Feedback of Antibiotic Prescribing in Primary Care (FAPPC) trial: results of a real-world cluster randomized controlled trial in Scotland, UK

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Objectives: To evaluate the effect of general practice-level prescribing feedback on antibiotic prescribing in a real-world pragmatic cluster randomized controlled trial

Methods: Three hundred and forty general practices in four territorial Health Boards in NHS Scotland were randomized in Quarter 1, 2016 to receive four quarterly antibiotic-prescribing feedback reports or not, from Quarter 2, 2016 to Quarter 1, 2017. Reports included different clinical topics, benchmarking against national and health board rates, and behavioural messaging with improvement actions. The primary outcome was total antibiotic prescribing rate. There were 16 secondary prescribing outcomes and 5 hospital admission outcomes (potential adverse effects of reduced prescribing). The main evaluation timepoint was 1 year after the final report (Quarter 1, 2018), with an additional evaluation in the quarter after the final report (Quarter 2, 2017). Routine administrative NHS data were used to generate the feedback reports and analyse the effects.

Results: Total antibiotic prescribing rates were lower at the main evaluation timepoint in both intervention (1.83 versus baseline 1.93 prescriptions/1000 patients/day) and control (1.90 versus baseline 1.98) practices, with no evidence of intervention effect [adjusted rate ratio (ARR) 0.98 (95% CI 0.94–1.02; P=0.35)]. At the additional timepoint, adjusted total antibiotic prescribing rates were 1.67 and 1.73 prescriptions/1000 patients/day, with evidence of a small intervention effect, ARR 0.99 (0.98–1.00; P=0.03).

Conclusions: This well-designed, practice-level antibiotic-prescribing feedback had limited evidence of additional effects in the context of decreasing antibiotic prescribing and an established national stewardship programme.

Introduction

Antibiotic use in humans is a key driver of emerging antibiotic resistance. Antimicrobial stewardship interventions and programmes have been widely implemented to reduce inappropriate use of antibiotics. The Scottish Antimicrobial Prescribing Group (SAPG), established in 2008, provides a national framework for antimicrobial stewardship.1 SAPG-coordinated stewardship initiatives, delivered locally by NHS health board antimicrobial management teams and prescribing support teams, have been associated with considerable reductions in primary care antibiotic prescribing but increasing targets for reductions in antibiotic prescribing within the UK continue to challenge.2

Feedback of practice is a common component of healthcare improvement interventions and feedback of prescribing rates can be facilitated by the availability of routine electronic data capture in many contexts.3 In UK primary care feedback identifying high-risk prescribing, such as combinations of chronic medications associated with increased risk of gastrointestinal bleeding or acute kidney injury, has been very effective in...
randomized controlled trials. Antibiotics are almost always prescribed acutely for short courses with associated risks more distant from the acute prescription. Feedback of antibiotic prescribing has had more mixed effects internationally, with limited effectiveness in reducing total antibiotic prescribing. However, a large-scale general practice trial (1581 practices randomized) in England targeted the 20% of practices with the highest prescribing rates in each local area and achieved an 3.3% reduction in intervention practices, an estimated 73 406 fewer antibiotic items dispensed. Low-cost interventions that can be delivered at scale can thus have a large overall impact despite a relatively small absolute effect.

A systematic review of audit and feedback as a healthcare improvement strategy reported variable effects but feedback may be more effective when it includes both explicit targets and an action plan. Primary care prescribing feedback trials have included intervention arms with and without behaviour change components, including action planning, and reported increased effectiveness when this was included. There are limited antibiotic prescribing trials using this approach in the literature, but it was effective in a primary care dental study in Scotland. SAPG provided reports on antibiotic prescribing including a range of quality indicators at national and Health Board level for the 14 regional NHS Health Boards in Scotland since soon after its inception in 2008 and these have been generated using the Prescribing Information System (PIS) since 2009. Prescribing support teams within Health Boards could also utilize the PIS to generate general practice-level reports to support engagement with prescribers on antibiotic use. This combination of national and bespoke local reporting approaches is not conducive to evaluating the effect on prescribing practice. The Feedback on Antibiotic Prescribing in Primary Care (FAPPC) trial reported here involved SAPG providing feedback directly to practices, with action planning, for the first time. A randomized design was applied to facilitate evaluation and inform decisions on continuation and national roll-out.

