

Fogelberg, Sara; Karlsson, Jonas

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## Competition and antibiotics prescription

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IFN Working Paper No. 949, 2012

# **Competition and Antibiotics Prescription**

Sara Fogelberg and Jonas Karlsson

# Competition and Antibiotics Prescription \*

Sara Fogelberg<sup>†</sup> and Jonas Karlsson<sup>‡</sup>

January 2, 2013

## Abstract

The introduction of antibiotics as a medical treatment after World War II helped to dramatically increase life expectancy in the industrialized world. As a consequence of over-prescription the last decades have however seen a sharp increase in prevalence of multi-resistant bacteria, disarming once powerful anti-pathogens. This paper investigates the effect of increased competition between healthcare providers on prescription of antibiotics. We make use of a competition-inducing reform implemented in different counties in Sweden at different points in time during 2007 to 2010. Our dataset contains monthly data on all prescribed antibiotics in Sweden which makes us able to estimate the effects on all antibiotics prescribed, as well as different subcategories of antibiotics. The results indicate that increased competition had a positive and significant effect on antibiotics prescription.

*Keywords:* Healthcare, competition, competition reform, antibiotics.

*JEL codes:* C23, H30, I11, I18.

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<sup>†</sup>Department of Economics, Stockholm university and IFN

<sup>‡</sup>The Institute for Social Research and SULCIS, Stockholm University

# 1 Introduction

During the last decades there has been a sharp increase in the prevalence of multi-resistant bacteria, which has left once powerful antibiotics without effect. The consequences are rising medical expenses and increased mortality, especially among children and the elderly. The main reason for this development is excessive use of antibiotics and their evolutionary pressure on bacteria. One problem is that patients do not internalize the externalities associated with antibiotics and might want them even in situations where they are not medically motivated. There exists an information asymmetry between patient and physician which makes it difficult for the patient to assess the quality of healthcare that is given. In this context willingness to prescribe antibiotics may serve as a signal of quality, attentiveness and care (Avorn and Solomon, 2000).<sup>1</sup>

Several European countries have recently issued reforms in their healthcare organizational structures in order to induce more competition between healthcare providers. This intensifies pressure on healthcare providers to meet patients' needs and demands and thereby creates a channel for quality improvements. However, given patients' preference for having antibiotics prescribed prescription rates of antibiotics can potentially increase through the same channel. To show how a change in competition between healthcare providers affects prescription rates of antibiotics we exploit a reform aimed at increasing competition between healthcare providers implemented in different counties in Sweden during the years 2007 to 2010. We use a difference

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<sup>1</sup>See also Butler et al. (1998), Bauchner et al. (1999) and Das and Sohnesen (2006).

in differences approach where we compare prescription rates of antibiotics in treated "big city" municipalities with prescription rates in untreated municipalities' years before the reform with the reform year. In the regression we separate the effects for treated areas where healthcare providers carries a part the costs for prescribed medicine from treated areas where healthcare providers do not have such a cost.

The results indicate that in areas where there is a pure treatment effect, i.e. where there is no medicine cost responsibility, the reform was associated with a 5% increase of all antibiotics prescribed, a 3% increase in a broad spectrum antibiotics and a 7% increase in narrow spectrum antibiotics. For areas with mixed treatment effects there were small and negative effects. We do several placebo tests where we substitute the treatment year for mock-treatment years and we check general health trends in case the results could be assymetric health shocks. Finally we estimate our models on county level instead of using a municipality-big-city specification. The different placebo tests give us no reason to doubt our results.

The previous literature on economic determinants of antibiotics prescription is sparse. Bennet et al. (2008) use the Herfindahl index and fixed effects to estimate the effect of competition on antibiotics prescription in Taiwan. The results show that an increase in competition with one standard deviation increases antibiotics use with 2.4 percent. The authors also interact the Herfindahl index with a reform dummy that captures a reform aimed to limit unnecessary antibiotics use. This specification shows that after the reform has been carried out, competition no longer has a significant effect on antibiotics prescription. This paper contributes with a clearer identification

strategy as we use a quasi-experimental design instead of fixed effects. We further more directly measure the effect of competition since we are able to use a reform aimed specifically at increasing competition.

