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Pragmatic randomised trial assessing the impact of peer comparison and therapeutic recommendations, including repetition, on antibiotic prescribing patterns of family physicians across British Columbia for uncomplicated lower urinary tract infections

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ABSTRACT

Objective To evaluate the impact of a personalised audit and feedback prescribing report (AF) and brief educational summary (ES) on empiric treatment of uncomplicated lower urinary tract infections (UTIs) by family physicians (FPs).

Design Cluster randomised control trial.

Setting The intervention was conducted in British Columbia, Canada between 23 September 2021 and 28 March 2022.

Participants We randomised 5073 FPs into a standard AF and ES intervention arm (n=1691), an ES-only arm (n=1691) and a control arm (n=1691).

Interventions The AF contained personalised and peer-comparison data on first-line antibiotic prescriptions for women with uncomplicated lower UTI and key therapeutic recommendations. The ES contained detailed, evidence-based UTI management recommendations, incorporated regional antibiotic resistance data and recommended nitrofurantoin as a first-line treatment.

Main outcome measures Nitrofurantoin as first-line pharmacological treatment for uncomplicated lower UTI, analysed using an intention-to-treat approach.

Results We identified 21 307 cases of uncomplicated lower UTI among the three trial arms during the study period. The impact of receiving both the AF and ES increased the relative probability of prescribing nitrofurantoin as first-line treatment for uncomplicated lower UTI by 28% (OR 1.28; 95% CI 1.07 to 1.52), relative to the delay arm. This translates to additional prescribing of nitrofurantoin as first-line treatment, instead of alternates, in an additional 8.7 cases of uncomplicated UTI per 100 FPs during the 6-month study period.

Conclusion AF prescribing data with educational materials can improve primary care prescribing of antibiotics for uncomplicated lower UTI.

Trial registration number NCT05817253.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Urinary tract infections (UTIs) are common bacterial infections in outpatients and inappropriate antibiotic prescribing has contributed to the rise of antimicrobial resistance. Audit and feedback (AF) can alter prescribing habits for this condition in small groups of family physicians (FPs).

WHAT THIS STUDY ADDS

⇒ Sending FPs personalised prescribing AF with peer comparison and educational materials with local antibiotic resistance data was effective at improving first-line treatment of UTIs on a provincial scale. Repeated messaging appeared to sustain the impact of the intervention.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study provides a roadmap for successfully implementing an AF intervention into large-scale antibiotic stewardship programmes to optimise antibiotic use and combat antimicrobial resistance.

INTRODUCTION

Urinary tract infections (UTIs) are one of the most common bacterial infections in outpatients and result in substantial morbidity and healthcare costs.[1] Uropathogenic *Escherichia coli* is the primary causal agent of UTIs.[2] Inappropriate antibiotic prescribing practices, such as the overuse of broad-spectrum agents, have contributed to the rise of antimicrobial resistance making effective treatment more challenging.[3] The increasing resistance of uropathogens to commonly prescribed antibiotics necessitates a shift towards alternatives with a narrower spectrum and lower regional resistance rates, such as nitrofurantoin.[4] Since empiric antibiotic recommendations are guided by local resistance rates, audit and feedback (AF) interventions have gained attention as a strategy to address regional knowledge gaps and support clinician behavioural change.[5–8]

In a systematic review of physician-targeted interventions for the management of UTIs, small trials of written and in-person AF, sometimes paired with education, show promise[9]; however, the largest trial which involved in-person workshops had an almost 50% opt-out rate did not improve antibiotic selection statistically and faced barriers in spread.[10] None of these trials included individualised feedback with local or regional comparisons. Peer comparison AF interventions have shown promise in improving healthcare provider performance and enhancing guideline adherence.[11–14] In the context of encouraging family physicians (FPs) to prescribe nitrofurantoin as first-line treatment for uncomplicated lower UTIs, a mail-based programme of personalised prescribing AF comparing an individual physician's practice with their peers coupled with educational summaries (ESs), may offer a valuable strategy to improve appropriate antibiotic use. Because receiving AF multiple times is more effective than one instance and there remains uncertainty as to which measures could improve the durability of the effect of AF, we sought to test one form of repeated intervention.[15] We present an evaluation of a cluster-randomised trial that explores the impact of permutations of mailing AF including peer-comparison and an ES promoting the appropriate use of nitrofurantoin as first-line treatment for UTIs.