The aim of the FAPPC trial was to evaluate the effect in Scottish primary care of actionable, practice-level antibiotic prescribing feedback on rates of primary care antibiotic prescribing. A secondary aim was to examine changes in hospital admissions with infection, a potential unintended consequence of change in prescribing practice.

Methods

Study design

The design was a two-arm cluster randomized controlled trial with general practice as the unit of randomization and analysis. The trial was highly pragmatic, and embedded in existing information and stewardship systems, to rigorously evaluate the effect of an NHS-led intervention.

Participants

All primary care general medical practices ("practices") located in 4 of the 14 territorial NHS Health Boards in Scotland were eligible, except practices: with <250 registered patients (typically very unusual practices e.g. serving homeless or very remote populations); with missing list size, age, gender or deprivation categories, and/or missing prescribing data required for stratification, and/or which ceased to exist or merged with another practice (in different arm) during the trial. Data analysed included all patients registered with each practice. All eligible practices were randomized in Quarter 1, 2016 to receive the intervention or not, with no requirement for active recruitment or consent.

Intervention

The intervention consisted of four feedback reports containing each practice’s quarterly antibiotic prescribing rates, with comparison to Health Board and national benchmarks, at 25th percentiles. Practice and benchmarking rates were presented as quarterly time series for the 4 years prior to the report issue date. The reports incorporated behaviour change techniques associated with increased effectiveness of feedback, and hospital-based antibiotic prescribing interventions. These included providing repeated feedback from a credible source (authoritative NHS organization) and clear guidance on expected behaviour with target-setting (local and national benchmarks). Reports also included educational information and links to resources produced by SAPG and the Royal College of General Practitioners (see Supplementary data, available at JAC Online).

Reports were delivered by e-mail from an NHS National Services Scotland (NSS) e-mail address to all intervention practices, with a cover letter signed by the Scottish Government’s Chief Medical Officer and the Chair of the Scottish Antimicrobial Prescribing Group (see Supplementary data). Control practices did not receive intervention feedback reports but links to the educational resources are freely available via the Scottish Antimicrobial Prescribing Group website, and practices in both arms received continuing national and local antimicrobial stewardship interventions, which may have included locally produced prescribing feedback. Such feedback could not have included the national benchmarking data, and we are not aware of any that used the clinical themes and behavioural messaging that were key components of FAPPC feedback reports. No practices were aware this was a randomized trial and only practices open for the duration of the trial were included in analysis. The only potential source of contamination was individual GPs moving between intervention and control practices during the trial, but it is unlikely that this would significantly impact on overall results (no data were available on GP movement).

The data used to generate the reports are held within the NHS NSS Prescribing Information System (PIS), which is used for reimbursement of pharmacies for all dispensed NHS primary care prescriptions. Antibiotic ‘prescriptions’ in feedback reports and trial outcome analyses were defined as dispensed prescribed items for any systemic drugs in the British National Formulary chapter 5.1 (Antibacterials), excluding 5.1.9 (drugs for tuberculosis) and 5.1.10 (drugs for leprosy).

The first report was distributed in calendar Quarter 2 of 2016 (Figure 1). Every report contained rates of total antibiotic prescribing (prescriptions per 1000 registered patients per day), with each report then including a different subset of antibiotic prescribing. The subject for each report was agreed by SAPG and targeted areas of high antibiotic use in primary care and/or specific national stewardship priorities at that time: Report 1—children and older people; Report 2—treatment and prophylaxis of urinary tract infections; Report 3—broad-spectrum antibiotics associated with increased risk of Clostridioides difficile infection; and Report 4—treatment for skin and soft tissue infections (Table 1).

Outcome measures

The primary outcome was the quarterly rate of antibiotic prescriptions per 1000 registered patients per day, using the practice list size in that quarter as the denominator. There were 21 secondary outcome measures. The main evaluation timepoint, defined at trial registration, was 1 year after the final feedback report (Quarter 1, 2018). An additional evaluation timepoint in the calendar quarter immediately following the final feedback report (Quarter 2, 2017), specified after registration but before data extraction, aimed to determine whether there might be transient effects that were not sustained.
Secondary antibiotic outcome measures included rates of prescriptions in three age groups, and prescriptions of 10 individual and 3 groups of antibiotic drugs (grouped by most common clinical indication), all per 1000 registered patients per day, and all specified at trial registration (Box S1 and Table 3).

