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RESEARCH

Performance associated effect variations of public reporting in promoting antibiotic prescribing practice: a cluster randomized-controlled trial in primary healthcare settings

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Aim: To evaluate the variations in effect of public reporting in antibiotic prescribing practice among physicians with different performance in primary healthcare settings. **Background:** Overprovision of antibiotics is a major public health concern. Public reporting has been adopted to encourage good antibiotic prescribing practices. However, which group, for instance, high, average or low antibiotic prescribers, accounted for antibiotic prescription reduction has not been fully understood. **Methods:** A cluster randomized-controlled trial was conducted. In total, 20 primary healthcare institutions in Qianjiang city were paired through a six indicators-synthesized score. Coin flipping was used to assign control–intervention status; 10 were then subjected to intervention where prescription indicators were publicly reported monthly over a one-year period. Prescriptions for upper respiratory tract infections (URTIs) before and after the intervention were collected. Physicians were divided into high, average and low antibiotic prescribers based on their antibiotic prescribing rates last month, which were publicly reported in intervention arm. Multilevel difference-in-differences logit regressions were performed to estimate intervention effect in each physician group on three outcome indicators: prescriptions containing antibiotics, two or more antibiotics and antibiotic injections. **Findings:** In total, 31 460 URTI prescriptions were collected (16 170 in intervention arm and 15 290 in control arm). Reduction in antibiotic prescription attributed to intervention was 2.82% [95% confidence intervals (CI): –4.09, –1.54%, $P<0.001$], least significant in low prescribers (–1.41%, 95% CI: –3.81, 0.99%, $P=0.249$) and most significant in average prescribers (–5.01%, 95% CI: –6.94, –3.07%, $P<0.001$). Reduction in combined antibiotics prescriptions attributed to intervention was 3.81% (95% CI: –5.23, –2.39%, $P<0.001$), least significant in low prescribers (–2.42%, 95% CI: –4.39, –0.45%, $P=0.016$) and most significant in average prescribers (–5.01%, 95% CI: –7.47, –2.56%, $P<0.001$). **Conclusion:** Public reporting can positively influence antibiotic prescribing patterns of physicians for URTIs in primary care settings, with reduction in antibiotic and combined antibiotic prescriptions. The reduction was mainly attributed to average and high antibiotic prescribers.

Key words: antibiotic prescribing; China; difference in differences; primary care; public reporting; upper respiratory tract infections

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Background

Antibiotics abuse has been identified as one of the main problems involved in irrational drug use (Shankar, 2009). An investigation shows that antibiotic use has remained sub-optimal in all regions of the world over the last 20 years and the situation does not appear to be improving (Lu *et al.*, 2011). Antibiotic prescriptions for upper respiratory tract infections (URTIs) make up a great portion of overall antibiotic prescriptions (Schroeck *et al.*, 2015). Although the routine use of antibiotics for URTIs has been proven unnecessary and wasteful (Kenealy and Arroll, 2013), antibiotics are still commonly overused for URTIs worldwide (Hurley, 2014). Well-documented evidence indicates that over prescribing of antibiotics for URTIs in primary care settings does contribute to antimicrobial resistance (AMR) (Costelloe *et al.*, 2010), an alarming public health threat, which has cost the United States US$4000–5000 million and Europe €9000 million annually (Smolinski *et al.*, 2003; Strategic Council on Resistance in Europe, 2004).

The excessive mortality and dramatic economic burden caused by AMR (Birnbaum, 2003; EJW Group, 2009) has triggered a surge of research on interventions in antibiotic prescribing practices worldwide (World Health Organization, 2012), especially interventions targeted at physicians (van der Velden *et al.*, 2012). Audits and feedback on prescribing performance can result in a small to moderate change in the prescribing practices of physicians (ranging from a 16% decrease to 70% increase in compliance with prescription guidelines) (Jamtvedt *et al.*, 2006). Although recent studies reported a relatively stronger effect of 'audit and feedback' when it was combined with 'peer academic detailing' (Gerber *et al.*, 2013; Gjelstad *et al.*, 2013), the enhanced effect can often be offset by the resources required and practical considerations (Naughton *et al.*, 2009). A review by the Cochrane Collaboration (Jamtvedt *et al.*, 2006) concluded that intensive feedback may have a greater potential given that the tested 'feedback' interventions are usually confidential and contain only benchmarks on average.