This paper also relates to literature that evaluates if increased competition among healthcare providers leads to quality improvements and efficiency gains. Theoretical evidence suggests a positive effect on quality in healthcare of competition when prices are regulated.<sup>2</sup> Empirical evidence have been more mixed and while Robinson and Luft (1985) and Propper et al. (2008) find a negative relationship between healthcare quality and competition more recent literature points in the direction of a positive relationship.<sup>3</sup> Using a British healthcare reform targeted towards increasing competition Bloom et al. (2010), Gaynor et al. (2010) and Cooper et al. (2011) all find evidence for a positive effect of competition on healthcare outcomes such as heart attack survival rates. Kessler and McClellan (2000) find similar results using American data.

The paper is organized as follows. In the following section the Swedish healthcare reform is explained. In the data section the details of our data are described and in the econometric strategy part our econometric model is presented. Finally results and conclusions follow.

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<sup>2</sup>See for instance Calem and Rizzo (1995) Gravelle (1999) Gravelle and Masiero (2000), Beitia (2003), Nuscheler (2003), Brekke et al. (2007), Karlsson (2007) and Greener and Mannion (2009).

<sup>3</sup>Propper et al. (2008) is a rather recent publication but the paper evaluates an older reform.

## 2 Healthcare organization and reform

The Swedish government decided 2007 that reforming the healthcare system was necessary in order to increase the competition in the healthcare sector and to ensure the right of the patient to choose healthcare provider. The public healthcare system in Sweden is mainly organized through the 21 county councils of Sweden. The county councils are responsible for healthcare budget administration and for setting up directives for how healthcare should be operated in assigned municipalities, which are in total 290. The Swedish system consists of both public and private healthcare providers, but it is tax based and universal. Several evaluations of European healthcare systems have ranked Sweden among the top countries when it comes to patient outcomes and cost efficiency. Availability and patient satisfaction has however been a problem.

The individual county councils were assigned responsibility for making changes deemed necessary for the competition inducing reform. Common features was that there should be a free entry for healthcare providers into the market and that healthcare providers should be compensated according to number of patients listed and number of patient visits. Before the reform healthcare providers were compensated according to location (and indirectly expected number of patients), poverty and health of the region etc. After the reform there is a much clearer incentive to maximize the actual number of visits from patient and the number of patients listed. It also becomes important to keep other healthcare providers from entering the market. Patient satisfaction is hence of central importance.

The following counties went through with reforms before the reform became compulsory: Halland (2007), Stockholm (2008), Västmanland (2008), Skåne (2009), Östergötland (2009), Kronoberg (2009) and Västergötland (2009). In all counties except Halland, Stockholm, Västmanland and Gotland healthcare providers are responsible for 50-100% of patients' medicine costs. This means of course that healthcare providers face a slightly different incentive structure in counties with medicine cost responsibility. In these counties it is not costless for healthcare providers to compete using prescription of medicine. Even when it comes to relative cheap medicine a responsibility for medicine costs might function as a reminder for the doctor to limit less motivated prescriptions. In our regressions we therefore separate the counties that receive a pure competition shock from counties where both increased competition and cost responsibility matters. We will henceforth refer to the different effects as "pure competition effect/pure treatment effect" and "mixed incentives effect" respectively.

The number of listed patients determines the major part of income for healthcare providers in all treated counties, also in counties where formally a high share of income is determined by number of patient visits. For the patient there is a clear advantage to visit the same healthcare provider each time and healthcare providers also encourage patients to list themselves after a certain number of visits, which means that there is a high correlation between where a patient is listed and where the patient will seek healthcare. Healthcare providers hence have a very clear incentive to maximize the number of listed patients in all the counties where the reform has been carried out. The majority of listings take place the year during which the reform is carried out, which means that there is a substantial competition



shock that year. Possible effects on antibiotics prescription should therefore be largest during the reform year. To capture this, and to account for the fact that the effects of the reform may change over time we specify a modified difference-in-differences estimation. More about this in the empirical strategy part of the paper.

