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An evaluation of a price transparency intervention for two commonly prescribed medications on total institutional expenditure: a prospective study

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KEY POINTS

Question: Does the provision of healthcare costs influence clinicians' prescribing choices for antibiotics and inhalers?

Findings: Provision of cost information resulted in a transient, non-sustained drop in weekly institutional spending on antibiotics and no change in inhaled corticosteroids expenditure. The introduction of new clinical prescribing guidelines for inhaled corticosteroids was associated with a substantial decrease in weekly costs for this medication category.

Meaning: Provision of cost information at the point of prescribing had no sustained impact on weekly antibiotic or inhaled corticosteroid costs. The introduction of new clinical guidelines for inhaled corticosteroids during the study period was associated with a drop in weekly expenditure for these medications. This approach may have more leverage in modifying clinical decision-making than the provision of cost-feedback.

ABSTRACT

Importance: Providing cost feedback has been demonstrated to decrease demand from clinicians.

Objective: We tested the hypothesis that providing the cost of drugs to clinicians would modify total expenditure.

Design: A prospective study design with a step-wise intervention.

Setting/Participants: Individuals who were admitted to the XXX from November 2013 to November 2015 under the physicians.

Intervention: The cost of all antibiotics and inhaled corticosteroids was added to the electronic prescribing system.

Main outcomes: The weekly cost for antibiotics and inhaled corticosteroids in the intervention period compared to baseline.

Results: Mean weekly expenditure on antibiotics per patient decreased by £3.75 (95% confidence intervals CI: -6.52 to -0.98) after the intervention from a pre-intervention mean of £26.44, and then slowly increased subsequently by £0.10/week (95%CI: +0.02 to +0.18). Mean weekly expenditure on inhaled corticosteroids per patient did not substantially change after the intervention (-£0.03, 95%CI: -0.06 to -0.01 after the intervention from a pre-intervention mean of £5.29 per person).

New clinical guidelines for inhaled corticosteroids were associated with a decrease in weekly expenditure.

Conclusions and relevance: Provision of cost feedback resulted in no sustained change in institutional expenditure. However, clinical guidelines have potential for modifying clinical prescribing behaviour.

Increasing demand for health care has led to a need for strategies to rationalise unnecessary demand, without reducing the quality of heathcare provision. There is variation in the cost of treating similar conditions between individual clinicians [1], which may represent a degree of sub-optimal usage of health care resources. This is probably because physicians' choice of medication is predominantly determined by heterogeneous past clinical experiences as well as local and national guidelines.

Behavioural insight theory suggests that knowledge of psychological processes may be utilised to design interventions that enable doctors to make more informed decisions [2,3]. This approach is light touch, with no element of obligation for those who are happy with their current practice. An example of this approach is the provision of extra information to clinicians, not with the intention of directing the clinician in decision making (potentially reducing their autonomy and clinical obligations to the patient), but simply informing them of the cost of this decision. We have previously added the cost of a commonly used blood test to the reports that clinicians receive and observed a 32% decrease in demand over 12 months [4]. Testing this approach in other areas of healthcare is important, as it is low-cost and easily scalable if demonstrated to be effective in modifying demand safely.

The purpose of the current study was to extend this cost-feedback approach to prescription drugs in a hospital setting. Specifically, we used electronic prescribing software to provide the cost of all antibiotics and corticosteroid inhalers to clinicians, and evaluated the impact of this intervention using a prospective study design. These interventions were selected as there are a number of options in each therapeutic category available to prescribers, and hence this permitted testing of the hypothesis that provision of cost information will modify choice of medication. During the period of this prospective study, new clinical guidelines were introduced to help physicians in their choice of inhaled corticosteroids. As a consequence, we were also able to explore the efficacy of a different non-nudge intervention on clinical decision-making.