In the recent decades, research interest in the role of public reporting on improving patient care is growing, especially in developed countries (Haustein *et al.*, 2011; Rechel *et al.*, 2016). Public reporting usually involves three broad types of information: healthcare outcomes, provider performance and patient experience (Shahian *et al.*, 2011; Burns *et al.*, 2016; Rechel *et al.*, 2016). The rationale is anchored in both the citizens' involvement in public affairs and the hypothesis that public reporting can be used to promote quality improvement (Nilsen *et al.*, 2006). Extensive studies have been undertaken to evaluate the effectiveness of public reporting on patient outcomes, and the findings indicated that public reporting did trigger greater improvement than private disclosure of the same data (Hibbard *et al.*, 2005).

The mechanism of public reporting to performance improvement is complicated. The expectations from the 'selection pathway' (Berwick *et al.*, 2003), in specific, users modifying their choice of providers or other decisions based on available performance measures, may fail in practice (Fung *et al.*, 2004) given that consumers may have limited choice in some health systems (Fung *et al.*, 2004; Faber *et al.*, 2009). How physicians react to these publicly reported information is then the key to understanding the mechanisms (Contandriopoulos *et al.*, 2014a). Healthcare providers may face pressure from managerial interventions and social expectations to change their practices (Contandriopoulos *et al.*, 2014b).

Antibiotic abuse has been a severe problem in China. Over 80% URTI visits receive antibiotics as a recent study demonstrated (Li *et al.*, 2016). Recent works by Yang *et al.* (2014) and Liu *et al.* (2015) have made initial attempts to applying public reporting as a prescription quality promoting strategy. The conclusions were promising: public reporting of prescription quality significantly caused the reduction in the antibiotic prescribing of physicians to URTI patients. However, which group, for instance, high, average or low antibiotic prescribers, accounted for the reduction in antibiotic prescription has not been fully understood. The major purpose of this study was to fill this information gap by examining the changes in antibiotic prescribing practices among different publicly reported physician performance groups in URTI visits, which would benefit us with a better understanding of the mechanisms behind the relationship. Therefore, we designed a cluster randomized trial of public reporting of antibiotic prescribing across a relatively large primary care network (20 primary healthcare institutions).

Although the unit of observation was the prescription, we randomized at the institution level to avoid intra-practice contamination of the intervention.

Methods

We conducted a clustered randomized-controlled trial.

Study setting

This study was undertaken in Qianjiang city of Hubei province. Hubei is located in central China with a population of over 61 million. The average annual per capita income ranks in the middle of all provinces: 6898 Yuan for rural and 18 374 Yuan for urban residents (in 2012). Qianjiang has a population of around 950 400 and 47.5% of the population reside in the rural area. In 2012, Qianjiang produced a GDP of 49.3 billion (Yuan). The average annual per capita income reached 8785 Yuan for rural and 17 451 Yuan for urban residents.

Randomization

Qianjiang has 20 primary care institutions, on average 10 km away from the nearest counterpart. All of these primary care institutions participated in this study. We used matched-pair cluster randomization to assign the participating institutions into the intervention and control groups.

(1) A technique for order preference by similarity to ideal solution (TOPSIS) score was calculated for each institution based on six indicators: local population size, number of beds, number of physicians, annual outpatient visits, annual episodes of admissions and annual revenue from drug sales.
(2) The participating institutions were sorted in an ascending order according to the TOPSIS score and adjacent institutions were paired.
(3) For each pair, we flipped a coin to randomly assign one into the intervention group and another into the control group.

More details about the research setting, trial design and intervention strategies can be found in the study protocol published elsewhere (Du *et al.*, 2015). This study was approved by the Ethics Review Committee of Tongji Medical College, Huazhong University of Science and Technology (no. IORG0003571).

Interventions

The public reporting contained information regarding (1) percentage of prescriptions containing antibiotics; (2) percentage of prescriptions containing injections; and (3) average expenditure per prescription. The indicators were calculated by the research team using the computerized hospital information management systems of the participating institutions. They were ranked in ascending orders at the institution level and the prescriber level.

The ranking information was disseminated through a poster displayed in a conspicuous place at each institutions, and handout brochures together with a report submitted to the local health authority. The posters and brochures included a brief introduction of the purpose of the reporting. It was made clear that health risks are associated with excessive use of antibiotics and injections.

During the intervention period, four or five researchers disseminated the reporting information at the intervention sites on the ninth day of each month. To maximize compliance, the local health authority issued a policy to ensure the information dissemination activities. Meanwhile, the research team inspected the intervention sites irregularly. Damaged posters, if found, were replaced immediately.