Hospital admissions were assessed to detect whether any change in antibiotic prescribing in primary care was associated with change in secondary care presentations with complicated bacterial infections. Outcome measures included rates per 10 000 registered patients per quarter with hospital admissions with four types of bacterial infection [respiratory tract infection (RTI), skin/soft tissue infection (SSTI), urinary tract infection (UTI), sepsis], and a composite measure including all four types (Box S1 and Table 3). The RTI admission outcome was specified at trial registration. The other three infection types and the composite measure were specified after registration but prior to data extraction. Data on all NHS hospital admissions in Scotland are held in the Scottish Morbidity Record 01 (SMR01)20 dataset, hosted by NHS NSS. Data on patients registered with trial practices with admissions with International Classification of Diseases, Tenth Revision (ICD-10)21 codes indicating relevant bacterial infections were extracted (Table S1).

Sample size calculation

The sample size calculation used Scottish national data from 2014 and was based on the primary outcome. It assumed a mean practice list size of 5600 patients and a mean baseline antibiotic prescribing rate of 2.05 per 1000 patients per day. There was very large between-practice variation (from 0.19 to 8.35 prescriptions/1000 residents/day), which complicated accurate sample size calculation. An estimated 183 practices per arm were required to detect a 7.5% difference between arms at the 5% significance level, with 80% power. Four territorial Health Boards, including a total of 391 practices, were selected.

Randomization and blinding

Intervention allocation was performed by the Bespoke Services Division, within the Information Services Division of NHS NSS. The randomization used stratified random sampling within each Health Board, with strata based on the mean age, deprivation quintile (Scottish Index of Multiple Deprivation)22 and rurality index (Scottish Government Urban/Rural classification)23 of registered patients in each practice, and on quintiles of practice list size and total dispensing volume (prescriptions/1000 patients/quarter). Strata that contained only one practice were grouped together, within each Health Board, before randomization. Computer-generated simple random sampling (using CSPLAN function in IBM SPSS Statistics) was applied within each stratum.

The NSS teams allocating practices to intervention or control arms and preparing the reports could not be blinded to practices’ allocation. Practices in both arms were unaware that prescribing feedback was being delivered as a randomized trial. The analysis of trial outcomes was at the University of Dundee and was completely independent to NSS. The statistician was blinded to practice allocation until the analysis was complete.

Statistical analysis

Analyses for all outcomes examined intervention effects 1 year after the final feedback report (Quarter 1, 2018), and at an additional timepoint in the quarter immediately after the final report (Quarter 2, 2017). Analyses were ITT and included all practices that existed until the end of the study. Analyses were at cluster (practice) level, the same as the unit of randomization.

Prescribing outcomes were analysed using negative binomial regression models, an extension of Poisson regression that accommodates over-dispersion. Models included the log of the number of patients per practice as an offset and Health Board as a random variable and were adjusted for practice strata used in randomization (mean patient age, rurality and deprivation indices, and practice list size), and for the baseline prescribing rate (rate in Quarter 1, 2016) for that outcome where possible. Hospital admission outcomes were analysed used Poisson regression with negative binomial extension if required. Due to the small numbers of admissions per practice, data were aggregated at Health Board level, and rates were adjusted for the baseline rate of each outcome only.
Analyses used R (sample size calculation), IBM SPSS Statistics (randomization) and STATA 15 (outcome analysis). A template for intervention description and replication (TIDieR) checklist and CONSORT checklist for reporting a cluster randomized trial have been completed (Tables S2 and S3).

Ethics and registration
This study was reviewed by the East of Scotland Research Ethics Service and NHS Tayside Research Governance, who deemed it service evaluation that did not need ethics committee review.

Trial registration: ISRCTN70810031; https://doi.org/10.1186/ISRCTN70810031.

Results

Randomization and baseline characteristics
Of a total 391 practices in the four Health Boards at the time of randomization, 340 practices were eligible. One hundred and eighty-one practices were randomized to receive the intervention and 159 to normal practice (imbalance resulting from the large number of small strata, with randomization done separately in each stratum). Nine (5.6%) intervention and five (3.1%) control practices were lost to follow-up post-randomization, due to practice closures, with six or more prescriptions for trimethoprim, nitrofurantoin, ciprofloxacin or cefalexin in the previous 12 months.