### 3 Data

The data used is on municipality level and collected for every month between January 2003 and December 2011. The source is the Swedish Institute for Communicable Disease Control and Apotek Service AB (an agency responsible for collecting and administrating data from all pharmacies in Sweden). All dependent variables are defined as per 10 000 inhabitants.

The main variable of analysis is total quantity of prescribed antibiotics, that is, an aggregate of all antibiotics types prescribed and then collected by patients. Further we look at two variables defined as narrow spectrum antibiotics and broad spectrum antibiotics. The antibiotics types in each definition have been selected by medical expertise at the Swedish Institute for Communicable Disease Control. Narrow spectrum antibiotics are antibiotics types that kill a small segment of bacteria which mean that potential problems with development of multi-resistant bacteria are smaller for this antibiotics type. Broad spectrum antibiotics then is antibiotics types which kills a large segment of bacteria and hence this type of antibiotics is associated with higher risks. Together the antibiotics types in the broad spectrum variable and narrow spectrum variable account for a clear majority of all pre-

scribed antibiotics in Sweden. A description of which antibiotics types that are in each category is found in the appendix. Data for all the antibiotics variables are available in defined daily dosages and prescriptions. In this paper we report results using prescriptions but using defined daily dosages gives very similar results.

Our theory depends on there being a "grey zone" in which antibiotics might be more or less medically motivated. If it is true that the increased leverage of the patient make physician more willing to prescribe antibiotics this should be especially true for cases where it is ambiguous whether antibiotics is motivated or not. A high share of the narrow spectrum antibiotics consists of antibiotics for upper respiratory tract infections which are often caused by viruses which makes use of antibiotics redundant. Antibiotics might be motivated in case the infection is bacterial and severe, but since it is often hard to judge whether antibiotics is motivated or not we expect an increased leverage of patient through the reform to have a larger effect on narrow spectrum antibiotics than broad spectrum antibiotics. Given knowledge of the dangers of prescribing antibiotics, and especially broad spectrum antibiotics, doctors might also prefer to prescribe narrow spectrum antibiotics as a patient pleaser.

The results in this paper could theoretically be driven by asymmetric health shocks/epidemics that coincide with our treatment. To test for this we use antibiotics given to hospitalized patients as a dependent variable. In care hospital treatment is not affected by the studied reform and further antibiotics given at hospitals are correlated with major health trends and epidemics, two factors that should make the variable a suitable placebo.

## 4 Econometric strategy

In order to isolate the effect of the reform on antibiotics prescription we estimate a model with the structure:

$$antib_{it} = \alpha_1 Pure\_Ref_{it} + \alpha_2 Mixed\_Ref_{it} + \beta PR_{it} + \gamma' controls_{it} + error_{it} \quad (1)$$

$antib_{it}$  is logged number of prescriptions for antibiotics in total, broad spectrum antibiotics and narrow spectrum antibiotics respectively, all per 10 000 inhabitants on a municipality level monthly.  $Pure\_Ref_{it}$  and  $Mixed\_Ref_{it}$  are dummy variables taking the value one the year of the reform in treated areas and zero otherwise. The difference between  $Pure\_Ref_{it}$  and  $Mixed\_Ref_{it}$  is that  $Pure\_Ref_{it}$  includes the municipalities that belong to counties where healthcare providers are not responsible for medicine costs. This variable hence measures the pure competition effect.  $Mixed\_Ref_{it}$  instead measures the effect of competition combined with medicine cost responsibility. In treated areas we include municipalities which have a city with more than 100 000 inhabitants and municipalities located just by a municipality which has a city with more than 100 000 inhabitants. Municipalities located right next to a big city arguably share healthcare market with the big city municipality.

$PR_{it}$  is a post reform dummy taking the value one for all years post the reform.  $Controls_{it}$  include fixed effects for months and municipalities. The standard errors are clustered on a municipality level.

The econometric model is slightly differently specified compared to a standard difference-in-differences models. The used model is chosen in order to capture the pro-competition incentive shock that the reform trigger on the reform year, rather than capturing a permanent shift in prescription after the reform. In a standard difference in differences model a dummy variable indicates one for the reform year and all following years whereas we separate the effects for treatment and years post treatment. This is necessary since politicians evaluated effects of the reform on antibiotics prescription one year after the reform and issued counter measures where prescriptions had increased. A standard difference- in -difference model will hence not capture a pure competition effect. Another reason to why this specification is better for our purpose is that most of the listings took place during the reform year and it is reasonable to assume that the reform year is the year where the competition effect would matter most. Our specification captures this competition shock better than a standard differences-in-difference model.