Data collection

The data used in this study came from two sources. Prescription data were extracted from the electronic medical records, which included the name and work unit of the prescriber, time when the prescriptions were issued, demographic characteristics of recipients (age, sex and type of insurance), reason for prescription (only one diagnosis was recorded for each prescription) and details of medicines prescribed (drug name, administration route, dosage, frequency and costs). Data on the characteristics of prescribers were collected through a self-administered questionnaire including name, age, sex, level of education, professional title and income. The two data sets were linked by matching the name of each prescribers.

Physicians who provided services for URTI patients were included and analysed. The physicians who had lower than 10 URTI patient visits in each study months were excluded in our study for lack of sensitivity. In total, 60 physicians (27 in the intervention group and 33 in the control group) were then included and followed up from March 2014 to

September 2014 (post-intervention period). In addition, the URTI prescriptions of the physicians in the months of 2013 (pre-intervention period) were also included in our analysis.

Statistical analysis

The International Network for Rational Use of Drugs developed a list of prescription indicators which have become widely accepted internationally (World Health Organization, 1993). We selected three prescription-level indicators for the purpose of this study, which covered the type (antibiotics) and administration route (injections) of medicines that are most frequently abused:

(1) percentage of prescriptions containing antibiotics
(2) percentage of prescriptions containing two or more antibiotics
(3) percentage of prescriptions containing antibiotic injections.

According to the antibiotic prescription rate in the previous month, the physicians included in both the intervention and control arms were divided into three equal groups with references to similar studies (Xu *et al*., 2010; Tang *et al*., 2013), namely, high, average and low prescribers. For instance, for the physician grouping strategy of March 2014, we referenced all antibiotic use rates of the physicians in February 2014 (this rates were publicly reported of physicians in the intervention arm on the first few days of March 2014, but not public reported in the control arm). Descriptive analysis were carried out for selected antibiotic prescribing indicators in earlier and later periods of both arms separately for three groups of physicians.

We adopted a difference-in-differences (DID) approach to test the effects of the intervention. Logit regression models were applied to these binary dependent variables (prescriptions containing antibiotics, prescriptions containing two or more antibiotics and prescriptions containing parenteral antibiotics, 1 for yes and 0 otherwise). The analysis unit were individual prescriptions. We randomized the study sample at the institution level. Considering the hierarchical structure of the data (prescription–prescriber-facility level), we used mixed effect logistic regression using the 'xtmelogit' command in Stata, which accounted for random intercepts of individual prescribers and facilities. The models used can be expressed as follows:

$$\text{Logit}\left(P_{ijk}\right) = \left(\beta_0 + \mu_{0jk} + \mu_{0k}\right) + \Sigma_1\beta_1 X_{1ij} + \Sigma_2\beta_2 X_{2ij} + \beta_m M_{ij} + \beta_t T_{ij} + \beta_p P_{ij} + \beta_\text{e} E_{ij} \qquad (1)$$

where μ_{0k} is the random intercept of individual facility k and μ_{0jk} the random intercept of individual physician j nested in facility k; X_1 a set of prescription-level covariate including patient sex, age and insurance status; X_2 a set of physician level covariate including physician sex, age, education level, professional title and income level; T_{ij} indicates whether prescription i from physician j was or was not in the intervention arm (0 for control and 1 for intervention); and P_{ij} indicates whether prescription i from physician j was or was not from the post-intervention period (0 for pre and 1 for post). M_{ij} is a month pair dummy variable that indicates the seven time pair (the same month in two different years were matched as a pair). E_{ij} indicates interaction between the intervention–control status and pre–post-intervention periods and β_e the DID estimators (effect size). The effect margins for β_e were then calculated which can be explained as percentage change from baseline as recommended (Williams, 2011). Statistical analysis was performed using Stata 12.1 (Stata Corp; College Station, Texas, USA).

The characteristic difference between the two arms were tested by χ^2 test for categorical variables and independent t test for continuous variables.

Results

Overall, 60 physicians were included in this study (27 in the intervention arm and 33 in the control arm). The physicians in the intervention arm had an average age of 39.89, younger than those in the control arm (mean age = 46.39, $P = 0.007$). The professional titles were also significantly different between the groups ($\chi^2 = 11.101$, $P = 0.004$). No significant difference was observed in the rest of physician characteristics.

