication skills training to reduce overprescribing of antibiotics: a stepped-wedge cluster randomized trial in general practice. *JAC-antimicrobial resistance*, *4*(3), dlac070. https://doi.org/10.1093/jacamr/dlac070.

Dowell, J., Pitkethly, M., Bain, J., & Martin, S. (2001). A randomised controlled trial of delayed antibiotic prescribing as a strategy for managing uncomplicated respiratory tract infection in primary care. *The British journal of general practice: the journal of the Royal College of General Practitioners*, *51*(464), 200–205. http://www.ncbi.nlm.nih.gov/pmc/articles/pmc1313951/.

Ferrat, E., Le Breton, J., Guéry, E., Adeline, F., Audureau, E., Montagne, O., Roudot-Thoraval, F., Attali, C., Le Corvoisier, P., & Renard, V. (2016). Effects 4.5 years after an interactive GP educational seminar on antibiotic therapy for respiratory tract infections: a randomized controlled trial. *Family practice*, *33*(2), 192–199. https://doi.org/10.1093/fampra/cmv107.

Figueiras, A., López-Vázquez, P., Gonzalez-Gonzalez, C., Vázquez-Lago, J. M., Piñeiro-Lamas, M., López-Durán, A., Sánchez, C., Herdeiro, M. T., Zapata-Cachafeiro, M., & GREPHEPI Group (2020). Impact of a multifaceted intervention to improve antibiotic prescribing: a pragmatic cluster-randomised controlled trial. *Antimicrobial resistance and infection control*, *9*(1), 195. https://doi.org/10.1186/s13756-020-00857-9.

Finkelstein, J. A., Davis, R. L., Dowell, S. F., Metlay, J. P., Soumerai, S. B., Rifas-Shiman, S. L., Higham, M., Miller, Z., Miroshnik, I., Pedan, A., & Platt, R. (2001). Reducing antibiotic use in children: a randomized trial in 12 practices. *Pediatrics*, *108*(1), 1–7. https://doi.org/10.1542/peds.108.1.1.

Francis, N. A., Butler, C. C., Hood, K., Simpson, S., Wood, F., & Nuttall, J. (2009). Effect of using an interactive booklet about childhood respiratory tract infections in primary care consultations on reconsulting and antibiotic prescribing: a cluster randomised controlled trial. *BMJ (Clinical research ed.)*, *339*, b2885. https://doi.org/10.1136/bmj.b2885.

Gerber, J. S., Prasad, P. A., Fiks, A. G., Localio, A. R., Grundmeier, R. W., Bell, L. M., Wasserman, R. C., Keren, R., & Zaoutis, T. E. (2013). Effect of an outpatient antimicrobial stewardship intervention on broad-spectrum antibiotic prescribing by primary care pediatricians: a randomized trial. *JAMA*, *309*(22), 2345–2352. https://doi.org/10.1001/jama.2013.6287.
Gjelstad, S., Høye, S., Straand, J., Brekke, M., Dalen, I., & Lindbæk, M. (2013). Improving antibiotic prescribing in acute respiratory tract infections: cluster randomised trial from

Norwegian general practice (prescription peer academic detailing (Rx-PAD) study). *BMJ (Clinical research ed.)*, *347*, f4403. https://doi.org/10.1136/bmj.f4403.

Gold, N., Sallis, A., Saei, A., Arambepola, R., Watson, R., Bowen, S., Franklin, M., & Chadborn, T. (2022). Using text and charts to provide social norm feedback to general practices with high overall and high broad-spectrum antibiotic prescribing: a series of national randomised controlled trials. *Trials*, *23*(1), 511. https://doi.org/10.1186/s13063-022-06373-y.

Gold, N., Ratajczak, M., Sallis, A. et al. (2022). Provision of social-norms feedback to general practices whose antibiotic prescribing is increasing: a national randomized controlled trial. Journal of Public Health (Berl.) **30**, 2351–2358. https://doi.org/10.1007/s10389-021-01645-4.