The model look at treatment effects in municipalities with a big city or municipalities bordering a municipality with a big city. Specifications similar to this are common in the literature<sup>4</sup> and the underlying assumption is that effects of a competition reform should only matter in regions where choice of healthcare provider is feasible. As a robustness test we also run a regression on treated counties rather than municipalities with a big city. In this specification we can only include Halland, Stockholm and Västmanland

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<sup>4</sup>See for instance Cooper et al. (2011), Propper et al. (2008). Card (1992) have used a concentration index in a difference- in -differences estimation to study effect on employment by minimum wages.

however since the reform became mandatory in January 2010 and in counties except for the mentioned ones the reform was carried out during the second half of 2009 or in 2010.

## 5 Results

The results indicate that the effect of competition on antibiotics prescription is positive. As can be seen in Table 1 the pure treatment effect of a competition inducing reform is positive and significant for all antibiotics, broad spectrum antibiotics and narrow spectrum antibiotics. The effect on all antibiotics is 5% and as predicted the effect on narrow spectrum antibiotics was the largest at 7%. Broad spectrum antibiotics have the smallest effect at 3%.

Table 1: Results from the difference-in-differences regression on the three outcome variables. The dependent variable is logged.

	All antibiotics	Broad spectrum antibiotics	Small spectrum antibiotics
Pure treatment effect	0.05*** (0.01)	0.03** (0.01)	0.07*** (0.01)
Mixed treatment effect	-0.01** (0.01)	-0.03** (0.01)	-0.00 (0.01)
Numbers of obs.	31320	31320	31320
R <sup>2</sup>	0.72	0.73	0.59

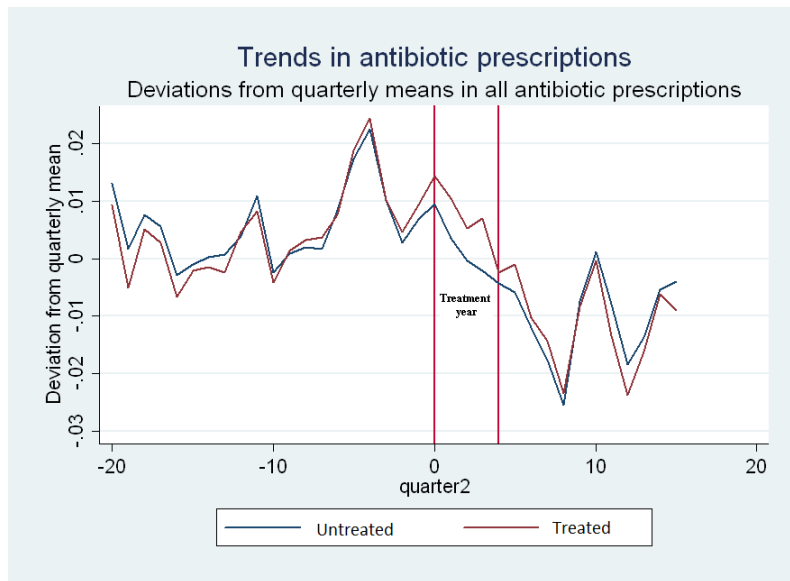
Standard deviations within brackets. P-values indicated with stars where 0.1=\*, 0.05=\*\* and 0.01=\*\*\*.

Interestingly all positive significant effects on antibiotics prescription in association with the reform disappear when healthcare providers are held

responsible for medicine costs. Broad spectrum antibiotics has a significant effect at -3% for this treatment whereas there is no effect on narrow spectrum antibiotics. Broad spectrum antibiotics are on average more expensive than narrow spectrum antibiotics which might explain this result.