Methods

Study population

The study population consisted of all individuals who were admitted to the XXX and discharged by the medical general physicians who care for adults between November 2013 and November 2015. The XXX is a busy acute medical hospital that admitted 140,960 individuals in 2014. The study was an evaluation of a health service modification and no ethical approval was required. The study was designed as a single intervention that was added to the existing framework of healthcare professionals (including microbiologists and pharmacists) that support clinical decision making.

Intervention

The XXX uses iSoft Electronic Prescribing and Administration software to permit electronic prescribing of drugs. This has a setting that permits the cost of the drug to be added to the display that the prescribing clinician sees immediately prior to selecting the medication of choice. The prescribing clinician only sees the cost of the antibiotic or inhaled corticosteroid selected as demonstrated in Figure 1. To provide a comprehensive list of medications, costs for every antibiotic (cost per day) and inhaled corticosteroids (cost per puff) listed in the March-September 2014 edition of the British National Formulary were provided by the XXX pharmacy department including adjustment for the extra costs of administering intravenous drugs [5]. They were then added to the prescribing software. The intervention was implemented on the 8th November 2014.

During the period of the study, generic inhaled corticosteroids became available at the XXX during the first 6 months of 2015, and new guidelines for the use of inhaled corticosteroids by clinicians were independently introduced by the respiratory medicine department in May/June 2015. These promoted the use of the cheaper generic medications where possible. This change became evident when the weekly cost data were analysed (Figure 2), and it was evident that an external change had modified inhaled corticosteroid usage in the institution.

Data

The data collection period spanned 11th November 2013 to 2nd November 2015. Weekly data on all prescribed drugs were collected from the electronic prescribing system along with the number of individuals who were prescribed those drugs. The data from the preceding 52 weeks were compared with the 52 weeks after the intervention was implemented.

The prescribing data were combined with the data on drug costs to calculate the total weekly expenditure on antibiotics and inhaled corticosteroids. Data on the total weekly numbers of patients on both therapeutic categories (antibiotics and inhaled corticosteroids) was also collected to permit adjustment for clinical activity in the statistical analysis by estimating a cost per patient.

Statistical analysis

We used segmented regression analyses to evaluate the effect of the intervention on a) total weekly expenditure on antibiotics and inhalers and b) weekly per patient expenditure on antibiotics and inhalers. The impact on oral doxycycline capsules was also modelled, as this is a relatively cheap but commonly used treatment for respiratory infection that we hypothesised would increase in prescribing frequency once prescribing costs were made available to physicians. Segmented

regression is a powerful interrupted time series method which can identify whether an intervention introduced at a single, known point in time had an immediate or delayed impact on the outcome measure and whether it was a transient or long-term effect over time. [6]

Parsimonious models were identified by backward elimination, dropping any parameters that were not significant at the 5% significance level.[6,7] All of the parsimonious models were checked to see whether there was any autocorrelation; the correlation between successive observations. using the autocorrelation function (ACF), which plots the residuals from the segmented regression analysis. Stata software (Texas, USA) was used for the statistical analysis.

Results

Over the study period the mean numbers of individuals who were prescribed antibiotics and corticosteroids were 428 and 55 individuals per week respectively. The total weekly expenditure per patient for both antibiotics and inhalers over the period of study are shown in Figure 2. The mean weekly expenditure on antibiotics per patient was at £26.44 in the baseline period, and £25.40 in the post-intervention period (Table 1). Comparable expenditure for inhaled corticosteroids was also lower in the post-intervention period (£4.17 per patient per week), compared to the baseline period (£5.29 per patient per week). This decrease in the weekly cost of inhaled corticosteroids was largely due to a change in local prescribing policy from June 2015 onwards and further analysis of this period is therefore adjusted for this event by fitting a dummy variable in the inhaler models.

The results of the segmented regression analysis are presented in Table 1, and allow more detailed analysis of the time course of changes in the expenditure after the intervention was implemented. Per patient expenditure on antibiotics demonstrated an immediate decrease after the intervention, (£3.75 per patient per week or 14% baseline, p=0.008) followed by an increasing trend (£0.10 per patient week or 0.4% baseline p=0.015). There was an immediate increase in weekly prescribing of doxycycline capsules, a cheaper oral antibiotic, of 18% (confidence Intervals: CI: 15 to 26) from a baseline of 1.78 pence per patient per week after the intervention. (Table 1, Figure 3).