Gonzales, R., Anderer, T., McCulloch, C. E., Maselli, J. H., Bloom, F. J., Jr, Graf, T. R., Stahl, M., Yefko, M., Molecavage, J., & Metlay, J. P. (2013). A cluster randomized trial of decision support strategies for reducing antibiotic use in acute bronchitis. *JAMA internal medicine*, *173*(4), 267–273. https://doi.org/10.1001/jamainternmed.2013.1589.

Hallsworth, M., Chadborn, T., Sallis, A., Sanders, M., Berry, D., Greaves, F., Clements, L., & Davies, S. C. (2016). Provision of social norm feedback to high prescribers of antibiotics in general practice: a pragmatic national randomised controlled trial. *Lancet (London, England)*, *387*(10029), 1743–1752. https://doi.org/10.1016%2FS0140-6736(16)00215-4.

Hanlon, J. T., Weinberger, M., Samsa, G. P., Schmader, K. E., Uttech, K. M., Lewis, I. K., Cowper, P. A., Landsman, P. B., Cohen, H. J., & Feussner, J. R. (1996). A randomized, controlled trial of a clinical pharmacist intervention to improve inappropriate prescribing in elderly outpatients with polypharmacy. *The American journal of medicine*, *100*(4), 428–437. https://doi.org/10.1016/s0002-9343(97)89519-8.

Higgins, J.P., Li, T. and Deeks, J.J. (2019). Choosing effect measures and computing estimates of effect. In Cochrane Handbook for Systematic Reviews of Interventions (eds J.P.T. Higgins, J. Thomas, J. Chandler, M. Cumpston, T. Li, M.J. Page and V.A. Welch). https://doi.org/10.1002/9781119536604.ch6

Hoffmann, T. C., Jones, M., Glasziou, P., Beller, E., Trevena, L., & Mar, C. D. (2022). A Brief Shared Decision-Making Intervention for Acute Respiratory Infections on Antibiotic Dispensing Rates in Primary Care: A Cluster Randomized Trial. *Annals of family medicine*, *20*(1), 35–41. https://doi.org/10.1370/afm.2755.

Høye, S., Gjelstad, S., & Lindbæk, M. (2013). Effects on antibiotic dispensing rates of interventions to promote delayed prescribing for respiratory tract infections in primary care. *The British journal of general practice: the journal of the Royal College of General Practitioners*, *63*(616), e777–e786. https://doi.org/10.3399/bjgp13x674468.

Hürlimann, D., Limacher, A., Schabel, M., Zanetti, G., Berger, C., Mühlemann, K., Kronenberg, A., & Swiss Sentinel Working Group (2015). Improvement of antibiotic prescription in outpatient care: a cluster-randomized intervention study using a sentinel surveillance network of physicians. *The Journal of antimicrobial chemotherapy*, *70*(2), 602–608. https://doi.org/10.1093/jac/dku394.

Ilett, K. F., Johnson, S., Greenhill, G., Mullen, L., Brockis, J., Golledge, C. L., & Reid, D. B. (2000). Modification of general practitioner prescribing of antibiotics by use of a therapeutics adviser (academic detailer). *British journal of clinical pharmacology*, *49*(2), 168–173. https://doi.org/10.1046%2Fj.1365-2125.2000.00123.x.

Kronman, M. P., Gerber, J. S., Grundmeier, R. W., Zhou, C., Robinson, J. D., Heritage, J., Stout, J., Burges, D., Hedrick, B., Warren, L., Shalowitz, M., Shone, L. P., Steffes, J., Wright, M., Fiks, A. G., & Mangione-Smith, R. (2020). Reducing Antibiotic Prescribing in Primary Care for Respiratory Illness. Pediatrics, 146(3), e20200038. https://doi.org/10.1542/peds.2020-0038.