In total, 61 843 URTI prescriptions from these physicians were included form both the pre- and post-intervention periods, with 31 952 prescriptions in the intervention arm (14 931 in pre- and 17 021 in post-intervention periods) and 29 882 in the control arm (14 945 in pre- and 14 937 in post-intervention periods) were collected from the health information

Table 1 Characteristics of recipients (patients) and prescribers (physicians) of prescriptions

	Intervention arm		Control arm	
	Pre	Post	Pre	Post
Prescriber characteristic				
Sex (male)	23 (85.19)		25 (75.76)	
Age	39.89 ± 9.23		46.39 ± 8.61	
Education level				
High school	5 (18.52)		15 (45.45)	
College degree	16 (59.26)		15 (45.45)	
Bachelor degree	6 (22.22)		3 (9.09)	
Title				
Assistant	10 (37.04)		5 (15.15)	
Resident	9 (33.33)		4 (12.12)	
Attending	8 (29.63)		24 (72.73)	
Income level				
<1500	7 (25.93)		6 (18.18)	
1500–2000	10 (37.04)		12 (36.36)	
2001–2500	6 (22.22)		11 (33.33)	
2500–3000	2 (7.41)		2 (6.06)	
>3000	2 (7.41)		2 (6.06)	
Prescription characteristic				
Sex (male)	7528 (50.4)	8642 (50.8)	7529 (50.3)	7761 (52.0)
Age	23.79 ± 23.54	23.24 ± 23.59	24.88 ± 22.69	23.44 ± 23.26
Insurance type				
NCMS	12 320 (82.5)	14 616 (85.9)	12 222 (81.7)	12 452 (83.4)
URBMI	481 (3.2)	364 (2.1)	279 (1.9)	259 (1.7)
SF	2130 (14.3)	2041 (12.0)	2453 (16.4)	2226 (14.9)

NCMS = new cooperative medical scheme; URBMI = urban resident basic medical insurance; SF = self-funded.

system for analysis. The insurance status of the recipients was significantly different between the two groups in both the pre-intervention ($\chi^2 = 76.83$, $P < 0.001$) and post-intervention periods ($\chi^2 = 63.092$, $P < 0.001$). Age was only significantly different between the group in the pre-intervention period recipients ($t = 4.064$, $P < 0.001$). Sex was only significantly different between the groups in the post-intervention period recipients ($\chi^2 = 4.477$, $P = 0.043$). The detailed characteristics at both physician and prescription levels are shown in Table 1.

Antibiotic prescribing rate was high among the URTI patient visits at our investigated primary healthcare institutions. Overall, the percentage of prescriptions requiring antibiotics was 88.67%, percentage of prescriptions requiring two or more antibiotics was 17.65% and percentage of prescriptions requiring injection antibiotics was 75.24%. The prescription performances of all three physician groups before and after intervention are shown in Table 2.

In DID logit analysis, the intervention showed positive significant effects on reducing the overall antibiotics prescribing rate (2.82% reduction, $P < 0.001$) and combined antibiotic prescribing rate (3.81% reduction, $P < 0.001$) of the physicians. However, the intervention showed no effect on reducing the overall prescribing rate of injection antibiotics.

Among the three-level prescribers, the effect size of the reduction in antibiotic prescriptions in the low antibiotic prescriber group was smallest (–1.41%, $P = 0.25$) and combined antibiotic prescriptions (–2.42%, $P = 0.016$), whereas largest in average antibiotic prescribers (–5.01 and –5.01% for reducing antibiotic prescriptions and combined antibiotic prescriptions, respectively, $P < 0.001$) (Table 3).

Discussion

Principle findings

To the best of our knowledge, this study is the first quantitative investigation that examined physicians' prescribing performance after public reporting intervention with special concentration on the

Table 2 Prescribing indicators for groups in pre- and post-intervention periods

	Intervention arm		Control arm	
	Pre	Post	Pre	Post
Low group				
Total number of prescription	4463	5689	3345	4296
Prescriptions containing antibiotics (%)	85.44	84.88	80.42	77.40
Prescriptions containing two or more antibiotics (%)	16.22	12.66	16.80	13.43
Prescriptions containing antibiotic injections (%)	64.73	65.79	67.47	66.99
Middle group				
Total number of prescription	4699	5494	5533	5761
Prescriptions containing antibiotics (%)	90.44	85.82	90.08	89.46
Prescriptions containing two or more antibiotics (%)	19.28	15.07	17.08	15.57
Prescriptions containing antibiotic injections (%)	70.97	64.74	76.02	74.66
High group				
Total number of prescription	5769	5838	6076	4880
Prescriptions containing antibiotics (%)	93.60	87.44	96.61	97.13
Prescriptions containing two or more antibiotics (%)	21.09	17.71	18.73	18.42
Prescriptions containing antibiotic injections (%)	83.72	79.22	90.08	90.90

Table 3 Estimates of effect sizes derived from the difference-in-difference analyses