Primary outcome
Prior to the study start, total antibiotic prescribing rates were decreasing in both study arms and this downward trend continued during the study period (Figure S1). There was no evidence of intervention effect on total antibiotic prescribing at the main analysis timepoint (Quarter 1, 2018), with adjusted rate ratio (ARR) for intervention versus control of 0.98 (0.94–1.02; P=0.35) (Table 3). At the
additional analysis timepoint (Quarter 2, 2017) there was evidence of a small intervention effect on total antibiotic prescribing. Adjusted post-intervention rates were 1.67 and 1.73 prescriptions/1000 patients/day in intervention and control practices, respectively, with ARR 0.99 (0.98–1.00; P = 0.03) (Table S4).

**Secondary prescribing outcomes**

There was no evidence of intervention effect on most secondary antibiotic prescribing outcomes, at either evaluation timepoint, with small changes in both directions that would not be clinically meaningful given the relatively small numbers of prescriptions affected (Table 3 and Table S4). There were changes in the intended direction at the additional analysis timepoint for prescribing of any antibiotics for patients aged 65 years and over [ARR 0.97 (0.94–1.00)], who have relatively high rates of prescriptions, and amoxicillin in all age groups [ARR 0.95 (0.91–1.00)], which is the most commonly prescribed antibiotic in primary care in the UK (Table S4).

**Hospital admissions**

There was no evidence of intervention effects on hospital admissions with complicated respiratory tract infections, skin infections, urinary tract infections, sepsis, or the composite of these four groups, at either evaluation timepoint (Table 3 and Table S4).

**Discussion**

**Summary of main findings**

In this pragmatic real-world randomized controlled trial of practice-level antibiotic prescribing feedback compared with...
usual practice, in the context of sustained antimicrobial stewardship activity and falling antibiotic prescribing, there was no evidence of effect on the primary outcome (overall antibiotic prescribing) at the main analysis timepoint (1 year after the last feedback report). At the additional evaluation timepoint (the quarter following the last feedback report) there was evidence of an effect on the primary outcome, and potentially clinically useful effects on two secondary prescribing outcomes (decreases in all antibiotic prescribing for patients aged ≥65 years and amoxicillin prescribing). However, these effects were not sustained at 1 year post intervention and were observed in the context of multiple secondary outcomes analysed. There was no evidence of effect on infection-related hospital admissions.

**Strengths and weaknesses**

The main strength is the pragmatic randomized trial design involving a large number of general practices, conducted as part of NHS improvement work within a pre-existing nationally coordinated antimicrobial stewardship programme, the type of intervention that could be deployed at scale in routine care. Prescribers in trial practices were unaware that they were in a trial and the statistician analysing the trial outcomes was blinded to

| Table 2. Baseline characteristics of practices included in analysis |
|---------------------------------------------------------------|
| **Practice characteristics**                    | **Intervention 172 practices** | **Control 154 practices** |
| List size Mean (SD) | 6244 (3554) | 6284 (3428) |
| Dispensing | Yes 17 (9.9) | 16 (10.4) |
| | No 155 (90.1) | 138 (89.6) |
| Health Board | A 28 (16.3) | 25 (16.2) |
| | B 43 (25.0) | 41 (26.6) |
| | C 41 (23.8) | 38 (24.7) |
| | D 60 (34.9) | 50 (32.5) |
| Practice contract type | General Medical Services (17J) 145 (84.3) | 133 (86.4) |
| | Other (17C or 2C) 26 (15.7) | 21 (13.6) |
| Urban/rural | Urban areas 105 (61.0) | 90 (58.4) |
| | Accessible small towns and rural areas 28 (16.3) | 24 (15.6) |
| | Remote small towns and rural areas 13 (7.6) | 16 (10.4) |
| | Very remote small towns and rural areas 26 (15.1) | 24 (15.6) |
| Gender of registered patients | Male 543653 (50.6) | 490466 (50.7) |
| | Female 530285 (49.4) | 477232 (49.3) |
| Age group of registered patients (years) | 0–4 53971 (5.0) | 50565 (5.2) |
| | 5–14 109826 (10.2) | 103760 (10.7) |
| | 15–24 127571 (11.9) | 109055 (11.3) |
| | 25–44 300355 (28.0) | 252515 (26.1) |
| | 45–64 296389 (27.6) | 273770 (28.3) |
| | 65–74 104666 (9.7) | 100425 (10.4) |
| | 75–84 60089 (5.6) | 57572 (5.9) |
| | ≥85 21071 (2.0) | 20036 (2.1) |
| Deprivation (quintiles of SIMD score) | Q1 (most deprived) 201891 (18.8) | 177057 (18.3) |
| | Q2 237050 (22.1) | 236439 (24.5) |
| | Q3 231229 (21.6) | 188651 (19.5) |
| | Q4 191120 (17.8) | 175350 (18.1) |
| | Q5 (most affluent) 208984 (19.5) | 188077 (19.4) |
| | Missing 2563 (0.2) | 2356 (0.2) |
| Baseline antibiotic prescribing rate | Items per 1000 patients per day in Quarter 1, 2016 1.93 | 1.98 |