Lagerløv, P., Loeb, M., Andrew, M., & Hjortdahl, P. (2000). Improving doctors' prescribing behaviour through reflection on guidelines and prescription feedback: a randomised controlled study. *Quality in health care: QHC*, *9*(3), 159–165. https://doi.org/10.1136/qhc.9.3.159.

e Corvoisier, P., Renard, V., Roudot-Thoraval, F., Cazalens, T., Veerabudun, K., Canoui-Poitrine, F., Montagne, O., & Attali, C. (2013). Long-term effects of an educational seminar on antibiotic prescribing by GPs: a randomised controlled trial. *The British journal of general practice : the journal of the Royal College of General Practitioners*, *63*(612), e455–e464. https://doi.org/10.3399/bjgp13x669176.

Légaré, F., Labrecque, M., Cauchon, M., Castel, J., Turcotte, S., & Grimshaw, J. (2012). Training family physicians in shared decision-making to reduce the overuse of antibiotics in acute respiratory infections: a cluster randomized trial. *CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne*, *184*(13), E726–E734. https://doi.org/10.1503%2Fcmaj.120568.

Légaré, F., Labrecque, M., Godin, G., LeBlanc, A., Laurier, C., Grimshaw, J., Castel, J., Tremblay, I., Frémont, P., Cauchon, M., Lemieux, K., & Rhéaume, C. (2011). Training family physicians and residents in family medicine in shared decision making to improve clinical decisions regarding the use of antibiotics for acute respiratory infections: protocol for a clustered randomized controlled trial. *BMC family practice*, *12*, 3. https://doi.org/10.1186/1471-2296-12-3.

Lemiengre, M. B., Verbakel, J. Y., Colman, R., De Burghgraeve, T., Buntinx, F., Aertgeerts, B., De Baets, F., & De Sutter, A. (2018). Reducing inappropriate antibiotic prescribing for children in primary care: a cluster randomised controlled trial of two interventions. *The British journal of general practice: the journal of the Royal College of General Practitioners*, *68*(668), e204–e210.https://doi.org/10.3399/bjgp18x695033.

Linder, J. A., Schnipper, J. L., Tsurikova, R., Yu, D. T., Volk, L. A., Melnikas, A. J., Palchuk, M. B., Olsha-Yehiav, M., & Middleton, B. (2010). Electronic health record feedback to improve antibiotic prescribing for acute respiratory infections. *The American journal of managed care*, *16*(12 Suppl HIT), e311–e319. https://pubmed.ncbi.nlm.nih.gov/21322301/.

Little, P., Gould, C., Williamson, I., Moore, M., Warner, G., & Dunleavey, J. (2001). Pragmatic randomised controlled trial of two prescribing strategies for childhood acute otitis media. *BMJ (Clinical research ed.)*, *322*(7282), 336–342. https://doi.org/10.1136/bmj.322.7282.336.

Little, P., Rumsby, K., Kelly, J., Watson, L., Moore, M., Warner, G., Fahey, T., & Williamson, I. (2005). Information leaflet and antibiotic prescribing strategies for acute lower respiratory tract infection: a randomized controlled trial. *JAMA*, *293*(24), 3029–3035. https://doi.org/10.1001/jama.293.24.3029.

Little, P., Stuart, B., Francis, N., Douglas, E., Tonkin-Crine, S., Anthierens, S., Cals, J. W. L., Melbye, H., Santer, M., Moore, M., Coenen, S., Butler, C. C., Hood, K., Kelson, M., Godycki-Cwirko, M., Mierzecki, A., Torres, A., Llor, C., Davies, M., Mullee, M., … GRACE consortium (2019). Antibiotic Prescribing for Acute Respiratory Tract Infections 12 Months After Communication and CRP Training: A Randomized Trial. *Annals of family medicine*, *17*(2), 125–132.https://doi.org/10.1370%2Fafm.2356.