METHODS

Trial design

We conducted a 3-arm cluster-randomised trial in the primary care setting of the Canadian province of British Columbia (BC).[16] The trial protocol has been registered with ClinicalTrials.gov. The unit of randomisation was individual FPs. The trial arms were: (1) 'Standard Intervention', receiving their AF plus ES at time 0 (23 September 2021), (2) 'Control', receiving their AF and ES 6 months later (28 March 2022) and (3) 'Repeated Intervention', receiving the AF only at time 0 and then their AF and ES repeated 6 months later (figure 1). In addition to the AF and ES, a letter introducing the trial was mailed to each eligible physician providing them with contact information to provide feedback or to withdraw from the trial.

Interventions

AF: The first page of the confidential personalised prescribing tool shows 2019–2020 first-line prescribing patterns for oral antibiotics used to treat uncomplicated lower UTI and the current recommendations for BC.[17] The primary recommendation is to choose nitrofurantoin for empiric treatment of uncomplicated UTI. A second message recommends choosing fosfomycin as first-line therapy for patients who cannot tolerate nitrofurantoin due to allergy or have impaired renal function. A final recommendation advises against prescribing ciprofloxacin, trimethoprim-sulfamethoxazole (TMP-SMX) and other antibiotics as first-line empiric therapy due to

	Standard Intervention n=1691	**Control Group** n=1691	**Repeated Intervention** n=1691
Time 0 *Sept 23, 2021*	Early *AF* + *Educational Summary*		Early *Educational Summary* Only
Time 0 + 6 Months *Mar 28, 2022*		Delayed *AF* + *Educational Summary*	Delayed *AF* + *Educational Summary*

Evaluation of Study Period: Sept 23, 2021 to March 28, 2022
Evaluation of Delay (repeated intervention) Period: March 29, 2022 to Sept 28, 2022

Figure 1 Trial arm interventions. The first intervention on 23 September 2021 sent the audit and feedback report and educational summary letter to the standard intervention group and sent the educational summary letter to the repeated intervention group. The second intervention on 28 March 2022 sent the AF report and educational summary letter to both the control group and the repeated intervention group. AF, audit and feedback.

bacterial resistance rates in BC and adverse effects associated with fluoroquinolones. Each message is accompanied by a bar chart depicting the physicians' individual prescribing compared with the average BC FP. The second page of the AF provides supporting evidence for why nitrofurantoin is recommended for empiric treatment of uncomplicated UTI including a graph of 10-year history of *E. coli* isolates resistance rates by an antibiotic agent from the BC Centre for Disease Control Antimicrobial Resistance Dashboard. It shows escalating resistance to cephalexin over 50%, relative stability of~40% resistance to amoxicillin, ~20% resistance to ciprofloxacin and TMP-SMX and low or declining<10% resistance to nitrofurantoin and fosfomycin.[18] This makes it visually obvious which antibiotic is least likely to be resisted.

The evidence summary describes antimicrobial best practices for the treatment of symptomatic, uncomplicated lower UTI in BC.[19] It recommends diagnosing uncomplicated UTI based on patient symptoms and against routine use of a urine dipstick/urinalysis or urine culture for diagnosing as testing abnormalities increase with age. Empiric treatment with nitrofurantoin (Macrobid 100 mg two times a day or Macrodantin 50 mg four times a day) for 5–7 days is recommended with fosfomycin recommended as an alternative when there is an allergy or intolerance to nitrofurantoin. TMP-SMX, fluoroquinolones and beta-lactams are unsuitable for empiric therapy (unguided by susceptibility profile) in BC due to bacterial resistance. See online supplemental files 1 and 2 for the sample AF and ES.

Data sources

The BC Ministry of Health maintains a comprehensive data warehouse containing linked medical records for BC residents including: Community pharmacy dispensed prescriptions; physician services; hospital discharges; and patient and prescriber demographic information. Health records for federally insured residents (Canadian Armed Forces, veterans, inmates in federal penitentiaries) and residents receiving benefits through the First Nations Health Benefit plan were excluded from our data access.