Values are numbers (percentages) unless stated otherwise. Q, quintile.
practice allocation until analysis was complete. The intervention incorporated the majority of 'best practices' recommended by the authors of the Cochrane feedback review (Table 4). The feedback was valid, recent, about the team's own behaviour, and repeated over time. The reports came from a trusted source and included comparative data. The behaviour is amenable to feedback, the recipients can generate improvement, and the 25th percentile benchmark provided a performance target. Goal setting, with multiple elements of best practice, is more complicated with some elements not feasible for every practice and/or individuals in a large-scale intervention, but FAPPC incorporated those elements that were feasible (Table 4). Finally, clear action plans were included. Thus, the intervention incorporated at least 10 of 13 best practices recommended as active ingredients of feedback interventions. One potential explanation for the null result (for the primary outcome at the main timepoint) is that this feedback added little to existing stewardship interventions that had been applied over the previous 14 years, with steady and substantial reductions in antibiotic prescribing. Total primary care antibiotic use in Scotland had already reduced by 11%, from 2.2 to 2.0 prescriptions per 1000 population per day, between 2012 and 2016, when this trial started. However, there was evidence of effect immediately after the last feedback that was not sustained once the feedback stopped (Table S4, Table 3 and Figure S1). There is virtually no published evidence on whether impacts are sustained, despite considerable literature on feedback interventions, and such analyses should take changes over time into account. Although the early intervention effect we observed for the primary outcome was small [ARR 0.99 (0.98 to 1.00)] it would equate to a clinically meaningful reduction in the annual number of antibiotic prescriptions nationwide and contribute to progress towards targets for reduction. There were no data collected on engagement with existing stewardship interventions, and there will be practice-level variation in prioritization and available resource. However, it is unlikely that this was systematically

Table 3. Adjusted rates and rate ratios for prescribing outcomes (per 1000 registered patients per day) and hospital admission outcomes (per 10 000 patients per quarter, aggregated at Health Board level) at the main analysis timepoint—1 year after the last feedback

|                          | Intervention | Control | Intervention effect ARR (95% CI) |
|--------------------------|--------------|---------|---------------------------------|
| **Primary outcome**      |              |         |                                 |
| All antibiotic prescriptions | 1.83         | 1.90    | 0.98 (0.94–1.02)                 |
| **Secondary prescribing outcomes** |         |         |                                 |
| Antibiotics for patients aged 0–4 years<sup>a</sup> | 0.78         | 0.74    | 1.05 (0.58–1.19)                 |
| Antibiotics for patients aged 5–64 years<sup>a</sup> | 0.53         | 0.52    | 1.01 (0.97–1.05)                 |
| Antibiotics for patients aged ≥65 years<sup>a</sup> | 1.29         | 1.31    | 0.98 (0.95–1.01)                 |
| Amoxicillin              | 0.52         | 0.56    | 0.96 (0.92–1.02)                 |
| Phenoxy methyl penicillin| 0.12         | 0.12    | 1.05 (0.98–1.12)                 |
| Fluocloxacin             | 0.18         | 0.19    | 0.93 (0.89–0.99)                 |
| Co-amoxiclav             | 0.06         | 0.06    | 1.03 (0.95–1.14)                 |
| Doxycycline              | 0.19         | 0.20    | 0.98 (0.92–1.05)                 |
| Clarithromycin           | 0.12         | 0.13    | 0.93 (0.84–1.02)                 |
| Trimethoprim             | 0.20         | 0.19    | 1.01 (0.95 to 1.06)              |
| Nitrofurantoin           | 0.12         | 0.12    | 0.97 (0.92–1.03)                 |
| Ciprofloxacin            | 0.05         | 0.05    | 1.03 (0.94–1.12)                 |
| Cefalexin                | 0.05         | 0.05    | 0.99 (0.89–1.10)                 |
| Antibiotics commonly used for RTIs<sup>b</sup> | 0.82         | 0.87    | 0.98 (0.93–1.03)                 |
| Antibiotics commonly used for UTIs<sup>c</sup> | 0.47         | 0.48    | 1.00 (0.95–1.04)                 |
| Antibiotics commonly used for long-term skin infections<sup>d</sup> | 0.09         | 0.09    | 1.00 (0.93–1.06)                 |
| **Hospital admission outcomes** |         |         |                                 |
| Mastoiditis, peritonsillar abscess, pneumonia or COPD | 7.4          | 7.6     | 0.97 (0.91–1.02)                 |
| Cellulitis or erysipelas  | 2.3          | 2.3     | 0.99 (0.88–1.12)                 |
| UTI                      | 2.9          | 2.8     | 1.05 (0.85 to 1.32)              |
| Sepsis                   | 4.0          | 4.2     | 0.97 (0.87 to 1.08)              |
| Composite of all above infections | 14.0        | 14.4    | 0.98 (0.93–1.02)                 |