Little, P., Stuart, B., Francis, N., Douglas, E., Tonkin-Crine, S., Anthierens, S., Cals, J. W., Melbye, H., Santer, M., Moore, M., Coenen, S., Butler, C., Hood, K., Kelly, M., Godycki-Cwirko, M., Mierzecki, A., Torres, A., Llor, C., Davies, M., Mullee, M., … GRACE consortium (2013). Effects of internet-based training on antibiotic prescribing rates for acute respiratory-tract infections: a multinational, cluster, randomised, factorial, controlled trial. *Lancet (London, England)*, *382*(9899), 1175–1182. https://doi.org/10.1016/s0140-6736(13)60994-0.

Llor, C., Madurell, J., Balagué-Corbella, M., Gómez, M., & Cots, J. M. (2011). Impact on antibiotic prescription of rapid antigen detection testing in acute pharyngitis in adults: a randomised clinical trial. *The British journal of general practice: the journal of the Royal College of General Practitioners*, *61*(586), e244–e251. https://doi.org/10.3399%2Fbjgp11X572436.

Macfarlane, J., Holmes, W., Gard, P., Thornhill, D., Macfarlane, R., & Hubbard, R. (2002). Reducing antibiotic use for acute bronchitis in primary care: blinded, randomised controlled trial of patient information leaflet. *BMJ (Clinical research ed.)*, *324*(7329), 91–94. https://doi.org/10.1136/bmj.324.7329.91.

Mainous, A. G., 3rd, Hueston, W. J., Love, M. M., Evans, M. E., & Finger, R. (2000). An evaluation of statewide strategies to reduce antibiotic overuse. *Family medicine*, *32*(1), 22–29. https://pubmed.ncbi.nlm.nih.gov/10645510/.

McIsaac, W., Kukan, S., Huszti, E., Szadkowski, L., O'Neill, B., Virani, S., Ivers, N., Lall, R., Toor, N., Shah, M., Alvi, R., Bhatt, A., Nakamachi, Y., & Morris, A. M. (2021). A pragmatic randomized trial of a primary care antimicrobial stewardship intervention in Ontario, Canada. *BMC family practice*, *22*(1), 185. https://doi.org/10.1186/s12875-021-01536-3.

McIsaac, W. J., Goel, V., To, T., Permaul, J. A., & Low, D. E. (2002). Effect on antibiotic prescribing of repeated clinical prompts to use a sore throat score: lessons from a failed community intervention study. *The Journal of family practice*, *51*(4), 339–344. https://pubmed.ncbi.nlm.nih.gov/11978257/.

McIsaac, W. J., Goel, V., To, T., Permaul, J. A., & Low, D. E. (2002). Effect on antibiotic prescribing of repeated clinical prompts to use a sore throat score: lessons from a failed community intervention study. *The Journal of family practice*, *51*(4), 339–344. https://pubmed.ncbi.nlm.nih.gov/11978257/.

McIsaac, W. J., & Goel, V. (1998). Effect of an explicit decision-support tool on decisions to prescribe antibiotics for sore throat. *Medical decision making: an international journal of the Society for Medical Decision Making*, *18*(2), 220–228. https://doi.org/10.1177/0272989x9801800211.

McNulty, C., Hawking, M., Lecky, D., Jones, L., Owens, R., Charlett, A., Butler, C., Moore, P., & Francis, N. (2018). Effects of primary care antimicrobial stewardship outreach on antibiotic use by general practice staff: pragmatic randomized controlled trial of the TARGET antibiotics workshop. *The Journal of antimicrobial chemotherapy*, *73*(5), 1423–1432. https://doi.org/10.1093/jac/dky004.

Meeker, D., Knight, T. K., Friedberg, M. W., Linder, J. A., Goldstein, N. J., Fox, C. R., Rothfeld, A., Diaz, G., & Doctor, J. N. (2014). Nudging guideline-concordant antibiotic prescribing: a randomized clinical trial. JAMA internal medicine, 174(3), 425–431. https://doi.org/10.1001/jamainternmed.2013.14191.