Participants

FPs were included if they (1) were registered by the BC Medical Services Plan with a specialty in family medicine, (2) had a valid BC mailing address, (3) were active prescribers with ≥100 prescriptions in 2020 and (4) prescribed an oral antibiotic to at least one eligible patient with UTI in 2019–2020. Eligible physicians (n=5073) were randomised into the three trial arms. Physicians who opted out of the programme were excluded from the intention-to-treat (ITT) analysis (n=20) for ethical considerations. Physicians with an invalid mailing address were excluded from the per-protocol (PP) analysis (n=215).

Patient data were included in the AF if they: (1) Were women, (2) had a physician visit with a diagnosis of UTI between 27 December 2018 and 31 December 2020, (3) were dispensed an oral antibiotic prescription within 5 days of the physician visit for UTI during the study period, (4) had provincial health insurance and (5) were at least 15 years old at the time of the oral antibiotic dispensing. Antibiotics were identified by Health Canada Drug Identification Numbers and are listed in online supplemental file 3.

Patient data were excluded if they met any of the following criteria on the date of their UTI physician visit (1) were pregnant in the prior 270 days, (2) had recurrent UTI, defined as a physician record of a UTI diagnosis in the prior 90 days or ≥4 UTI diagnoses in the prior 3 years, (3) discharged from the hospital in the previous 30 days, (4) were diagnosed with kidney infection (pyelonephritis) in the previous or following 10 days, (5) were diagnosed with chronic kidney disease in the previous 365 days, (6) had an indwelling catheter in the prior 3 months, (7) were diagnosed with impaired renal function in the previous 365 days, (8) had structural or functional abnormality of the urinary tract in the previous 365 days, (9) were diagnosed with a sexually transmissible and blood-borne infection in the previous or following 14 days, (10) were dispensed a systemic antibiotic in the prior 90 days or (11) received benefits through the provincial palliative care or long-term residential care benefit plans. Case definitions are available in online supplemental file 4.

Randomisation and masking

Eligible FPs were individually randomised to one of the three trial arms in a 1:1:1 ratio using a random number generator in R statistical software. Due to the nature of AF intervention, FPs were not masked to their group allocation but were not aware of the trial arm variations being evaluated or the analytical approach. The statistical analysis plan was developed by an evaluation committee who were masked to the trial arm allocation. The allocations were revealed only once the statistical analysis plan was finalised.

Statistical analysis

Our evaluation had four comparisons: (1) The standard intervention arm versus the control arm to estimate the combined impact of the AF and ES, (2) the repeated intervention arm versus the control arm to estimate the impact of the ES alone, (3) the standard intervention arm versus the repeated intervention arm to estimate the added impact of AF in physicians who also received the ES, (4) the repeated intervention arm versus the control arm during the delay period to estimate the impact of repeated messaging. For each estimation, we implemented an ITT analysis. The baseline-adjusted impact measures from the ITT approach were then used to estimate the magnitude of prescribing change per 100 FPs. A sensitivity analysis

implemented a PP analysis that additionally removed physicians with an invalid mailing address.

The primary outcome was the change in first-line prescribing of nitrofurantoin for the treatment of uncomplicated UTI in women between the three intervention cohorts during the study period. Secondary outcomes included first-line prescribing of fosfomycin, ciprofloxacin, TMP-SMX and other antibiotics. Because our sample size, the number of FPs randomised to each intervention arm is fixed via the population of FPs in the province, we calculated the minimum impact that can be detected with 80% power. From power calculations in our publicly available protocol, we estimated being able to detect a 7% relative difference (adjusted odds ratio (aOR)=1.07) in first-line nitrofurantoin prescribing with 80% power between the standard intervention group and control group during the study period.