	Adjusted OR (95% CI)	*Z*	*P*	Effect margins (95% CI) (%)
Prescriptions requiring antibiotics				
Overall	0.70 (0.62, 0.78)	−6.29	<0.001	−2.82 (−4.09, −1.54%)
Low group	0.90 (0.76, 1.07)	−1.16	0.245	−1.41 (−3.81, 0.99%)
Average group	0.54 (0.44, 0.66)	−6.24	<0.001	−5.01 (−6.94, −3.07%)
High group	0.57 (0.43, 0.75)	−4.00	<0.001	−3.28 (−4.99, −1.56%)
Prescriptions requiring two or more antibiotics				
Overall	0.75 (0.68, 0.82)	−6.02	<0.001	−3.81 (−5.23, −2.39%)
Low group	0.78 (0.64, 0.94)	−2.57	0.010	−2.42 (−4.39, −0.45%)
Average group	0.69 (0.59, 0.81)	−4.62	<0.001	−5.01 (−7.47, −2.56%)
High group	0.75 (0.65, 0.87)	−3.73	<0.001	−4.32 (−6.65, −2.00%)
Prescriptions requiring injection antibiotics				
Overall	0.95 (0.87, 1.03)	−1.23	0.218	−0.39 (−1.75, 0.97%)
Low group	0.97 (0.85, 1.11)	−0.43	0.664	−0.67 (−3.70, 2.36%)
Average group	0.87 (0.76, 1.00)	−1.99	0.047	−2.29 (−4.58, 0.00%)
High group	0.85 (0.71, 1.02)	−1.80	0.072	−1.87 (−3.93, 0.19%)

OR = odds ratio; CI = confidence interval.
Parameter of interest is β_e, which under our assumptions, indicates the effect of intervention. The effect margins for β_e were calculated and reported using Stata software. *Z* and *P* values were derived from the result of regression analysis (Equation 1).

physicians' different publicly reported performance status. The findings from this study demonstrate that a decrease in the combined antibiotic prescription after public reporting was experienced by all physicians, regardless of whether the baseline before the public release rates was high, average or low. However, the decrease in the antibiotic prescription was only observed among physicians with average and low baseline groups, which is publicly reported. The study findings also reveal that physicians who had average outcomes in the initial period showed the most significant improvement and the providers who had the best outcomes in the initial period showed the least significant improvement. No significant decrease in the injection antibiotic prescription was observed in all physician groups.

The antibiotic prescription rate for URTI patients was high even in the low physician group (77.40–85.44%). A recent systematic review has made a clearer view on antibiotic use for URTI patients in China, which indicated an 83.7% antibiotic prescribing rate out of the 45 individual eligible studies (Li *et al*., 2016). Together with the present study, we can conclude that the antibiotic prescribing rate was very high in China, far from a recent study in Denmark that revealed a 59.3% antibiotic use for URTI patient visits in general practice (Sigurøardøttir *et al*., 2015).

The antibiotics favouring the prescribing pattern were established by the interaction of both the health provider and patients. From a patient perspective, antibiotics are considered able to shorten the duration of URTI. Nevertheless, little was known about the bacterial resistance (Yu *et al*., 2014). The providers, who generally know that antibiotics should not be prescribed when encountering common colds, would still prescribe antibiotics to URTI visitors anyway (Sun *et al*., 2015). Two main reasons are involved in such conflict in perception and behaviour as concluded by a qualitative study (Reynolds and McKee, 2009). Historically, the 15% drug sales mark-up policy encourages physicians to over prescribe, and antibiotics are definitely among them. The patient preferences worsened the situation as physicians attempt to satisfy the patients to retain them. Although the national essential medicines system was introduced to promote rational drug use, evidence to date reveals that such goal is hard to achieve.

