Improving antibiotic prescribing quality by an intervention embedded in the primary care practice accreditation: the ARTI4 randomized trial

Alike W. van der Velden*, Marijke M. Kuyvenhoven and Theo J. M. Verheij

Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht (STR 6.103), Heidelberglaan 100, 3584 CX Utrecht, The Netherlands

*Corresponding author. Tel: +31-88-756-8511; Fax: +31-88-756-8099; E-mail: a.w.vandervelden@umcutrecht.nl

Received 16 March 2015; returned 1 June 2015; revised 11 July 2015; accepted 9 September 2015

Objectives: Antibiotic overprescribing is a significant problem. Multifaceted interventions improved antibiotic prescribing quality; their implementation and sustainability, however, have proved difficult. We analysed the effectiveness of an intervention embedded in the quality cycle of primary care practice accreditation on quantity and quality of antibiotic prescribing for respiratory tract and ear infections (RTIs).

Methods: This was a pragmatic, cluster-randomized intervention trial in 88 Dutch primary care practices. The intervention (physician education and audit/feedback on antibiotic prescribing quantity and quality) was integrated in practice accreditation by defining an improvement plan with respect to antibiotic prescribing for RTIs. Numbers and types of dispensed antibiotics were analysed from 1 year prior to the intervention to 2 years after the intervention (pharmacy data). Overprescribing, underprescribing and non-first-choice prescribing for RTIs were analysed at baseline and 1 year later (self-registration).

Results: There were significant differences between intervention and control practices in the changes in dispensed antibiotics/1000 registered patients (first year: −27.6% versus +0.4%, \( P = 0.002 \); second year: −4.3% versus +2%, \( P = 0.015 \)), which was more pronounced for macrolides and amoxicillin/clavulanate (first year: −12.7% versus +2.9%, \( P = 0.001 \); second year: −7.8% versus +6.7%, \( P = 0.005 \)). Overprescribing for RTIs decreased from 44% of prescriptions to 28% (\( P < 0.001 \)). Most general practitioners (GPs) envisaged practice accreditation as a tool for guideline implementation.

Conclusions: GP education and an audited improvement plan around antibiotics for RTIs as part of primary care practice accreditation sustainably improved antibiotic prescribing. Tools should be sought to further integrate and facilitate education and audit/feedback in practice accreditation.

Introduction

Antibiotic resistance is a worldwide public health problem and resistant microorganisms are increasingly identified in the community.¹ The vast majority of antibiotics are prescribed in primary care and respiratory tract and ear infections (RTIs) are the most common reason for antibiotic treatment in this setting.² ³ There is firm evidence that antibiotics are heavily overprescribed for respiratory disease,² ³ thereby contributing to resistance development,⁶ medicalization of patients and exposure to side effects. These negative effects of irrational antibiotic use result in unnecessary costs and worse outcomes for patients.⁷ ⁸

Primary care guidelines recommend restrictive antibiotic use for RTIs because of their limited treatment effectiveness for these indications.⁹ ¹⁰ Guidelines furthermore recommend the use of narrower-spectrum antibiotics, like penicillin V and amoxicillin, because of their lower selection pressure. Despite guidelines, public campaigns, surveillance of antibiotic use and awareness of antibiotic-related problems, there seem to be hardly any relevant and sustainable improvements in prescribing quality for RTIs in daily practice, with respect to reducing irrational prescribing, as well as increasing smaller spectrum prescribing.⁶ ¹¹ ¹⁵ In trials, however, multifaceted interventions, especially those including physician education, did improve antibiotic prescribing quality.¹⁶ ¹⁷ Implementation of such programmes and sustainability of improvements is, however, often hampered by practicalities. Embedment in a national quality assurance cycle could aid in efficient and sustained uptake. The accreditation procedure, increasingly used in primary care, is an excellent opportunity for this. In the Netherlands, the practice accreditation of the Dutch College of General Practitioners (Netherlands Practice Accreditation (NPA)) offers a 5 year cycle to systematically improve quality of care and practice organization. By complying with self-evaluation, improvement plans, monitoring systems and yearly audits, practices receive the NPA quality mark.
We embedded a multifaceted intervention to improve antibiotic prescribing for RTIs in the NPA quality cycle, by defining and facilitating audit of practice-specific improvement plans. Effectiveness with respect to improving appropriate prescribing (according to the specific recommendations of the guidelines) and reducing overall and non-first-choice antibiotic use were analysed for up to 2 years after the intervention.