The outcome measures were based on preference—for example, the proportion of first-line dispensations that were for nitrofurantoin—and the corresponding preference odds.[20] We looked at both the overall group preference as well as each individual physician's preference. The primary outcome metrics were trends: Changes in preference between the 6-month periods before and after the early mailing where changes were quantified by after-to-before preference ratios, preference ORs and preference differences. The primary impact measures were contrasts between magnitudes of trends in two randomised comparison groups: Ratios of ratios or differences in preference differences. We further adjusted the ratio of preference ORs (RPOR) using logistic regression with an indicator variable for the randomised comparison group. We used generalised estimating equations (GEE) to calculate the 95% CIs, adjusting for clustering of patients by FP (resulting in violation of the independence assumption) by applying an independent correlation structure.[21]

To assess potential modification by the interventions influencing the frequency of UTI diagnoses, we also measured secondary outcomes: Changes in the number of UTI diagnoses in physician billings and changes in the frequency of first-time dispensations of nitrofurantoin per 100 FPs regardless of the numbers of UTI diagnoses.

RESULTS

Physician demographics

We identified 6813 active FPs in BC in 2021. We excluded from randomisation 639 who wrote fewer than 100 prescriptions during 2020, 771 who had 0 prescriptions for any oral antibiotic medications and 330 who did not meet our mailing criteria (deceased, retired or blank or out-of-province mailing address). 5073 physicians were randomised to 1 of 3 trial arms (figure 2). A comparison of physician characteristics with absolute standardised differences between the trial arms is shown in table 1. Physician age, sex, time since medical school graduation, prescribing volumes and frequency of UTI diagnosis were all well-balanced.

Primary outcomes

Table 2 shows the ITT preferences in each group before and after the early mailing, the trends in each group (preference ratios and differences) and the contrasts between trends. Online supplemental file 5 shows the corresponding ratios of preferences ORs and their 95% CIs from GEE logistic models and comparison by correlation structure types.

Combined impact of AF and ES

In the ITT analysis, the standard intervention arm had 7246 cases of uncomplicated UTI and the control arm had 7191 cases of uncomplicated UTI. The AF and ES led to a 4.8% increase in preference for nitrofurantoin with a corresponding decrease in preference for any of the other antibiotics. In terms of the preference odds, the GEE showed the odds of prescribing nitrofurantoin rather than another antibiotic increased by 28% (95% CI: 7% to 52%). The increase in nitrofurantoin preference was accompanied by decreases in preferences for the other antibiotics although the cluster-adjusted CIs included the null value. The primary result was consistent in the PP analysis and similar magnitudes of decreased preferences in the secondary outcomes (online supplemental file 6).

Impact of ES alone

The impact of the ES alone, comparing the repeated intervention arm versus the control arm, found a 3.3% increase in the preference—and the GEE model showed the corresponding preference odds increased by 17% (95% CI: −1% to 38%). Decreased preference odds were observed for all secondary antibiotic measures. The increased precision of the PP analysis resulted in a statistically significant increase in first-line nitrofurantoin prescribing (OR=1.19, 95% CI: 1.003 to 1.40).

Impact of the AF among physicians who received the ES

In those who received the AF in addition to the ES compared with those who got the ES only, the preference for nitrofurantoin increased by 1.5% which was not statistically significant. We observed little change in fosfomycin prescribing and non-significant decreases in the preference odds for the secondary outcome measures. Results were consistent in the PP analysis.

Impact of repeated messaging

We estimated the impact of repeated messaging by comparing the ES-only group with the control group in the 6-month period after the delayed mailing when both received the ES with AF (28 March 2022). The