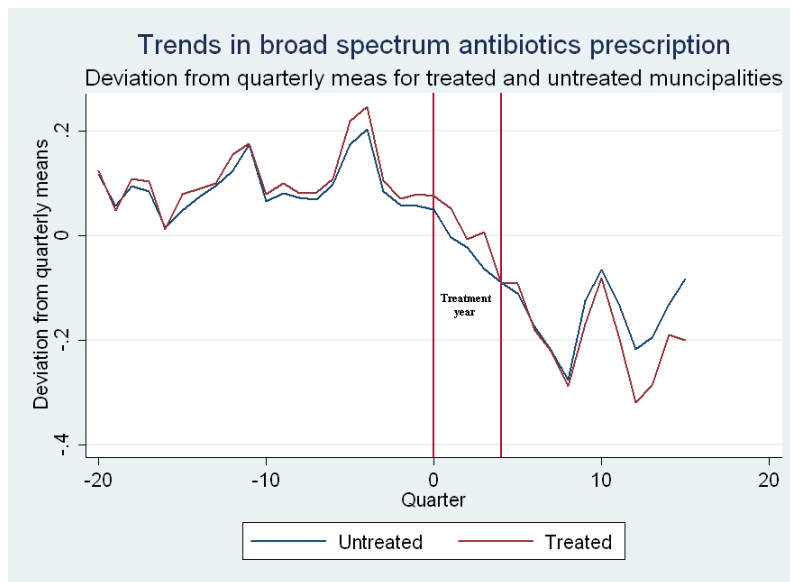
Below Figure 1 illustrates the pure treatment effect for all antibiotics. The plot indicates that the parallel trends assumption will hold, which will be formally tested in this paper's robustness checks section. However the treatment effect seems to kick in a few months before the treatment year, which could be a consequence of healthcare providers internalizing an incentive scheme they know will come into place.

Figure 1: All antibiotics prescription, quarterly deviation from means.



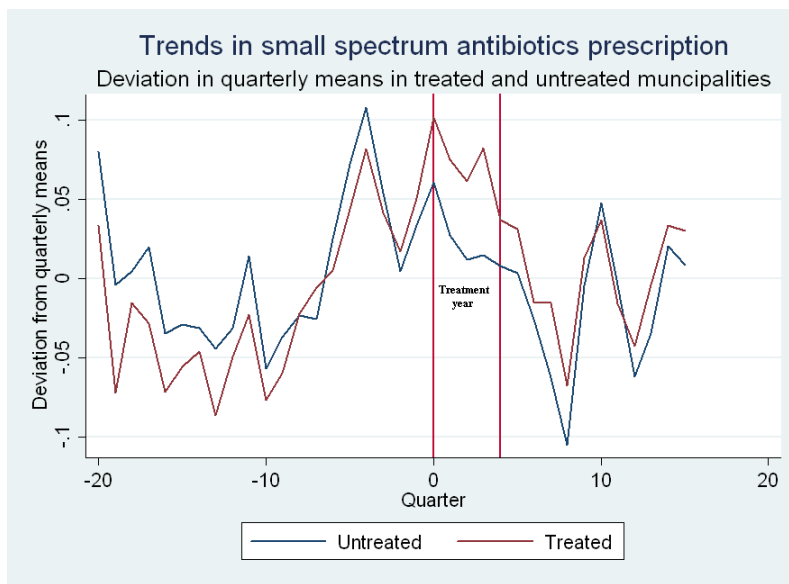
For broad spectrum antibiotics the development is less clear visually as can be seen in Figure 2 below. There is a clear treatment effect but this effect is shadowed by a large decrease in prescription of broad spectrum antibiotics starting the year before treatment.

Figure 2: Broad spectrum antibiotics prescription, quarterly deviation from means.



Finally in Figure 3 we see that narrow spectrum antibiotics follows the same trends as all antibiotics, although the treatment effect for narrow spectrum antibiotics is more pronounced.

Figure 3: Small spectrum antibiotics prescription, quarterly deviation from means.



## 6 Robustness checks

To test the robustness of our results for our big-city specification, and in order to find a lower bound for the general effect of the competition reform we estimate our model using treated counties instead of treated municipalities with a big city. In this specification we can only use Halland, Stockholm and Västmanland since the reforms in the other counties were in the last six months of 2009 or at 2010 and hence lack a proper reference group. Halland, Stockholm and Västmanland are all counties without medicine cost responsibilities for healthcare providers and the results of this regression should therefore be compared with the pure treatment effect in Table 1.