Prescribing analyses used negative binomial regression and admission analyses used Poisson regression, except UTI, which used negative binomial.<sup>a</sup> Adjusted only for baseline rate of antibiotic prescriptions in that age group. All other prescribing analyses were adjusted for practices' strata for age, deprivation, urban/rural classification and list size, and practices' baseline prescribing rate for that outcome. Admission outcomes were adjusted only for the baseline rate of those admissions.<sup>b</sup> Includes amoxicillin, doxycycline, phenoxy methyl penicillin.<sup>c</sup> Includes trimethoprim, nitrofurantoin, ciprofloxacin, cefalexin, co-amoxiclav.<sup>d</sup> Includes oxytetracycline, lymecycline, minocycline.
and that the number of in
15,24
26 and there
-
-
An Irish intervention achieved a 2%
Those
-
contrary to findings and recom
17
-
14
13,32
40% reductions in targeted prescribing.4
We anticipated that a mature stewardship environment might
enhance receptiveness to feedback compared with other
settings but, conversely, it may have meant that additional
improvements are more challenging.
Internationally, large-scale primary care trials of prescribing
feedback aiming to reduce total antibiotic use have typically
had limited effects,7–9,11,12 although one intervention found
that added ‘behavioural impact optimization’ had marginal
benefit.8 An Irish intervention achieved a 2%–3% reduction in to-
tal prescribing,10 a similar effect size to the larger English study
targeting the highest prescribing practices,14 but it only included
a small number of volunteer practices. Prescribing feedback trials
aiming to improve the choice of antibiotic for specific clinical indica-
tions in primary care, typically UTI13,27,28 RTI29–31 or both,32,33
report larger effect sizes of up to 20%.27 However, such trials that also measured total antibiotic use found no effect
or an unintended increase.13,32 Appropriate prescribing for specific
clinical indications was the topic of some FAPPC feedback re-
ports but the outcomes measured total prescriptions in each
category. We did not evaluate dose or duration of prescriptions
so there may have been undetected improvements in appropri-
ate prescribing.
Primary care feedback trials of high-risk prescribing other than
antibiotics have typically reported much larger effect sizes, in
the region of 30%–40% reductions in targeted prescribing.4–6 Those
interventions targeted long-term prescriptions that confer risks
in combination and/or in specific patients and the desired action
is that prescribers review and revise chronic prescriptions. This is
quite different to antibiotic feedback, where the desired action is
to reduce future acute prescribing, which is plausibly more chal-
loving to have affected the result.
Comparison with other work
The most directly comparable published randomized trial,14
which had a statistically significant effect of similar magnitude
to the non-significant difference in our study (3% reduction),
was conducted in England in 2014. At that time, the steward-
ship programme was less well established without the back-
ground of falling primary care prescribing. In addition, that
intervention targeted the highest prescribing 20% of practices14
and poor baseline performance is a predictor of larger feedback
effect size.15 In a trial of antibiotic prescribing feedback in gen-
eral dental practice in Scotland, there was a 5.7% reduction in in-
tervention practices. Behaviour change messages increased
the effect but health board comparator data and an additional
round of feedback did not, contrary to findings and recom-
endations from the Cochrane group.15,24 Antibiotic steward-
ship in dentistry is relatively recent in Scotland,25 and there
was not a comparable background of falling prescribing rates.