Meeker, D., Linder, J. A., Fox, C. R., Friedberg, M. W., Persell, S. D., Goldstein, N. J., Knight, T. K., Hay, J. W., & Doctor, J. N. (2016). Effect of Behavioral Interventions on Inappropriate Antibiotic Prescribing Among Primary Care Practices: A Randomized Clinical Trial. *JAMA*, *315*(6), 562–570. https://doi.org/10.1001/jama.2016.0275.

Milos, V., Jakobsson, U., Westerlund, T., Melander, E., Mölstad, S., & Midlöv, P. (2013). Theory-based interventions to reduce prescription of antibiotics--a randomized controlled trial in Sweden. *Family practice*, *30*(6), 634–640. https://doi.org/10.1093/fampra/cmt043.

O'Connell, D. L., Henry, D., & Tomlins, R. (1999). Randomised controlled trial of effect of feedback on general practitioners' prescribing in Australia. *BMJ (Clinical research ed.)*, *318*(7182), 507–511. https://doi.org/10.1136/bmj.318.7182.507.

O'Sullivan, J. W., Harvey, R. T., Glasziou, P. P., & McCullough, A. (2016). Written information for patients (or parents of child patients) to reduce the use of antibiotics for acute upper respiratory tract infections in primary care. *The Cochrane database of systematic reviews*, *11*(11), CD011360. https://doi.org/10.1002%2F14651858.CD011360.pub2.

Persell, S. D., Doctor, J. N., Friedberg, M. W., Meeker, D., Friesema, E., Cooper, A., Haryani, A., Gregory, D. L., Fox, C. R., Goldstein, N. J., & Linder, J. A. (2016). Behavioral interventions to reduce inappropriate antibiotic prescribing: a randomized pilot trial. *BMC infectious diseases*, *16*, 373. https://doi.org/10.1186/s12879-016-1715-8.

Pshetizky, Y., Naimer, S., & Shvartzman, P. (2003). Acute otitis media--a brief explanation to parents and antibiotic use. *Family practice*, *20*(4), 417–419. https://doi.org/10.1093/fampra/cmg414.

Raban, M. Z., Gonzalez, G., Nguyen, A. D., Newell, B. R., Li, L., Seaman, K. L., & Westbrook, J. I. (2023). Nudge interventions to reduce unnecessary antibiotic prescribing in primary care: a systematic review. *BMJ open*, *13*(1), e062688. http://dx.doi.org/10.1136/bmjopen-2022-062688.

Raebel, M. A., Charles, J., Dugan, J., Carroll, N. M., Korner, E. J., Brand, D. W., & Magid, D. J. (2007). Randomized trial to improve prescribing safety in ambulatory elderly patients. *Journal of the American Geriatrics Society*, *55*(7), 977–985. https://doi.org/10.1111/j.1532-5415.2007.01202.x.

Ranji, S. R., Steinman, M. A., Shojania, K. G., & Gonzales, R. (2008). Interventions to reduce unnecessary antibiotic prescribing: a systematic review and quantitative analysis. *Medical care*, *46*(8), 847–862. https://doi.org/10.1097/mlr.0b013e318178eabd.

Regev-Yochay, G., Raz, M., Dagan, R., Roizin, H., Morag, B., Hetman, S., Ringel, S., Ben-Israel, N., Varon, M., Somekh, E., & Rubinstein, E. (2011). Reduction in antibiotic use following a cluster randomized controlled multifaceted intervention: the Israeli judicious antibiotic prescription study. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America*, *53*(1), 33–41. https://doi.org/10.1093/cid/cir272.

Ryan, R., Santesso, N., Lowe, D., Hill, S., Grimshaw, J., Prictor, M., Kaufman, C., Cowie, G., & Taylor, M. (2014). Interventions to improve safe and effective medicines use by consumers: an overview of systematic reviews. *The Cochrane database of systematic reviews*, *2014*(4), CD007768.https://doi.org/10.1002%2F14651858.CD007768.pub3.