The mechanism from pubic reporting to quality improvement of healthcare is complicated. The earliest and most-cited theory was put forward by Berwick et al. in (2003), the 'selection pathway' and 'change pathway'. Selection pathway relies on the information users modifying their behaviour towards the 'high performer' and eventually improving the overall performance, and 'change pathway' is based on the effect of providers' efforts to use performance measures to improve their performance. Subsequently, an empirical study by Hibbard *et al.* indicated that a reputation pathway exists, where the providers are concerned about their public image when performance is made public (Hibbard *et al*., 2005). Based on these theories, a recent study conducted an analytical review and built a typology of four complementary causal pathways, which subdivided the 'change pathway' into three more detailed pathways, namely, change through managerial interventions, change through social structuring and change through internal pressures (Contandriopoulos *et al*., 2014a). Although all these analyses target the organization as a unit, they still shed great light on how individual physicians may act on public reporting, especially the internal pressure pathway. In a qualitative study, the investigated primary practitioners expressed their concerns that public reporting, which encourages the 'name and shame' culture, would exert stress on them (Marshall *et al*., 2002). This pressure, both from the political concerns and reputation, triggers change in behaviour and prescription patterns in this study, especially in low performers (Hannan *et al*., 1994; Baker *et al*., 2003). This study shows that when physicians perceive that their antibiotic prescribing rates were not in the lowest range, they tend to lower their antibiotic prescribing practice in the following month. From the theoretic analysis above, we can assume that when physicians' public reporting performances are not in the best range, they bear greater pressure to change that situation, and when the physicians' public reporting performance were in the best range, they bore less pressure and their motivation to be better was not that strong. Few empirical studies analysed the pressure level of physicians when their publicly reported performances were poor or good, and such analysis would make a clearer view of the intrinsic mechanism from public reporting to performance improvement.

Comparison with other studies

The previous study by Yang *et al.* indicated that, after four months of publicly reporting the prescribing indicators of physicians, significant reductions in oral antibiotics prescription and combined prescription practice were observed, but not in the case of injection prescription practice. The result was further explained by this study that the reductions in antibiotic and combined antibiotic prescription practices were mainly observed in the physicians when their public reporting performances were not in the best range.

Very few studies have analysed the individual physician's performance change when the public reported poor or good performance, but several studies analysed the organization, as an observation unit, and performance change when the public reported poor or good performance. Both results indicated that the groups that showed the highest initial mortalities manifested the most improvement. The result of this study differs from the results above, indicating that the publicly reported average range was the most change-inspired group. This implies that the personality of physicians also influence these changes as pointed out by researchers (Hamblin, 2007), which would be interesting to explore further.

Limitations

Although this study explored the change in the prescribing patterns of physicians after public reporting, the influence of such changes on the AMR is beyond the scope of our study because of constrained condition, such relationship would be of great practical significance. The depth of clinical coding was not sufficient to allow us to determine the cause (eg, bacterial, virus or other) of URTIs, which would provide a better understanding of excessive antibiotic prescription in China. Ideally, the whole sample of prescriptions should be included in the data analysis with proper risk adjustments. Unfortunately, we were not able to do so because of the unavailability of relevant data. However, the selection of patients with URTI in this study, which is the most common cause of visits in primary health institutions, provided us with some unique insights into the effect of public reporting interventions on different physician groups.

Conclusions

Public reporting can affect the antibiotic prescribing patterns of physicians when dealing with URTI patient visits, including decreased antibiotic and combined antibiotic prescribing rates. When the physicians' publicly reported antibiotic prescribing rates are in the optimal range, the possibilities that they would change their prescribing patterns the following month are much less. By contrast, the possibilities that they will lower their antibiotic prescribing practices are obviously larger in the average or highest ranges. However, antibiotic use remained high even after intervention, especially the use of injections, which may in themselves be hazardous.

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Conflicts of Interest

None.

Ethical Standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional guidelines on human experimentation [Ethics Review Committee of Tongji Medical College, Huazhong University of Science and Technology (no. IORG0003571)] and with the Helsinki Declaration of 1975, as revised in 2008.

References

Baker, D.W., Einstadter, D., Thomas, C., Husak, S., Gordon, N.H. and **Cebul, R.D.** 2003: The effect of publicly reporting hospital performance on market share and risk-adjusted mortality at high-mortality hospitals. *Medical Care* 41, 729–40.

Berwick, D.M., James, B. and **Coye, M.J.** 2003: Connections between quality measurement and improvement. *Medical Care* 41, I-30–38.

Birnbaum, D., **Canadian Committee on Antibiotic Resistance**. 2003: Antimicrobial resistance: a deadly burden no country can afford to ignore. *Relevé des maladies transmissibles au Canada (Canada Communicable Disease Report)* 29, 157.

Burns, E.M., Pettengell, C., Athanasiou, T. and **Darzi, A.** 2016: Understanding the strengths and weaknesses of public reporting of surgeon-specific outcome data. *Health Affairs (Millwood)* 35, 415–21.

Contandriopoulos, D., Champagne, F. and **Denis, J.-L.** 2014a: The multiple causal pathways between performance measures' use and effects. *Medical Care Research and Review* 71, 3–20.

Contandriopoulos, D., Champagne, F. and **Denis, J.-L.** 2014b: The multiple causal pathways between performance measures' use and effects. *Medical Care Research and Review* 71, 3–20.