For both overall inhaler spend and inhaler spend per patient, there was no statistically significant underlying trend, and no change in trend post-intervention. There was a small change in trend in spending on inhalers, such that weekly per patient spend was decreasing by 3p per week. Following a change in local prescribing policy in June 2015, the drop in weekly expenditure on

inhalers was 58p for per patient spend and £203 for total inhaler spend per week (representing a 65% drop from an unadjusted mean of £311 in the period prior to the local policy change).

Conclusions

This is the first study to prospectively explore the impact of providing the cost of antibiotics and inhaled corticosteroids to clinicians in a busy acute medical hospital in the United Kingdom. There was an immediate increase in prescriptions for doxycline by 18%, which is a relatively cheap option when treating respiratory infection, but this did not translate into a sustained decrease in overall weekly expenditure for antibiotics, which was the primary outcome of interest. There was no substantial change in expenditure for inhaled corticosteroids that could be attributed to the intervention, but a change in local clinical protocols for inhaled corticosteroids that was independent of our intervention and promoted generic alternatives was associated with a decrease in weekly expenditure of these medications.

By adding the costs of the drugs of interest so that they were clearly visible to the prescribing clinician, we can be confident that the intervention was implemented successfully, as it was impossible to prescribe the drugs without seeing the price once the intervention was in place (Figure 1). Our use of total institutional expenditure on medications as the primary outcome measure is a strength and this represents a composite macroeconomic measure that is pertinent to efficient healthcare delivery. A further strength of the study was our ability to collect electronic data on all drugs prescribed in the XXX, thus providing assurance that we obtained complete data on prescribing activity. By studying this population over a period of one year before and after the intervention, we can be confident that seasonal variation does not confound our analysis. Studying for a longer period is unlikely to be helpful as demographic changes may start to impact on our study population and we are unable to adjust for disease severity. There is one limitation of our intervention which is that the costs of the drug are only visible once that drug has been selected, and not alongside other therapeutic options. Hence, information about the cost of the medication is provided by our intervention, but not an immediate cost comparison with alternative drugs. Provision of direct cost comparisons between drugs is not a practical option as the decision to prescribe the medication is generally made at the patient's bedside and the prescribing is done subsequently, often elsewhere. This division of workload may contribute to the absence of any substantial sustained impact on total medication selection, as the person who makes the decision may not be the person who prescribes the drug and hence is exposed to the cost information. In addition, there are many antibiotics that can be selected to treat a clinical scenario, and comparing them all while attending the demands of a busy healthcare setting is not a feasible option.

It is surprising that there are no prior studies of the impact of adding price to commonly used medications on clinician decision making. This is probably a consequence of the challenge of rigorously evaluating change within healthcare settings, where many factors can impact on the demand for healthcare, and the 'system' remains in constant dynamic flux. As a consequence, our choice of the before/after or step-change regression model is probably the optimal study design that works in the 'real world' of applied health services research, as other options such as the randomized controlled trial are not either appropriate or deliverable in this context [8]. By knowing the exact date of the intervention, we are able to assess the change in prescribing patterns in the following weeks. It is evident that there was a change in physician behaviour from the 18% increase in prescribing of doxycline immediately after our cost-pricing intervention was implemented. This is a large increase in selection of a cheaper but effective antibiotic option that did not occur by chance, and hence provides evidence that our drug costs were observed by the prescribing doctor. This is important, as the negative results of the intervention were clearly not a consequence of the intervention not being seen by the clinicians. It is also important to note that this is pragmatic health services research that tested a simple hypothesis and was delivered with a limited budget. As a consequence, we were unable to follow up individual clinicians to ask what they thought of the intervention, although the increase in prescribing cheaper antibiotics immediately after the intervention suggest that they saw it. As with any new intervention, these interventions underwent a risk analysis to ensure that no harm was inadvertently delivered. There were no adverse events reported and future studies in this area should also consider similar measures.