**Methods**

**Study design, setting and participants**

This open, pragmatic, cluster-randomized intervention trial ran in 88 primary care practices participating in the NPA. These could be single-handed, two-handed or group practices; in total 169 general practitioners (GPs) were involved. Practices, not individual GPs, were randomly allocated (using a web-based randomization module hosted by the data-management department) to an intervention to optimize antibiotic prescribing for RTIs (in which we also included acute otitis media (AOM)) or to an intervention to reduce chronic use of proton pump inhibitors for reflux disease (simple randomization, 1:1 ratio). GPs in the practices were informed about their allocation after they had promised to participate. Practices in the two trial arms served as each other’s controls. The trial ran between 2009 and 2013 (trial stop: 2 years after the last educational meeting).

**Ethics approval**

The trial was exempted by the Ethics Committee of the University Medical Center Utrecht from obtaining patients’ consent and full protocol delivery (reference number METC 07-293/C). As the trial assigned GPs with the aim of changing their prescribing behaviour and did not analyse or include patients’ health outcomes, it did not fall under the Medical Research Involving Human Subjects Act.

**Aims and study outcome measures**

The overall aim of this study was to improve GPs’ antibiotic prescribing policy for RTIs, with the specific aims of decreasing overprescribing, as well as non-first-choice (macrolides and amoxicillin/clavulanate) prescribing. To analyse the effectiveness of the intervention, the following outcome measures were determined at the level of the practice:

(i) Primary outcome: change in the total numbers of dispensed antibiotic courses/1000 registered patients/year, from baseline to year 1, and from baseline to year 2.
(ii) Secondary outcomes: changes in the numbers of dispensed courses of specific subgroups of antibiotics/1000 registered patients/year and overprescribing, underprescribing and non-first-choice prescribing of antibiotics.

A tertiary outcome was GPs’ opinions about the intervention and its embedment in the NPA.

**Sample size calculation**

The primary outcome of this study was the change in antibiotic prescription from the year prior to the intervention to the year after the intervention, as measured per practice. We assumed a baseline level of prescribing of 300 antibiotics/1000 registered patients/year and that the intervention results in a decrease of at least 5% in antibiotic prescribing and no change in control practices. A standard deviation of 7% was assumed for these changes based on literature data. Using these assumptions, 42 practices are needed per group to detect this difference at an α level of 0.05 with a power of 90%. To account for possible drop-outs or missing pharmacy data, we aimed at including 88 practices.

**Data collection**

(i) Practice and individual GP characteristics were obtained via a short questionnaire before the start of the trial. As an indicator of the socio-economic status (SES) of the practice’s patient population, the mean SES code was determined using the zip code of the practice (The Netherlands Institute for Social Research, http://www.scp.nl/english).
(ii) Total and types of yearly dispensed antibiotic courses were collected via the Dutch Foundation for Pharmaceutical Statistics (SFK, http://www.sfk.nl/english); this could only be done at the level of the practice. The SFK collects and analyses pharmaceutical dispensing data of 95% of Dutch public pharmacies monthly. Affiliated pharmacies of all participating practices were asked for permission to collect all dispensed antibiotics that resulted from prescribing by the GP(s) of that practice. Dispensed medication coded with ATC-code J01 (antibacterials for systemic use, http://www.whocc.no/atc_ddd_index/) were collected via an online module for the exact year preceding the educational meeting (year 0) and for the exact 2 years after the meeting (year 1 and 2). J01 data were analysed in total and for the subgroups used for RTIs [tetracyclines (A), amoxicillin (CA), amoxicillin/clavulanate (CR), phenethicillin (CE) and macrodilides (FA)] and were related to the number of registered patients in the practice. We did not analyse the impact of the intervention on fluoroquinolone and cephalosporin prescribing, as <7% of prescribed fluoroquinolones are for RTIs and cephalosporins only account for 0.2% of total antibiotic prescribing in the Netherlands. Numbers of registered patients were updated every year.
(iii) To specifically determine antibiotic prescribing quality for RTIs, all GPs in the antibiotic intervention group registered all their RTI consultations for 4 weeks. All relevant patient, symptom and clinical investigation characteristics were registered on a specifically designed form. Every single consultation was benchmarked to the recommendations of the Dutch College of General Practitioners prescribing guidelines for AOM, rhinosinusitis, acute sore throat and acute cough, to determine overprescribing, underprescribing and non-first-choice prescribing. This procedure was described in full detail by Dekker et al. and a summary of the guidelines is provided as Supplementary data at JAC Online. In the first registration a total of 2732 consultations (from 45 practices) were analysed and 2503 (from 43 practices) were analysed in the second registration period. As total antibiotic prescribing was analysed at practice level, overprescribing, underprescribing and non-first-choice prescribing were also calculated at the level of the practice. To prevent GPs in the control group from becoming focused on their antibiotic prescribing, they did not do this 4 week registration of RTIs.
(iv) GPs’ opinions about the relevance of the separate elements of the multifaceted intervention were obtained by a questionnaire distributed at the end of the trial.