Table 2: Results from a difference-in-differences regression on the three outcome variables where the effect is estimated on a county level. The dependent variable is logged.

	All antibiotics	Broad spectrum antibiotics	Small spectrum antibiotics
Treatment effect	0.04*** (0.01)	0.04*** (0.01)	0.05*** (0.01)
Numbers of obs.	31320	31320	31320
R <sup>2</sup>	0.51	0.52	0.43

Standard deviations within brackets. P-values indicated with stars where 0.1=\*, 0.05=\*\* and 0.01=\*\*\*.

The results are similar for all variables except narrow spectrum antibiotics where the treatment effect now is significant at 5% instead of 7%. It is interesting to note however that the R<sup>2</sup> falls dramatically in this specification compared to the big city specification.

In order to check for random health shocks that could affect our estimation results we use antibiotics given to hospitalized patients as a dependent variable in a placebo regression. Incentives regarding hospitalized patients were not changed during the treatment periods and at the same time antibiotics given hospitalized patients is correlated with sickness trends which makes this a suitable placebo. Since not all municipalities have hospitals the regression is carried through on a county level.

Table 3: Placebo test with antibiotics given to hospitalised patients as the dependent variable in a difference-in-differences estimation. The dependent variable is logged.

All antibiotics	
Treatment effect	0.04 (0.06)
Numbers of obs.	1500
R <sup>2</sup>	0.58

Standard deviations within brackets. P-values indicated with stars where 0.1=\*, 0.05=\*\* and 0.01=\*\*\*.

As seen above there are no significant results. Our placebo test hence gives us no reason to suspect that our results are driven by health shocks.

Finally we test for parallel trends by creating placebo reform dummies for years when treatment was not carried out in Table 4.

Table 4: Placebo test corresponding to Table 1 with mock treatment years. This table shows the results for the "pure treatment" effect. Dependent variable logged.

	2004	2005	2006
All antibiotics	-0.01** (0.01)	0.00 (0.01)	0.01*** (0.01)
Broad spectrum	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)
Small spectrum	-0.01 (0.01)	0.00 (0.01)	0.02** (0.01)

Standard deviations within brackets. P-values indicated with stars where 0.1=\*, 0.05=\*\* and 0.01=\*\*\*.

The same placebo test for treatment effects in municipalities where healthcare providers are responsible for medicine costs can be see Table 5 below.

Table 5: Placebo test corresponding to Table 1 with mock treatment years. This table shows the results for the "mixed treatment" effect. Dependent variable logged.

	2004	2005	2006
All antibiotics	0.01 (0.01)	0.00 (0.01)	0.00 (0.01)
Broad spectrum	0.03** (0.01)	0.01 (0.01)	0.01 (0.01)
Small spectrum	-0.01 (0.01)	-0.01 (0.01)	0.00 (0.01)

Standard deviations within brackets. P-values indicated with stars where 0.1=\*, 0.05=\*\* and 0.01=\*\*\*.

There are a few small significant effects in the placebo tests, but they are all well below the treatment effects in magnitude. There is a 3% positive effect in broad spectrum antibiotics in 2004 for counties with responsibility for medicine costs which we have no explanation for. There are however no corresponding changes in prescriptions in the other variables that year and there is no effect for the same variable in the general treatment placebo test.

## 7 Discussion

The presented results show that the effect of the competition inducing reform had a positive and significant effect on antibiotics prescription as long as healthcare providers do not have to pay for prescribed medicine. This

is true for all outcome variables, that is, all antibiotics, narrow spectrum antibiotics and broad spectrum antibiotics. The treatment effect in areas where healthcare providers do have a medicine cost responsibility is insignificant or negative. This can be interpreted as that healthcare providers may provide patients with antibiotics as a way of competing with each other, as long as this channel of competition is costless. When healthcare providers instead have a medicine cost responsibility profit can also be increased by prescribing less medicine, and more generally competing with prescriptions becomes associated with a cost. This counteracts the competition effect on antibiotics prescription.