The impact of adding the price transparency to antibiotics on demand was biphasic. There was an initial immediate decrease of 14% from baseline in cost per patient per week, but was followed by a small weekly increase in costs over the following 12 months of 0.4% the baseline value per week. This represents a reversal of the initial effect that we are unable to explain, but is an important factor in the consideration of these data. It is possible that the presentation of the price displays could be optimized and even varied to prevent familiarisation resulting in 'alert blindness', and that this may improve awareness of the cost 'message' although we were constrained by the electronic prescribing software in the presentational options available. As can be seen from Figure 1, our cost data were clearly available to the prescribing clinician. While alternative strategies to optimise provision of the display of cost information could be considered in the future, it is important to be mindful that the primary purpose of electronic prescribing software is the safe prescribing of medications, and we did not want our cost feedback to detract from this. In addition,

we were unable to deliver qualitative research to assess clinicians' perspectives on the provision of health care costs due to budgetary constraints.

Consideration of the context of this study is important in interpreting the generalisability of the results. The study was set in a busy teaching hospital where clinicians assess and treat patients according to their clinical need, and there is no payment by the patient to contribute to their healthcare costs. Hence, while our observations may be applicable to other similar nationally funded health care systems, they may not be so generalizable to healthcare systems where healthcare management decisions and hence costs may also be influenced by the patients' ability to pay or where medications are rationed as a consequence of scarcity or economic necessity.

This work builds on our previous study, which demonstrated that adding the institutional cost to C reactive protein results was associated with a 32% decrease in demand over 52 weeks [4], although this was not observed in recent data from the USA [9]. We are not aware of any comparable studies that have prospectively studied the impact of provision of cost information for commonly used drugs on subsequent selection by clinicians. Conventional economic theory suggests that most individuals are influenced to some degree by costs, but applying this to medical decision-making is challenging and controversial. This is because physicians' choice of antibiotic is predominantly determined by clinical experience as well as local guidelines that already take into consideration both local patterns of microbial resistance to antibiotics and cost. Many established antibiotics have similar institutional costs, and the mode of delivery (oral versus intravenous) can be an important determinant in total cost once this is added into the retail price. However, although stepping down from intravenous antibiotics to oral antibiotics does vary depending on the day of the week [10] (and hence medical staffing levels), there was no impact of our intervention on total costs. Control of inappropriate antibiotic prescribing has been a priority area for the XXX to reduce complications such as *Clostridium difficile* gastro-intestinal infection and it is possible that the use of antibiotics in this hospital has reached a level where there is limited scope for improvement. Hence, these findings are probably generalisable to institutions with strong existing antibiotic guidelines that are actively promoted and supervised.

By delivering this evaluation of a cost-information intervention at the same time as a change in clinical guidelines for the use of inhaled corticosteroids, we inadvertently are able to observe a natural experiment where the impact of one passive 'nudge' intervention (cost-feedback) can be compared with a second more directive approach (clinical guidelines). We are cautious in our interpretation of these data as it represents a *post hoc* analysis that is derived from a necessity to explain the step-change decrease in weekly expenditure on inhaled corticosteroids data rather

than an *a priori* hypothesis. However, the implementation of new prescribing guidelines for inhaled corticosteroids does appear to be associated with a substantial decrease in the costs of prescribing these medications and supports the use of local protocols in promoting efficient prescribing.