**Intervention**

The multifaceted intervention on improving antibiotic use for RTIs was based on a combination of previously proven effective elements, GP education, audit/feedback and patient information, which we integrated in the NPA with an improvement plan. GP education was not specifically based on behavioural change frameworks, but contained elements we considered useful and informative for GPs. The following is a description of the elements of the ‘antibiotics for RTIs’ intervention.

(i) Participation of all GPs in the 4 week registration of all their RTI consultations, as described above.
(ii) A 60–90 min educational meeting at practice level, with all GPs working in that practice (one to six) in one session. First, the specific contents and backgrounds of the four Dutch College of General Practitioners guidelines (AOM, rhinosinusitis, acute sore throat and acute cough) with respect to diagnosis and antibiotic prescribing were presented; these were all preceded by a patient case to open...
the discussion. Second, antibiotic-related problems (resistance, medicalization, unnecessary side effects and costs) were discussed. Third, the reasons for patient consultation for an RTI and patient satisfaction after an RTI consultation were clarified. The GPs were provided with communication tools to explore patients’ concerns and patient expectations around antibiotics and to communicate their non-antibiotic treatment decision (resistance, antibiotics can do more harm than good, number needed to treat to benefit). Finally, detailed feedback on the amounts and types of antibiotics they prescribed in the year prior to the meeting, together with detailed analyses of their overprescribing, underprescribing and non-first-choice prescribing, was provided; their results were discussed and interpreted.

(iii) After the educational meeting, an improvement plan to optimize antibiotic prescribing for RTIs was defined by the GPs for their practice. Depending on the focus points identified during the meeting by the feedback and the interests of the GPs, focus could be on reducing total amounts of (non-first-choice) antibiotics and/or on reducing overprescribing for specific indications (with numerical targets).

(iv) Patient booklets with information on symptomatic treatment, natural course and alarm symptoms of RTIs were given by the GPs to patients presenting with RTIs or their parents, and were also available in the waiting room.

(v) All individual GPs participated in the second 4 week registration of RTIs, 10–12 months after the educational meeting. Together with analyses of the amounts and types of all antibiotics dispensed in the year after the educational meeting, this was used as feedback for the practices. In this way they could determine whether the targets as specified in their improvement plan were reached.

Analyses

Practices’ and GPs’ quantitative and qualitative baseline characteristics and the opinions of GPs about the intervention are presented as means, with minimal and maximal values, and percentages.

The intervention effects were determined with the practice as the unit of analysis. For each practice, the absolute changes in dispensed antibiotics were calculated as the numbers of dispensed antibiotic courses/1000 registered patients/year during year 1 (or 2) minus the numbers of dispensed antibiotic courses/1000 registered patients/year during year 0; for changes as percentages, these numbers were divided by the numbers of dispensed antibiotic courses/1000 registered patients/year during year 0 and multiplied by 100%.

For each practice, overprescribing was calculated as the percentage of non-indicated prescriptions, and this was also analysed separately for AOM, sore throat, rhinosinusitis and acute cough. Underprescribing was calculated as the percentage of non-prescriptions in which an antibiotic was actually indicated. Non-first-choice prescribing was the percentage of prescriptions other than the recommended first choice, without a specified reason, like allergy, pregnancy or breast feeding.