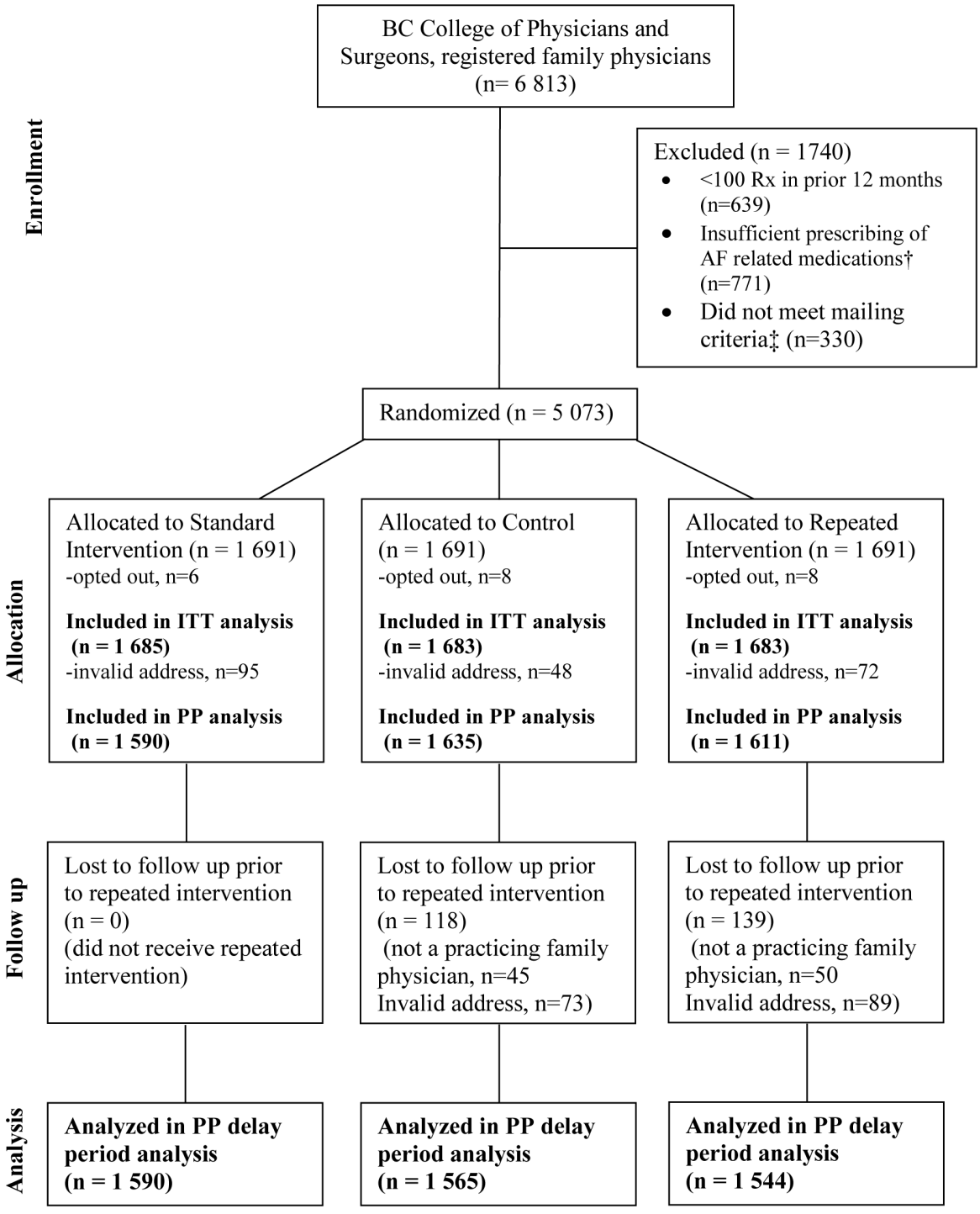

Figure 2 Physician flow diagram. Study flow chart of registered family physicians. †Physicians were required to have prescribed an oral antibiotic as first-line treatment to at least one eligible patient with urinary tract infection in 2019–2020. ‡Physicians did not meet our mailing criteria if they had opted out of the audit and feedback programme (or not yet been offered the opportunity). AF, audit and feedback; BC, British Columbia; ITT, intention-to-treat; PP, per-protocol. Rx, prescription.

ES-only group had the advantage of receiving the ES twice (alone in September and with AF in March) which appeared to carry over into the period after 28 March, RPOR=1.03 (95% CI: 0.85 to 1.25); comparing the enhanced intervention arm to the control arm, to estimate the impact of the repeated intervention, we found no evidence of a prescribing change in nitrofurantoin, ciprofloxacin or TMP-SMX (online supplemental file 5).