| Recommended best practices [24] | FAPPC incorporation |
|---------------------------------|---------------------|
| Data are valid                   | Yes                 |
| Data are based on recent perform-
ance                           | Yes                 |
| Data are about the individual/team’s own behaviour(s) | Yes |
| Audit cycles are repeated, with new data presented over time | Yes |
| Presentation is multimodal includ-
ing either text and talking or text and graphical materials | No—reports contained graphs of individual practice data and generic explanatory text so not multimodal performance feedback. |
| Delivery comes from a trusted source | Yes—cover letter signed by the Chair of SAPG and the Scottish Chief Medical Officer. |
| Feedback includes comparison data with relevant others | Yes—local Health Board and Scottish national. |
| Targeted behaviour is likely to be amenable to feedback | Yes |
| Recipients are capable and responsible for improvement | Yes—25th percentile rate was presented as a benchmark, an implicit target to meet or better. |
| The target performance is provided | Yes—partly reducing antibiotic prescribing is a national organizational priority but may not be a priority for individual practices or prescribers. |
| Goals set for the target behaviour are aligned with personal and organizational priorities | Partly—the target is specific and measurable, should be achievable (since has been met by 25% of practices), is relevant to those setting the targets, but with no time specified in the report. |
| Goals for target behaviour are specific, measurable, achievable, relevant, time-bound | Yes |
| A clear action plan is provided when discrepancies are evident | Yes |

different between intervention and control practices. Another po-
tential explanation is that the sample size calculation used an op-
timistic effect size, albeit one within the range of observed effects
of feedback15 and a published trial,14 and that the number of in-
eligible practices was somewhat higher than expected. However,
the observed CIs around the primary outcome effect estimate
[ARR 0.98 (0.94–1.02)] are not consistent with a type 2 error miss-
ing a large intervention effect. Another methodological weak-
ness was that the intervention and control arms were
unbalanced in number, but the baseline characteristics of prac-
tices and their registered patients were balanced so this is unlike-
ly to have affected the result.

Table 4. Best practices when designing audit and feedback interventions recommended by Ivers et al. [24] and the extent to which the FAPPC intervention incorporated these.
Implications for policy and practice
A more targeted approach may have better return on investment, for example targeting the highest prescribers. Post hoc analysis of subgroups of practices in FAPPC, stratified by baseline total prescribing rate, did not indicate a clear difference but the behavioural messaging in our reports was not designed to target high prescribers, in contrast to that in other work.\textsuperscript{15} This approach would need more evidence in the Scottish context to support investment and roll-out. The null result for the primary trial outcome raises questions around the resource supporting untested interventions in NHS practice improvement but multifaceted interventions are more effective in healthcare improvement than single interventions. The SAPG improvement programme embodies a long-term, real-world, multifaceted intervention and demonstrating effectiveness of one individual component may remain challenging. Initially after this trial follow-up period ended, SAPG produced and disseminated similar quarterly reports nationally, but this has subsequently reduced to annually.

Unanswered questions for future research
In this real-world, resource-constrained trial it was not possible to conduct a parallel process evaluation to capture practice response to the feedback or record baseline engagement with SAPG’s improvement programme. Process evaluation to understand and explain effect size and variation should be included in future evaluations, if at all possible. Electronic prescribing data in Scotland are becoming more accessible and available within a shorter time frame. The feasibility and acceptability, and then effectiveness, of more frequent feedback incorporating near real-time data merits investigation. The set-up of such feedback would likely be more resource intense, which needs to be considered in evaluation of effect. Finally, this work was carried out before the COVID-19 pandemic, which has had a major impact on patient access to primary healthcare and to prescribing behaviour. Prescribing feedback trials in this context require specific design considerations.

Conclusions
This well-designed, real-world, practice-level antibiotic prescribing feedback had minimal additional effects in the context of decreasing antibiotic prescribing and an established national stewardship programme. Designing and implementing effective feedback interventions remains a priority to support challenging targets for reductions in antibiotic prescribing.

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