Costelloe, C., Metcalfe, C., Lovering, A., Mant, D. and **Hay, A.D.** 2010: Effect of antibiotic prescribing in primary care on antimicrobial resistance in individual patients: systematic review and meta-analysis. *British Medical Journal* 340, c2096.

Du, X., Wang, D., Wang, X., Yang, S. and **Zhang, X.** 2015: Exploring the transparency mechanism and evaluating the effect of public reporting on prescription: a protocol for a cluster randomized controlled trial. *BMC Public Health* 15, 277.

EJW Group. 2009: The bacterial challenge: time to react. Stockholm. EMEA/576176, 13–42.

Faber, M., Bosch, M., Wollersheim, H., Leatherman, S. and **Grol, R.** 2009: Public reporting in health care: how do consumers use quality-of-care information?: a systematic review. *Medical Care* 47, 1–8.

Fung, A., Graham, M., Weil, D. and **Fagotto, E.** 2004: The political economy of transparency: what makes disclosure policies effective? Available at SSRN 766287. Retrieved 1 June 2016 from https://ash.harvard.edu/files/political_econ_transparency.pdf.

Gerber, J.S., Prasad, P.A., Fiks, A.G., Localio, A.R., Grundmeier, R.W., Bell, L.M., Wasserman, R.C., Keren, R. and **Zaoutis T.E.** 2013: Effect of an outpatient antimicrobial stewardship intervention on broad-spectrum antibiotic prescribing by primary care pediatricians: a randomized trial. *Journal of the American Medical Association* 309, 2345–352.

Gjelstad, S., Høye, S., Straand, J., Brekke, M., Dalen, I. and **Lindæk, M.** 2013: Improving antibiotic prescribing in acute respiratory tract infections: cluster randomised trial from Norwegian general practice (prescription peer academic detailing (Rx-PAD) study). *British Medical Journal* 347, f4403.

Hamblin, R. 2007: Publishing 'quality' measures: how it works and when it does not? *International Journal for Quality in Health Care* 19, 183–86.

Hannan, E.L., Kumar, D., Racz, M., Siu, A.L. and **Chassin, M.R.** 1994: New York State's cardiac surgery reporting system: four years later. *The Annals of Thoracic Surgery* 58, 1852–857.

Haustein, T., Gastmeier, P., Holmes, A., Lucet, J.-C., Shannon, R.P., Pittet, D. and **Harbarth, S.** 2011: Use of benchmarking and public reporting for infection control in four high-income countries. *The Lancet. Infectious Diseases* 11, 471–81.

Hibbard, J.H., Stockard, J. and **Tusler, M.** 2005: Hospital performance reports: impact on quality, market share, and reputation. *Health Affairs* 24, 1150–160.

Hurley, R. 2014: Can doctors reduce harmful medical overuse worldwide? *British Medical Journal* 349, g4289.

Jamtvedt, G., Young, J.M., Kristoffersen, D.T., O'brien, M.A. and **Oxman, A.D.** 2006: Audit and feedback: effects on professional practice and health care outcomes. *Cochrane Database of Systematic Reviews* 85, Issue 2. Art. No.: CD000259. DOI: 10.1002/14651858.CD000259.pub2.

Kenealy, T. and **Arroll, B.** 2013: Antibiotics for the common cold and acute purulent rhinitis. *Cochrane Database of Systematic Review* 6, Cd000247.

Li, J., Song, X., Yang, T., Chen, Y., Gong, Y., Yin, X. and **Lu, Z.** 2016: A systematic review of antibiotic prescription associated with upper respiratory tract infections in China. *Medicine* 95, e3587.

Liu, C., Zhang, X. and **Wan, J.** 2015: Public reporting influences antibiotic and injection prescription in primary care: a segmented regression analysis. *Journal of Evaluation in Clinical Practice* 21, 597–603.

Lu, Y., Hernandez, P., Abegunde, D. and **Edejer, T.** 2011: The world medicines situation 2011. Medicine expenditures. Geneva: World Health Organization.

Marshall, M.N., Hiscock, J. and **Sibbald, B.** 2002: Attitudes to the public release of comparative information on the quality of general practice care: qualitative study. *British Medical Journal* 325, 1278.

Naughton, C., Feely, J. and **Bennett, K.** 2009: A RCT evaluating the effectiveness and cost-effectiveness of academic detailing versus postal prescribing feedback in changing GP antibiotic prescribing. *Journal of Evaluation in Clinical Practice* 15, 807–12.