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Figure 1. Example of drug costing on electronic prescribing system

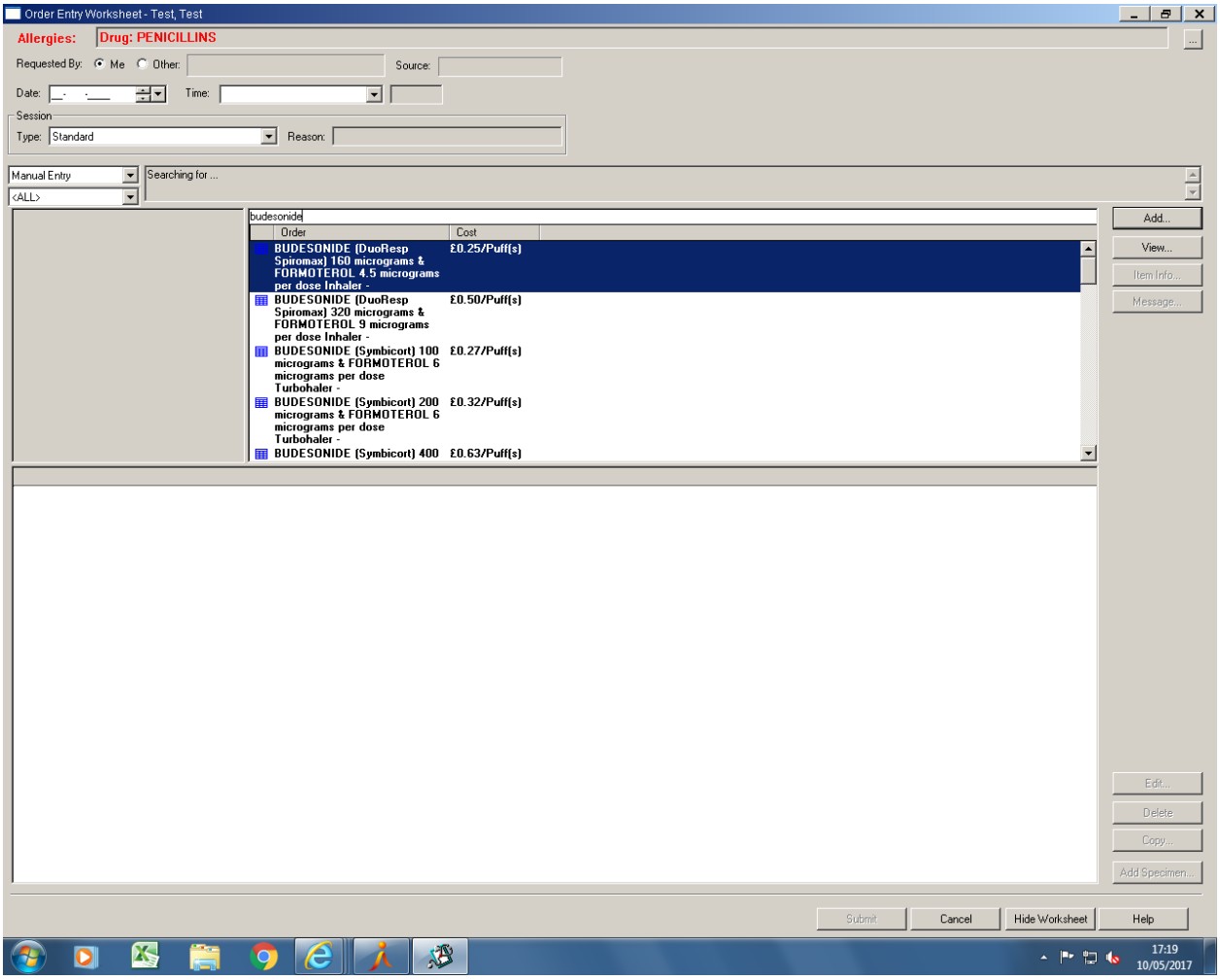
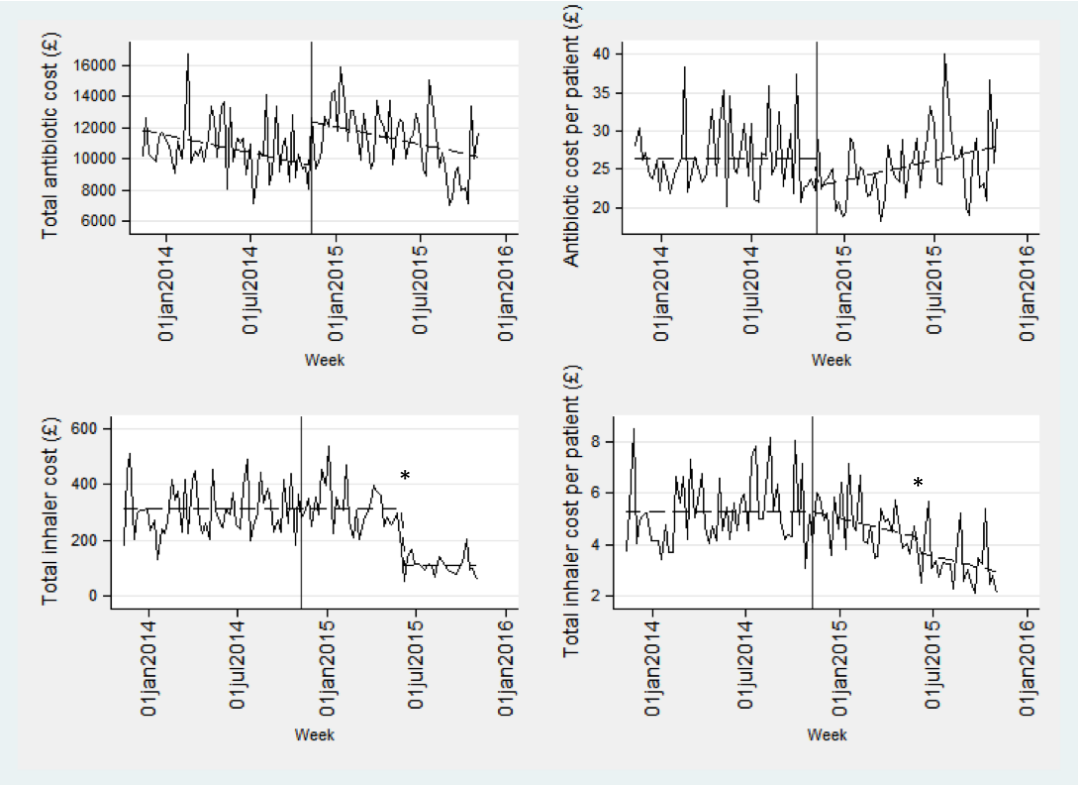