Magnitude of treatment change

Using the primary evaluation of the combined impact of the AF and ES during the 6-month study period, the standard intervention arm physicians prescribed

Table 1 Physician baseline characteristics

	All prescribers			
	Standard intervention	Control	Repeated intervention	SMD
n=	1691	1691	1691	
Sex=Male (%)	936 (55.4)	928 (54.9)	903 (53.4)	0.026
Degree year (median (IQR))	1998 (1989–2010)	2000 (1988–2010)	1999 (1988–2010)	0.016
Degree year (%)				
<1991	510 (30.2)	515 (30.5)	512 (30.3)	
1991–2000	396 (23.4)	358 (21.2)	366 (21.6)	
2001–2010	388 (22.9)	410 (24.2)	393 (23.2)	
>2010	397 (23.5)	408 (24.1)	420 (24.8)	
Medical school=International (%)	671 (39.7)	620 (36.7)	612 (36.2)	0.048
Specialty=FP—emergency medicine (%)	118 (7.0)	131 (7.7)	137 (8.1)	0.028
Rural (%)	164 (9.7)	176 (10.4)	156 (9.2)	0.027
2020 Rx count (median (IQR))	7019 (2575–14 656)	6907 (2333–13 901)	6953 (2268–13 754)	0.006
2020 Pt count (median (IQR))	1352 (909–1979)	1341 (879–2008)	1351 (880–1985)	0.021
Total UTI visits with Abx (2019–2020) (median (IQR))	4221 (2262–6716)	4044 (2159–6420)	4032 (2082–6428)	0.03
UTI visits with nitrofurantoin (2019–2020) (median (IQR))	21 (10–39)	21 (10–39)	22 (9–40)	0.014
≥6 UTI visits with Abx (2019–2020) (IQR)	12 (4–26)	11 (4–25)	12 (4–27)	0.009

Abx, antibiotic prescription; FP, family physician; Pt, patient; Rx, prescription; SMD, standardised mean difference; UTI, urinary tract infection.

nitrofurantoin to an additional 8.7 cases of uncomplicated UTI per 100 FPs relative to the control arm (table 3). Likewise, these physicians were responsible for a decrease in ciprofloxacin (−2.0 cases), TMP-SMX (−2.1 cases) and other antibiotics (−1.7 cases) per 100 FPs relative to the control arm. In the ES-only group, the total number of antibiotic-treated UTI cases decreased; the dispensations of nitrofurantoin increased by 3.6 patients per 100 FPs while the dispensation of other antibiotics decreased by 7.9 patients per 100 FPs compared with the control group.

DISCUSSION

This study is, to our knowledge, the largest AF trial focused on the treatment of uncomplicated UTI; it also incorporates the opportunity to assess the sustained impact of repeated messages. Our findings indicate that providing FPs with personal prescribing data with peer comparison accompanied with evidence-based therapeutic recommendations resulted in a notable increase in evidence-based prescribing of antibiotics for uncomplicated lower UTI. This study adds to the growing body of antimicrobial stewardship literature by demonstrating that targeted AF interventions can moderately improve appropriate antibiotic prescribing for uncomplicated lower UTI.

The favourable effects observed in our study are comparable with results from previous trials of AF for antibiotic prescribing for UTI in primary care. A systematic review investigated the effect of interventions targeted at general practitioners to improve antibiotic prescriptions for UTI.[9] The review found seven out of nine trials that recorded first-line prescribing saw an increased proportion of first-line antibiotics in the intervention groups compared with the delay group. In six studies that measured broad-spectrum antibiotic prescribing, five out of six studies found a decrease in first-line prescribing of broad-spectrum antibiotics. All of the studies identified in the systematic review were relatively small containing between 6 and 150 physicians or clinics. The intervention effects (ORs) on total antibiotic prescriptions for UTI ranged from 0.92 to 1.85 compared with our primary analysis OR of 1.28. Repeated messaging of interventions has also been shown to have incremental cumulative effects which is consistent with the sustained impact we observed in the repeat period.[22]

Our group's previous cluster randomised controlled trial of an AF tool found that simple messages, prescriber feedback, provincial averages and regional resistance patterns were impactful on the selection of first-line antibiotics for uncomplicated UTIs.[15] A recent pragmatic randomised trial in Switzerland provided an intervention group with quarterly antibiotic prescribing data, evidence-based guidelines for UTI management and community-based antibiotic resistance information.[23] The primary endpoint was the overall rate of antibiotic prescribing. Evaluation of the trial found the AF intervention did not reduce inappropriate antibiotic prescribing among primary care physicians including no statistically significant differences in all prespecified age-related subgroup analysis.