Nilsen, E.S., Myrhaug, H.T., Johansen, M., Oliver, S. and **Oxman, A.D.** 2006: Methods of consumer involvement in developing healthcare policy and research, clinical practice guidelines and patient information material. *Cochrane Database of Systematic Reviews* 3, Issue 3. Art. No.: CD004563. DOI: 10.1002/14651858.CD004563.pub2.

Rechel, B., Mckee, M., Haas, M., Marchildon, G.P., Bousquet, F., Blumel, M., Geissler, A., van Ginneken, E., Ashton, T., Saunes, I.S., Anell, A., Quentin, W., Saltman, R., Culler, S., Barnes, A., Palm, W. and **Nolte, E.** 2016: Public reporting on quality, waiting times and patient experience in 11 high-income countries. *Health Policy* 120, 377–83.

Reynolds, L. and **Mckee, M.** 2009: Factors influencing antibiotic prescribing in China: an exploratory analysis. *Health Policy* 90, 32–36.

Schroeck, J.L., Ruh, C.A., Sellick, J.A., Ott, M.C., Mattappallil, A. and **Mergenhagen, K.A.** 2015: Factors associated with antibiotic misuse in outpatient treatment for upper respiratory tract infections. *Antimicrobial Agents and Chemotherapy* 59, 3848–852.

Shahian, D.M., Edwards, F.H., Jacobs, J.P., Prager, R.L., Normand, S.L., Shewan, C.M., O'brien, S.M., Peterson, E.D. and **Grover, F.L.** 2011: Public reporting of cardiac surgery performance: part 1 – history, rationale, consequences. *Annals of Thoracic Surgery* 92, S2–11.

Shankar, P.R. 2009: Medicines use in primary care in developing and transitional countries: fact book summarizing results from studies reported between 1990 and 2006. *Bulletin of the World Health Organization* 87, 804–5.

Sigurøardøttir, N.R., Nielsen, A.B.S., Munck, A. and **Bjerrum, L.** 2015: Appropriateness of antibiotic prescribing for upper respiratory tract infections in general practice: comparison between Denmark and Iceland. *Scandinavian Journal of Primary Health Care* 33, 269–74.

Smolinski, M.S., Hamburg, M.A. and **Lederberg, J.** 2003: *Microbial threats to health: emergence, detection, and response*. Washington, D.C., USA: National Academies Press.

Strategic Council on Resistance in Europe 2004: *Resistance: a sensitive issue, the European roadmap to combat antimicrobial resistance*. Utrecht, the Netherlands: SCORE.

Sun, Q., Dyar, O.J., Zhao, L., Tomson, G., Nilsson, L.E., Grape, M., Song, Y., Yan, L. and **Lundborg, C.S.** 2015: Overuse of antibiotics for the common cold – attitudes and behaviors among doctors in rural areas of Shandong Province, China. *BMC Pharmacology and Toxicology* 16, 1.

Tang, Y., Zhang, X., Yang, C., Yang, L., Wang, H. and **Zhang, X.** 2013: Application of propensity scores to estimate the association between government subsidy and injection use in primary health care institutions in China. *BMC Health Services Research* 13, 1.

van der Velden, A.W., Pijpers, E.J., Kuyvenhoven, M.M., Tonkin-Crine, S.K., Little, P. and **Verheij, T.J.** 2012: Effectiveness of physician-targeted interventions to improve antibiotic use for respiratory tract infections. *British Journal of General Practice* 62, e801–807.

Williams, R. 2011: Using the margins command to estimate and interpret adjusted predictions and marginal effects. *Stata Journal* 12, 308–31.

World Health Organization. 1993. *How to investigate drug use in health facilities: selected drug use indicators*. Geneva: World Health Organization.

World Health Organization. 2012: *The evolving threat of antimicrobial resistance: options for action*. Geneva: World Health Organization.

Xu, J., Wang, W., Li, Y., Zhang, J., Pavlova, M., Liu, H., Yin, P. and **Lu, Z.** 2010: Analysis of factors influencing the outpatient workload at Chinese health centres. *BMC Health Services Research* 10, 1.

Yang, L., Liu, C., Wang, L., Yin,, X. and **Zhang, X.** 2014: Public reporting improves antibiotic prescribing for upper respiratory tract infections in primary care: a matched-pair cluster-randomized trial in China. *Health Research Policy and Systems* 12, 61.

Yu, M., Zhao, G., Lundborg, C.S., Zhu, Y., Zhao, Q. and **Xu, B.** 2014: Knowledge, attitudes, and practices of parents in rural China on the use of antibiotics in children: a cross-sectional study. *BMC Infectious Diseases* 14, 1.