Student’s t-test was used to analyse differences in the percentage changes in antibiotic prescribing between practices in the intervention and control groups. To assess changes in overprescribing, underprescribing and non-first-choice prescribing within the antibiotic intervention group, a paired-sample t-test was performed. Pearson’s correlation test was used to determine whether the magnitudes of change in antibiotic use were related to baseline prescribing quantities. P values <0.05 were considered significant. Analyses were performed using SPSS version 20.

Results

Practice flow and practice and GP characteristics

After randomization and the educational meeting two control practices were excluded from analyses, because their pharmacy’s dispensing data could not (reliably) be obtained, leaving 86 practices completing the study (165 GPs). All GPs participated in the educational meeting and all practices defined their improvement plan. GPs of two practices randomized to the antibiotic intervention did not participate in the second registration of RTIs, 1 year after the intervention, due to illness; specific overprescribing data are missing for these practices, but their pharmacy data could be used to determine intervention effectiveness. Two practices, one from each trial arm, were removed from the second year pharmacy’s analysis, due to new GPs running the practice (see the CONSORT flow diagram in Supplementary data at JAC Online).

Baseline practice and GP characteristics are shown in Table 1. Practices in both groups were comparable with respect to their patient population (size and SES), practice organization and geographical location within the Netherlands. Various GP characteristics were also comparable.

Baseline antibiotic use and prescribing characteristics

In the year preceding the intervention a total of 280 antibiotic courses were dispensed during the daytime per 1000 registered patients of practices in the antibiotic intervention group, with considerable variation between practices. Almost 40% consisted of first-choice antibiotics for RTIs (tetracyclines, amoxicillin and penicillin) and 24% were amoxicillin/clavulanate and macrolide treatments. Comparable use was seen in the control group (Table 2). The specific registration of RTI consultations revealed that antibiotic overprescribing for RTIs had a practice-based mean of 44%, with a range between 0% and 89%. Lowest
overprescribing was seen for AOM and highest for the upper RTIs. Non-first-choice antibiotic prescribing (mostly macrolides and amoxicillin/clavulanate) had a practice-based mean of 22% and underprescribing of 2.9%.

**First-year effectiveness of the intervention**

After 1 year, the intervention showed significant effectiveness on all relevant outcomes (Table 3). The most significant change was seen in macrolide and amoxicillin/clavulanate use, which decreased by a mean of nearly 13% in practices in the antibiotic intervention group, whereas a mean increase of 3% was seen in control practices ($P = 0.001$). Within the antibiotic intervention group, the magnitudes of decreases in amoxicillin, doxycycline and phenethicillin use (−7.7%) and in amoxicillin/clavulanate and macrolide use (−12.7%) were both correlated to their respective baseline quantities (correlation coefficients: −0.3, $P = 0.04$, and −0.36, $P = 0.01$, respectively); the largest decreases in antibiotic use were therefore seen in practices with higher baseline use. Within the control group no significant correlations were found between magnitudes of decreases and baseline quantities.

Furthermore, the intervention decreased overprescribing for RTIs from a practice-based mean of 44% to 28% ($P < 0.001$)—the decrease was most prominent in prescribing for rhinosinusitis and lower RTIs. The magnitude of decrease in overprescribing due to the intervention was again highly correlated to the practices’ level of baseline overprescribing (correlation coefficient: −0.7, $P < 0.001$). Of interest for prescribing quality was that underprescribing for RTIs significantly improved as well.

### Table 2. Baseline antibiotic use and prescribing

<table>
<thead>
<tr>
<th>Antibiotic Use and Prescribing</th>
<th>Intervention (n=45)</th>
<th>Control (n=41)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total J01/1000 registered patients/year</td>
<td>280 (146–560)</td>
<td>286 (144–733)</td>
</tr>
<tr>
<td>J01A+J01CA+J01CE/1000 registered patients/year</td>
<td>111 (46–240)</td>
<td>117 (48–244)</td>
</tr>
<tr>
<td>J01CR+J01FA/1000 registered patients/year</td>
<td>66 (27–169)</td>
<td>66 (27–217)</td>
</tr>
<tr>
<td>Overprescribing for RTIs</td>
<td>44% (0%–89%)</td>
<td>ND</td>
</tr>
<tr>
<td>Overprescribing for AOM</td>
<td>2.4% (0%–50%)</td>
<td>ND</td>
</tr>
<tr>
<td>Overprescribing for sore throat</td>
<td>54% (0%–100%)</td>
<td>ND</td>
</tr>
<tr>
<td>Overprescribing for rhinosinusitis</td>
<td>52% (0%–100%)</td>
<td>ND</td>
</tr>
<tr>
<td>Overprescribing for upper RTIs</td>
<td>57% (0%–100%)</td>
<td>ND</td>
</tr>
<tr>
<td>Non-first-choice prescribing for RTIs</td>
<td>22% (0%–72%)</td>
<td>ND</td>
</tr>
<tr>
<td>Underprescribing for RTIs</td>
<td>2.9% (0%–17%)</td>
<td>ND</td>
</tr>
</tbody>
</table>