Samore, M. H., Bateman, K., Alder, S. C., Hannah, E., Donnelly, S., Stoddard, G. J., Haddadin, B., Rubin, M. A., Williamson, J., Stults, B., Rupper, R., & Stevenson, K. (2005). Clinical decision support and appropriateness of antimicrobial prescribing: a randomized trial. *JAMA*, *294*(18), 2305–2314.https://doi.org/10.1001/jama.294.18.2305.

Schwartz, K. L., Ivers, N., Langford, B. J., Taljaard, M., Neish, D., Brown, K. A., Leung, V., Daneman, N., Alloo, J., Silverman, M., Shing, E., Grimshaw, J. M., Leis, J. A., Wu, J. H. C., & Garber, G. (2021). Effect of Antibiotic-Prescribing Feedback to High-Volume Primary Care Physicians on Number of Antibiotic Prescriptions: A Randomized Clinical Trial. *JAMA internal medicine*, *181*(9), 1165–1173. https://doi.org/10.1001/jamainternmed.2021.2790.

Søndergaard, J., Andersen, M., Støvring, H., & Kragstrup, J. (2003). Mailed prescriber feedback in addition to a clinical guideline has no impact: a randomised, controlled trial. *Scandinavian journal of primary health care*, *21*(1), 47–51. https://doi.org/10.1080/02813430310000564.

Spurling, G. K., Del Mar, C. B., Dooley, L., Foxlee, R., & Farley, R. (2017). Delayed antibiotic prescriptions for respiratory infections. *The Cochrane database of systematic reviews*, *9*(9), CD004417. https://doi.org/10.1002%2F14651858.CD004417.pub5.

Taylor, J. A., Kwan-Gett, T. S., & McMahon, E. M., Jr (2005). Effectiveness of a parental educational intervention in reducing antibiotic use in children: a randomized controlled trial. *The Pediatric infectious disease journal*, *24*(6), 489–493. https://doi.org/10.1097/01.inf.0000164706.91337.5d.

Tonkin-Crine, S. K., Tan, P. S., van Hecke, O., Wang, K., Roberts, N. W., McCullough, A., Hansen, M. P., Butler, C. C., & Del Mar, C. B. (2017). Clinician-targeted interventions to influence antibiotic prescribing behaviour for acute respiratory infections in primary care: an overview of systematic reviews. *The Cochrane database of systematic reviews*, *9*(9), CD012252. https://doi.org/10.1002/14651858.CD012252.pub2

Vervloet, M., Meulepas, M. A., Cals, J. W., Eimers, M., van der Hoek, L. S., & van Dijk, L. (2016). Reducing antibiotic prescriptions for respiratory tract infections in family practice: results of a cluster randomized controlled trial evaluating a multifaceted peer-group-based intervention. *NPJ primary care respiratory medicine*, *26*, 15083. https://doi.org/10.1038/npjpcrm.2015.83

Welschen, I., Kuyvenhoven, M. M., Hoes, A. W., & Verheij, T. J. (2004). Effectiveness of a multiple intervention to reduce antibiotic prescribing for respiratory tract symptoms in primary care: randomised controlled trial. *BMJ (Clinical research ed.)*, *329*(7463), 431. https://doi.org/10.1136/bmj.38182.591238.EB

Östervall, L. (2017). "Nudging to prudence? The effect of reminders on antibiotics prescriptions," Journal of Economic Behavior & Organization, Elsevier, vol. 135(C), pages 39-52. https://ideas.repec.org/a/eee/jeborg/v135y2017icp39-52.html.

Zwar, N., Wolk, J., Gordon, J., Sanson-Fisher, R., & Kehoe, L. (1999). Influencing antibiotic prescribing in general practice: a trial of prescriber feedback and management guidelines. *Family practice*, *16*(5), 495–500. https://doi.org/10.1093/fampra/16.5.495