Table 2 First-line antibiotic prescribing to treat uncomplicated lower urinary tract infection from ITT analysis

	Standard intervention (AF+ES) (n=1685)		Repeated intervention (ES only) (n=1683)		Control (Neither) (n=1683)	
First dispensations	**Before (n, %)**	**After (n, %)**	**Before (n, %)**	**After (n, %)**	**Before (n, %)**	**After (n, %)**
Nitrofurantoin	2618 (71.7)	2358 (75.6)	2428 (68.4)	2081 (70.8)	2498 (70.4)	2091 (69.5)
Fosfomycin	317 (8.7)	234 (7.5)	392 (11.0)	276 (9.4)	348 (9.8)	298 (9.9)
Ciprofloxacin	346 (9.5)	246 (7.9)	347 (9.8)	260 (8.8)	338 (9.5)	274 (9.1)
TMP-SMX	186 (5.1)	138 (4.4)	204 (5.7)	172 (5.9)	211 (5.9)	206 (6.8)
Other antibiotics	184 (5.0)	143 (4.6)	181 (5.1)	151 (5.1)	154 (4.3)	141 (4.7)
Any antibiotic (total)	3651 (100)	3119 (100)	3552 (100)	2940 (100)	3549 (100)	3010 (100)
Secondary outcomes						
Nitrofurantoin/100 FPs	155.4	139.9	144.1	123.5	148.2	124.1
Other antibiotic/100 FPs	61.3	45.2	66.7	51.0	62.4	54.5
Trend: After versus before change in preference	**Ratio**	**Difference**	**Ratio**	**Difference**	**Ratio**	**Difference**
Nitrofurantoin	1.05	3.9%	1.04	2.4%	0.99	−0.9%
Fosfomycin	0.86	−1.2%	0.85	−1.6%	1.01	0.1%
Ciprofloxacin	0.83	−1.6%	0.91	−0.9%	0.96	−0.4%
TMP-SMX	0.87	−0.7%	1.02	0.1%	1.15	0.9%
Other antibiotics	0.91	−0.5%	1.01	0.0%	1.08	0.3%
Secondary outcomes	**Ratio**	**Difference**	**Ratio**	**Difference**	**Ratio**	**Difference**
Nitrofurantoin/100 FPs	0.90	−15.4	0.86	−20.6	0.84	−24.2
Other antibiotic/100 FPs	0.74	−16.1	0.76	−15.7	0.87	−7.8
Antibiotic-treated UTI	0.85	−532	0.83	−612	0.85	−539
Impact	**AF+ES versus neither**		**ES only versus neither**		**AF+ES versus ES only**	
Contrast in trends	**Ratio of ratios**	**Difference in differences**	**Ratio of ratios**	**Difference in differences**	**Ratio of ratios**	**Difference in differences**
Nitrofurantoin	1.07	4.8%	1.05	3.3%	1.02	1.5%
Fosfomycin	0.86	−1.3%	0.84	−1.7%	1.02	0.5%
Ciprofloxacin	0.87	−1.2%	0.95	−0.5%	0.92	−0.7%
TMP-SMX	0.75	−1.6%	0.88	−0.8%	0.85	−0.8%
Other antibiotics	0.84	−0.8%	0.93	−0.3%	0.90	−0.5%
Secondary outcomes						
Nitrofurantoin/100 FPs	1.08	8.7	1.02	3.6	1.05	5.2
Other antibiotic/100 FPs	0.84	−8.3	0.87	−7.9	0.96	−0.4
Antibiotic-treated UTI	1.01	7	0.98	−73	0.96	80

AF, audit and feedback; ES, educational summary; FP, family physician; ITT, intention-to-treat; TMP-SMX, trimethoprim-sulfamethoxazole; UTI, urinary tract infection.