The reason for why narrow spectrum antibiotics increase the most as a consequence of increased competition in Sweden (as in the pure competition effect) is potentially complex. Even though satisfying the patient has become more important, physicians still might take societal welfare into consideration and hence avoid prescribing broad spectrum antibiotics in most cases. It is also possible that the reform in fact increase quality of healthcare and that more tests are performed and then followed by suitable antibiotics which in most cases will be narrow spectrum antibiotics. It is possible that patients responds positively to increased testing and view it as a sign of quality. Finally, prescribing narrow spectrum antibiotics without testing increases the chances of a second visit from the patient, and hence increased profits for the healthcare provider. This is especially relevant in the counties where a large segment of the compensation to the healthcare provider is through number of patient visits.

Development, culturation and spread of resistant bacteria depends on many factors, such as transmission and infection control, recent antibiotics use, choice of antibiotics treatment and dosage or duration of therapy. Antibiotic prescription is however the key determining factor driving resistance (Neu, 1992) and there is a high and significant correlation coefficient between antibiotic prescription and resistance in the European countries ranging between 0.65 to 0.84 depending on antibiotic type and bacteria investigated (Goossens et al. 2005). The policy relevant implication of this paper is that competition has a positive effect on antibiotics prescription, and that these effects can be quite large. There is hence a potential cost associated with introducing reforms aimed at increasing competition between health-care providers. Already now multi-resistant bacteria cause 19 000 deaths annually in the US Carlet et al. (2012) and 25 000 deaths annually in the European Union European Commission (2012).

The effect can be hampered however by either making healthcare providers responsible for medicine costs or by other counter measures such as information campaigns or financial premiums/punishments for deviating health-care providers. Making healthcare providers responsible obviously comes at a risk of under-prescription of medicine, especially expensive medicine. In the counties where there is a premium for low prescribing healthcare providers policymakers indirectly make themselves involved in patient treatments which can potentially become problematic. Relying on information campaigns rather than putting a price on the externalities associated with antibiotics prescription is potentially risky however since the effect of the campaigns might wear off with time. Which method to use in order to counteract increased prescription as a consequence of increased competition

is outside the scope of this paper, but it is a relevant question for further research.

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## A Appendix

*Antibiotics included in the definition of small spectrum antibiotics:*

PcV (fenoximetylpenicilin) J01CE02

Nitrofurantoin J01XE01

Pivmecillinam J01CA08

Trimetoprim J01EA01

*Antibiotics included in the definition of broad spectrum antibiotics:*

Amoxicillin J01CA04

Amoxicillin med klavulansyra J01CR02

Doxycyclin J01AA02

Cefalosporins J01DB + J01DC + J01DD + J01DE

Erytromycin J01FA01

Kinolones J01MA02 + J01MA06

Table A.1: Result for post-treatment dummies in a difference-in differences estimation corresponding to Table 1. Dependent variable logged.

	All antibiotics	Broad spectrum antibiotics	Small spectrum antibiotics
Pure treatment effect	-0.00 (0.01)	- 0.06*** (0.02)	0.04*** (0.01)
Mixed treatment effect	-0.02* (0.01)	-0.04*** (0.02)	-0.01 (0.01)
Numbers of obs.	31320	31320	31320
R <sup>2</sup>	0.72	0.73	0.59

Standard deviations within brackets. P-values indicated with stars where 0.1=\*, 0.05=\*\* and 0.01=\*\*\*.

Table A.2: Results from a classic difference-in-differences regression on the three outcome variables. The dependent variable is logged.

	All antibiotics	Broad spectrum antibiotics	Small spectrum antibiotics
Pure treatment effect	0.01 (0.01)	- 0.04*** (0.01)	0.05*** (0.01)
Mixed treatment effect	-0.01* (0.01)	-0.04** (0.02)	-0.00 (0.01)
Numbers of obs.	31320	31320	31320
R <sup>2</sup>	0.72	0.73	0.59

Standard deviations within brackets. P-values indicated with stars where 0.1=\*, 0.05=\*\* and 0.01=\*\*\*.