**Second-year effectiveness of the intervention**

To investigate the sustainability of the intervention effect, the changes in numbers of dispensed antibiotics were also analysed for the second full year after the intervention (Table 4). With respect to the total numbers of dispensed antibiotics and to the use of macrolides and amoxicillin/clavulanate, an enduring significant difference was detected between the intervention groups. As a measure of real antibiotic saving, we also analysed the absolute change in the numbers of dispensed RTI antibiotic courses. Seventeen fewer RTI antibiotic courses were dispensed per 1000 registered patients from intervention practices during the second year after the intervention (range: −90 to 34), whereas from control practices 3 more were dispensed (range: −45 to 86). This resulted in an absolute change of 20 antibiotic courses/1000 registered patients/year.

### Table 3. Intervention effect: first year

<table>
<thead>
<tr>
<th>Antibiotic Intervention (n=45/43*)</th>
<th>Control (n=41)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage change for total antibiotics</td>
<td>−7.6% (−27% to 22%)</td>
<td>−0.4% (−17% to 20%)</td>
</tr>
<tr>
<td>Percentage change for J01A+J01CA+J01CE antibiotics</td>
<td>−7.7% (−39% to 27%)</td>
<td>0.08% (−30% to 36%)</td>
</tr>
<tr>
<td>Percentage change for J01CR+J01FA antibiotics</td>
<td>−12.7% (−57% to 27%)</td>
<td>2.9% (30% to 48%)</td>
</tr>
<tr>
<td>Overprescribing for RTIs</td>
<td>from 44% to 28%</td>
<td>ND</td>
</tr>
<tr>
<td>Overprescribing for AOM</td>
<td>from 2.5% to 4.6%</td>
<td>ND</td>
</tr>
<tr>
<td>Overprescribing for sore throat</td>
<td>from 54% to 33%</td>
<td>ND</td>
</tr>
<tr>
<td>Overprescribing for rhinosinusitis</td>
<td>from 52% to 26%</td>
<td>ND</td>
</tr>
<tr>
<td>Overprescribing for upper RTIs</td>
<td>from 49% to 29%</td>
<td>ND</td>
</tr>
<tr>
<td>Non-first-choice prescribing for RTIs</td>
<td>from 21% to 16%</td>
<td>ND</td>
</tr>
<tr>
<td>Underprescribing for RTIs</td>
<td>from 2.8% to 1.5%</td>
<td>ND</td>
</tr>
</tbody>
</table>

**Appreciation of the antibiotic intervention**

Of the elements provided in the multifaceted intervention, the educational meeting and the yearly feedback were regarded as most useful (Table 5); this feedback was used for the definition

---

ND, not determined.

Dispensed antibiotics in the exact year preceding the intervention are presented as practice-based mean values with ranges. Overprescribing, underprescribing and non-first-choice prescribing were derived from a 4 week registration of RTIs and are presented as practice-based mean values with ranges.

---

*The pre- and post-intervention mean values for overprescribing, underprescribing and non-first-choice prescribing are shown; data are based on a total of 5235 registrations by GPs of 43 practices.
Practitioners at the University of Utrecht on March 21, 2016 http://jac.oxfordjournals.org/ Downloaded from

**Discussion**

**Principal findings**

Our intervention embedded in the practice accreditation of the Dutch College of General Practitioners (NPA) reduced overall antibiotic use and specifically decreased overprescribing for RTIs. Prescribing of non-first-choice antibiotics for RTIs (amoxicillin/clavulanate and macrolides) also significantly decreased. At least part of the intervention effect seemed sustainable, as differences between intervention groups were still present two full years after the intervention. The innovative features of our study are (i) providing specific feedback on overprescribing and underprescribing, using guideline benchmarking; (ii) using a new structural element for embedment, the NPA, with the aim of facilitating national implementation and enhancing sustainability. Notably, variation in antibiotic prescribing quality and quantity was considerable between practices, and our intervention was most effective in high-prescribing practices.