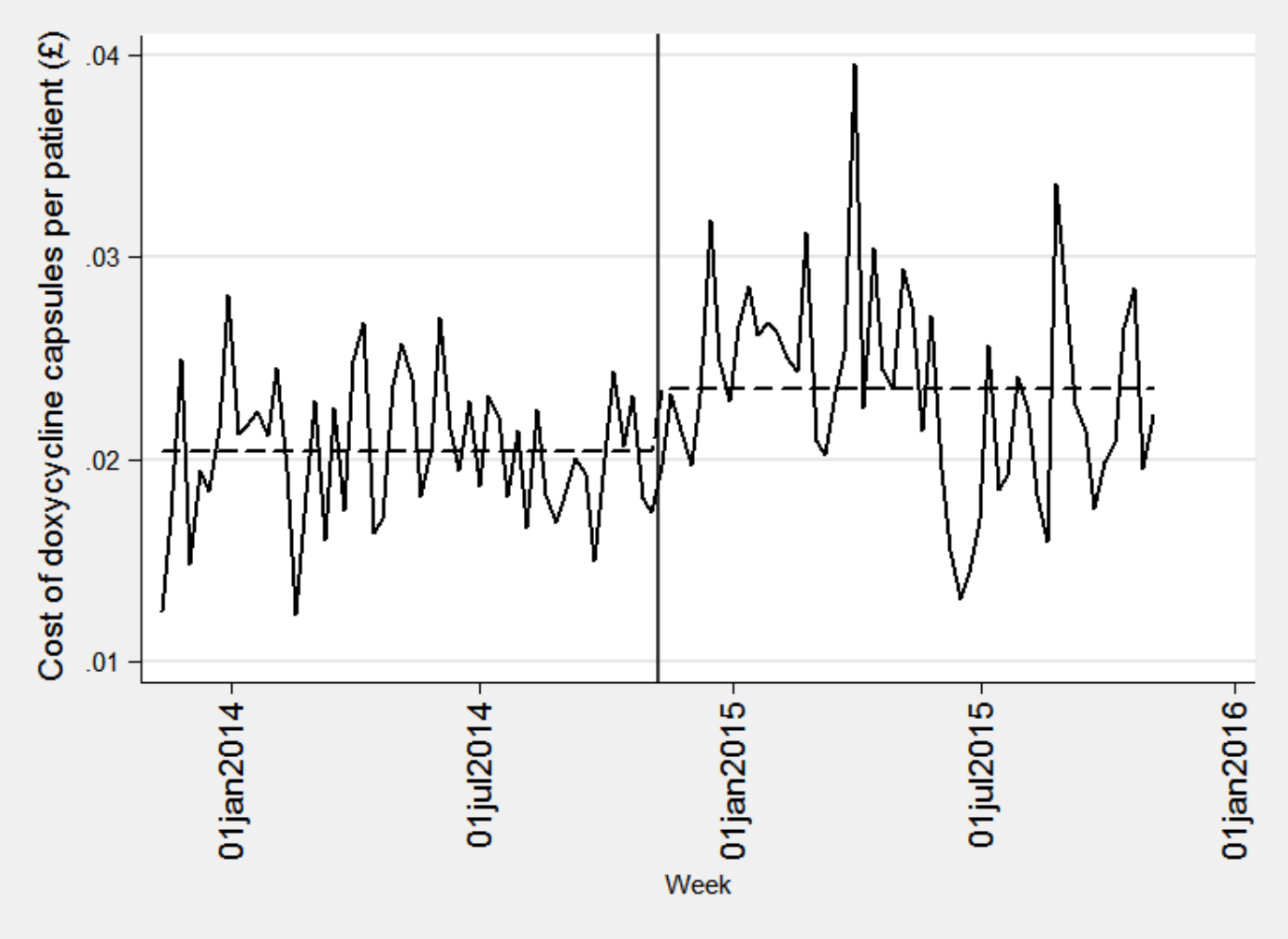
Figure 2. Change in cost of total antibiotics and total inhalers per patient per week