Table 3 Relative prescribing change per episode of uncomplicated UTI, ITT analysis

	AF+ES arm (n=1685)			Control arm (n=1683)			
Outcome measure	Baseline	Study period	Trend in treated UTI cases/100 FPs	Baseline	Study period	Trend in treated UTI cases/100 FPs	Impact: Difference in n of patients per 100 FPs
Nitrofurantoin	2618	2358	−15.4	2498	2091	−24.2	**8.7**
Fosfomycin	317	234	−4.9	348	298	−3.0	**−2.0**
Ciprofloxacin	346	246	−5.9	338	274	−3.8	**−2.1**
TMP-SMX	186	138	−2.8	211	206	−0.3	**−2.6**
Other antibiotic	184	143	−2.4	154	141	−0.8	**−1.7**

AF, audit and feedback; ES, educational summary; FP, family physician; ITT, intention-to-treat; TMP-SMX, trimethoprim-sulfamethoxazole; UTI, urinary tract infection.

Other smaller trials that have provided prescribing feedback in combination with academic detailing, practice accreditation or in combination with decision support systems have successfully achieved small relative reductions in antibiotic prescribing.[24–29]

The reasons for such variable success between AF interventions are not known. Intervention components such as providing personalised data, peer comparison, availability of accreditation and credibility of experts providing advice all appear to be positively correlated. The continued implementation of antimicrobial stewardship AF trials is greatly needed; we recommend routine randomisation and impact evaluation. As more AF trials are published on the same topic with detailed descriptions of their interventions, additional data points will be available for analysing the importance of individual intervention components in achieving quality improvement.

Strengths

First, we used comprehensive medication dispensing data to send personalised prescribing charts with peer comparisons accompanied by actionable evidence-based prescribing recommendations to a randomised group of over 5000 active FPs. The components of our intervention have been proven to be highly effective[30 31] resulting in a high level of physician engagement. Second, we collaborated with and used the logo of the BC Centre for Disease Control, a widely recognised and reputable organisation along with their renowned antimicrobial stewardship programme 'Do Bugs Need Drugs?'. We mutually developed the key messages and actionable empiric antibiotic therapy recommendations supported by clear, concise, local evidence on antibiotic resistance. Lastly, although not necessarily a strength of the intervention itself, the chosen topic likely played a role in its impact. At the time of the intervention, the prescribing rate of nitrofurantoin was significantly lower than the provincial target; this created an opportunity for substantial improvement in prescribing practices. Overall, these factors combined to create a highly effective intervention that successfully influenced physician prescribing behaviour. Ultimately, empowering physicians to select an antibiotic that is less likely to be resisted will result in improved patient outcomes and will likely reduce the need for repeat encounters with primary care physicians.

Limitations

The use of administrative health claims data is subject to data quality issues. This evaluation relies on the accuracy of diagnosis coding in the physician database, particularly the use of the International Classification of Diseases (ICD)-9 code 595 for UTI. Our study did not seek to reduce antibiotic initiations; while it may have the unintended effect of shifting antimicrobial selection for cases of asymptomatic bacteriuria, it would not have improved overtreatment of these cases which may have been included as a result of erroneous ICD-9 coding. Patient visits for UTI that were coded as another diagnosis would not have been included in the evaluation. While AF and ES were mailed to FP addresses, there is no way of knowing if they were opened and read; in the post-trial analysis of one Ontario-based study, only a third of physicians remembered viewing the intervention.[14] Therefore, estimates from the primary analysis are likely to be conservative (biased towards the null) due to many physicians not being exposed to the materials. Shifting to a digital delivery method in the future would allow tracking of how many FPs opened the AF or ES and of how long they spent viewing it.

Our standard protocol for impact evaluation of all our mailed AF and ES defined the baseline as 0-to-6 months immediately before the early mailing. However, studies show that the incidence of UTI has seasonal variation. The option of taking 6-to-12 months before as the baseline was theoretically sensible but would have been during the first winter of COVID-19.

Generalisability to other jurisdictions might be limited by the pronounced shortage of FPs in BC[32] which has increased time pressures on practising FPs and possibly reduced their receptiveness to mailed materials. BC has had lower overall rates of antibiotic dispensing than other provinces.[33] This, combined with ongoing antimicrobial stewardship efforts, may have diluted the impact of our intervention.

CONCLUSION

Our programme of sending FPs personalised prescribing AF reports with peer comparison and ESs with local antibiotic resistance data was effective at improving appropriate first-line treatment of uncomplicated acute cystitis on a large scale. Additional AF pragmatic trials are needed to enable future research into which individual components resonate best with FPs.

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