**Strengths and weaknesses of the study**

To evaluate our intervention, we used the optimal study design, a randomized trial, including pre- and post-intervention measurements of both the intervention and the control group. Second, we benchmarked inappropriate (non-)prescribing using the GP's own consultations and patient population, and provided this as personalized feedback. Third, the education was built around existing guidelines of the Dutch College of General Practitioners and comprised the whole entity of RTIs, including AOM, covering all age categories. Such an intervention is expected to have a broader effect on antibiotic use in the community than interventions focusing on a specific infection or age group. Fourth, the largest reduction in antibiotic use was obtained by practices with relatively high baseline prescribing. It therefore appears that GPs in these practices were open, motivated, and capable of changing their prescribing behaviour. The largest effects on community use can thus be obtained if interventions and programmes specifically target the high-prescribing physicians. This is also promising when envisaged in a broader context. The Netherlands is among the lowest antibiotic-prescribing countries in Europe. As our study showed that the highest-prescribing GPs responded best to this intervention, education and feedback adapted to other national guidelines—embedded in a quality structure when available—is probably also effective in high-prescribing countries.

Some possible limitations should be mentioned. The primary outcome was the number of dispensed antibiotics/year. It could be that physicians prescribed more, but that patients did not collect their medication, or that patients did collect their medication, but did not (completely) use it. We, however, expect these effects to be similar in both arms, thereby not influencing the intervention effect. Second, the collection of dispensing data from the pharmacies did not allow for the analysis of prescribing outcomes for individual prescribers within a practice, and therefore we used the practice as the unit of analysis. Third, benchmarking of RTI consultations was only done in the ‘antibiotic arm’ and therefore specific overprescribing data from the control group are lacking.

**Comparison with existing literature**

Numerous intervention trials also combining known effective elements into multifaceted interventions have been extensively...

---

**Table 4. Intervention effect: second year**

<table>
<thead>
<tr>
<th></th>
<th>Antibiotic intervention (n = 44)</th>
<th>Control (n = 40)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage change for total antibiotics</td>
<td>−4.3% (−39% to 26%)</td>
<td>2% (−19% to 40%)</td>
<td>0.015</td>
</tr>
<tr>
<td>Percentage change for J01A + J01CA + J01CE antibiotics</td>
<td>−6.9% (−35% to 34%)</td>
<td>−1.1% (−29% to 36%)</td>
<td>0.07</td>
</tr>
<tr>
<td>Percentage change for J01CR + J01FA antibiotics</td>
<td>−7.8% (−44% to 36%)</td>
<td>6.7% (−29% to 72%)</td>
<td>0.005</td>
</tr>
</tbody>
</table>

Percentage changes in the numbers of dispensed antibiotics were based on the complete second year after the educational meeting. Practice-based mean values with ranges are shown.

---

**Table 5. GPs' opinions about the intervention and its implementation**

<table>
<thead>
<tr>
<th></th>
<th>Percentage</th>
<th>Yes (%)</th>
<th>No (%)</th>
<th>No opinion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which element of the intervention was most useful to you? (maximum of 2 answers)</td>
<td>educational meeting</td>
<td>52%</td>
<td>6%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>written educational material</td>
<td>20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>improvement plan</td>
<td>50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>yearly feedback</td>
<td>56%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How do you rate...? (scale 1−10)</td>
<td>educational meeting</td>
<td>7.7 (6–9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>written educational material</td>
<td>7.1 (5–9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>improvement plan</td>
<td>7.6 (6–9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>yearly feedback</td>
<td>7.4 (6–8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you envisage additional value of education with respect to guideline implementation within practice accreditation?</td>
<td>yes</td>
<td>84%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>no</td>
<td>6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>no opinion</td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How would you like to receive this education? (maximum of 2 answers)</td>
<td>practice level</td>
<td>56%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>larger group of GPs</td>
<td>78%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>written</td>
<td>25%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>internet</td>
<td>31%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Percentages and mean values with ranges are shown.

and evaluation of the practice-specific improvement plans. Most GPs envisaged that education around guideline implementation could be integrated in the practice accreditation; they would like to receive this kind of education personally with their practice colleagues or in a larger group.
reviewed. The overall conclusion was that active clinical education, audit/feedback, as well as training in communication skills, seemed to be the most efficient elements in reducing antibiotic use. We also used these elements and showed favourable effects on all outcomes.