Vertical line represents intervention

* represents introduction of inhaled corticosteroid protocol

Figure 3. Change in cost of doxycycline capsules per patient per week



Vertical line represents intervention

Table 1. Segmented regression analysis of XXX drug cost data

	Pre-intervention mean (unadjusted)	Post-intervention mean (unadjusted)	β_1 - Baseline trend (95% CI)	β_2 - Step level change	β_3 - Change in trend
Total antibiotics spend per week (£)	10,719	11,260	-43.58 (-43.58 to -19.60) p<0.001	+2807.50 (+ 1367.83 to +4247.07) p<0.001	-
Antibiotics spend per patient per week (£)	26.44	25.40	-	-3.75 (-6.52 to -0.98) p=0.008	+0.10 (+0.02 to +0.18) p=0.015
100mg Oral doxycycline capsules spend per patient per week (£)	0.020	0.023	-	+0.003 (+0.001 to +0.005) p<0.001	-
Total inhaler spend per week (£)	309.29	227.74	-	-	-
Inhaler spend per patient per week (£)	5.29	4.17	-	-	- 0.03 (-0.06 to -0.01) p=0.11

β_1: weekly change in spending before intervention
β_2: step change in weekly spend after intervention
β_3: absolute change in trend in weekly spend after intervention, compared with baseline trend

$\beta_1+\beta_3 = \beta_4$ post-intervention slope.
Inhaler models include a dummy variable to adjust for a change in local prescribing policy
Only statistically significant variables are included in the parsimonious models. Gaps in the table reflect that variables were not significant and were not include in the final model.
CI: Confidence intervals