In most trials, however, the intervention effect often gradually declined after active involvement of academic researchers ended, and national implementation programmes are rare. By embedment in practice accreditation, we aimed to make use of an established quality structure within primary care. This should help to maintain GPs’ focus on the subject and help them to reflect on their own prescribing behaviour as long as possible. Defining and yearly evaluation of the improvement plan targets was expected to aid in this process. It seems that prolonged and repeated attention by using the NPA quality assurance cycle explains the favourable and prolonged results of this intervention.

Most earlier studies assessed volumes of prescribed (subtypes of) antibiotics and/or prescribing percentages. This harbours the potential danger of resulting in underprescribing. It was indeed shown that decreases in antibiotic use were accompanied by an increased incidence of pneumonia and risk of hospitalization. Specific analyses of overprescribing and underprescribing are crucial in determining prescribing quality, and were to our knowledge not incorporated in earlier interventions. Favourable effects on overall prescribing, as well as on overprescribing and underprescribing, are of pivotal importance in optimizing patient treatment.

The literature also shows that the use of point-of-care tests, like Strep A or C-reactive protein (CRP), effectively decrease antibiotic use. At the time we conducted our study, neither Step A nor CRP tests were performed at the point of care in the Netherlands. Recently, CRP testing was introduced for specific groups of patients with lower RTIs.

**Implementation**

Education and feedback were provided during face-to-face meetings led by an academic, which is most likely not feasible or cost-effective for national implementation. Especially within practice accreditation, however, we see numerous feasible possibilities for full and lasting national implementation of this intervention. The Dutch College of General Practitioners has already developed a large number of personal e-learning modules, which can be supplemented with a module on appropriate prescribing for RTIs. In a recent international trial we showed that internet-based education, like Strep A or C-reactive protein (CRP), effectively decrease antibiotic use. With respect to feedback, NPA practices collect pharmacy data on a number of medication groups, including antibiotics, at least yearly. For specific analyses of prescribing quality, prospective registration of the necessary signs, symptoms and patient characteristics is needed. Scandinavian primary care has developed easily applicable built-in modules that automatically allow benchmarking of the prescribing decision.

The current global situation of antibiotic overuse shows that achieving sustainable changes in clinical antibiotic prescribing behaviour is a complex goal. Our multifaceted intervention, embedded in primary care practice accreditation, offers an effective strategy to sustainably improve antibiotic prescribing quality for RTIs. The education and specialized audit/feedback can be computerized, and integrating these IT facilities with improvement targets in a quality management structure needs to be further developed and facilitated. Such integrated packages could also be used to improve prescribing quality of other medication groups.

**Acknowledgements**

We thank the GPs for their participation in the ARTI4 project and the pharmacists and the SFK for sharing and facilitating retrieval of antibiotic dispensing data. Truus Meijers, Eveline van der Velden and Susan van Hemert are thanked for practical assistance during the project, and Cas Kruitwagen and Paco Welsing for statistical advice.

**Funding**

This work was supported by the Netherlands Organization for Health Research and Development (ZonMw, grant number: 94517303). ZonMw did not interfere in the design and conduct of the trial, and did not have input into data collection, analysis and interpretation, or preparation of the manuscript.

**Transparency declarations**

None to declare.

**Author contributions**

A. W. v. d. V. conducted and coordinated the trial, collected and analysed all trial data and wrote the manuscript. M. M. K. applied for the grant and designed and supervised the study. T. J. M. V. designed and supervised the study. All authors had access to the data and take responsibility for the accuracy of the data analysis and were involved in drafting the manuscript.

**Supplementary data**

A guideline summary and the CONSORT flow diagram are available as Supplementary data at JAC Online (http://jac.oxfordjournals.org/).

**References**