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Effects of Competition between Healthcare Providers on Prescription of Antibiotics

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Abstract

The introduction of antibiotics as a medical treatment after World War II helped to dramatically increase life expectancy in the industrialized world. However, over-prescription of antibiotics during the last few decades has led to a sharp increase in multi-resistant bacteria, disarming once powerful anti-pathogens. This paper investigates the effects of increased competition between healthcare providers on prescription of antibiotics. The analysis makes use of a competition-inducing reform implemented in different counties in Sweden at different points in time between 2007 and 2010 for a difference-in-differences approach. Since the dataset contains monthly data on all prescribed antibiotics in Sweden it is possible to estimate the effects on all antibiotics prescribed, as well as on different subcategories of antibiotics. The results show that increased competition had a positive and significant effect on prescription of antibiotics. This increase in prescription of antibiotics was not associated with a reduction in sick leave.

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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 externality that is associated with antibiotics. In aggregate they therefore demand more antibiotics than welfare maximizing physicians would prescribe. Moreover, patients may have difficulties assessing the quality of healthcare they are given. In this context willingness to prescribe antibiotics may serve as a signal of quality, attentiveness and care (Avorn and Solomon, 2000).[1]

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 that patients have a preference for having antibiotics prescribed, prescription rates of antibiotics can potentially increase through the same channel. A Swedish reform, aimed at increasing competition between healthcare providers, is used in this paper to show how a change in competition between healthcare providers affects prescription rates of antibiotics. The reform was implemented in different regions at different times during the years 2007 to 2010, which makes it possible to use a difference-in-differences approach. In some of the treated areas healthcare providers carry a part of the cost for prescribed medicine and have to internalize this cost in their budget. Since incentives can be expected to be different in these areas compared to areas where providers do not face such a cost, the results for these two types of areas are separated in the regressions.

The results show that in areas where there is no medicine cost responsibility the reform was associated with a 5 percent increase of all antibiotics prescribed, a 3 percent increase in a broad spectrum antibiotics and a 7 percent increase in narrow spectrum antibiotics. Back of the envelope calculations give that a 5 percent increase in antibiotics use is associated with an increase in multi-resistant bacteria of between 3,25 and a 4,2 percent. For areas where healthcare

[1]See also Butler et al. (1998), Baucher et al. (1999), Das and Sohnesen (2006), and Coenen et al. (2006).

providers do have to pay for prescribed medicine there were small and negative effects. This indicates that physicians compete for patients using antibiotics only when they have no cost responsibility for prescribed medicine.

The results might be biased if the places where the reform was implemented were experiencing different trends before the onset of the reform. To be sure this is not an issue the parallel trend assumption is tested by placebo tests where treatment years are substituted for placebo-treatment years. The models are specified on a county level as well as with a municipality-big-city specification. The results are robust across specifications and after the placebo tests. Since increased antibiotics use may lead to reduced sickness, treatment effects on sick leave decisions are estimated in order to facilitate a discussion on welfare effects. Results show a small and insignificant increase for sick leave decisions due to infections. Hence there is no evidence that increased antibiotics use increased welfare in terms of reduced sick leave.

This paper relates to a literature that evaluates whether increased competition among healthcare providers leads to quality improvements and efficiency gains. Theoretical evidence suggests a positive effect of competition on quality in healthcare when prices are regulated.[2] Empirical evidence is more mixed and while Robinson and Luft (1985) and Proper (2008) find a negative relationship between healthcare quality and competition a more recent literature points in the direction of a positive relationship.[3] 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 & McClellan (2000) find similar results using American data.

Previous empirical evidence on the economic determinants of antibiotic prescription is sparse. Bennett et al. (2014) correlate a Herfindahl index with antibiotics use in Taiwan, and find that moving from the 75th percentile to the 25th percentile in market concentration is associated with an increase in prescription of antibiotics of 6.6 percent. The authors can control for confounding factors such as population density and community health. Compared to Bennett et al. (2014) this

[2]See for instance Calem and Rizzo (1995), Gravelle (1999), Gravelle and Masiero (2000), Beitia (2003), Nuscheler (2003), Brekke et al. (2007), Karlsson (2007) or Greener and Mannion (2009).
[3]Propper (2008) is a rather recent publication but the paper evaluates an older reform.

paper provides a better identification strategy (difference-in-differences) and it also extends the analysis to investigating welfare effects measured as sick leave decisions.

More generally, the contribution of this paper is that it provides insights into the trade-off that arises when healthcare providers are made more responsive to patient preferences. In most consumer markets it is optimal if firms maximize consumer preferences. However, in a market with externalities of utilization, as well as information asymmetry between provider and patient, the consequences of increased responsiveness can be expected to be ambiguous. Previous literature has primarily investigated how increased competition between healthcare providers can improve welfare through increased quality of care. In contrast, this paper provides evidence that an increase in responsiveness to patient preferences may also have welfare-reducing effects.

The paper is organized as follows. In section 2 some background is provided on antibiotic prescription and multi-resistant bacteria. Section 3 describes the Swedish healthcare reform and section 4 describes the details of the data. This is followed by the econometric strategy in section 5, results in section 6, robustness checks in section 7, effects on market structure in section 8 and a discussion on welfare effects in section 9. The last section concludes.

2. Development of multi-resistant bacteria, patient preferences and over-prescription

Multi-resistant bacteria is a large and growing problem associated with 23,000 deaths annually in the US, and 25,000 deaths in the European Union (European Commission, 2012). 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 prescription of antibiotics and resistance in the European countries ranging between 0.65 to 0.84 depending on antibiotic type and bacteria investigated (Goossens et al. 2005). Out of an economics point of view antibiotics can be viewed as a finite common resource, in the sense that antibiotics can be used until a certain limit is reached, that is, when the development of resistant bacteria catches up with the forefront of developed antibiotics. It is only a matter of time when this will happen given current antibiotics use (Goossens et al. 2005, CDC 2013).

All prescribed antibiotics put an evolutionary pressure on bacteria and increase the risk of resistant bacteria, even antibiotics that are used appropriately. It is estimated however that about 50 percent of all antibiotics in the US are prescribed unnecessarily or in an incorrect and hence inefficient dosage (CDC, 2013). These prescriptions constitute a pure cost for society since they contribute to rising rates of multi-resistant bacteria without giving the patient the benefit of a treatment effect. Sweden has low prescription rates of antibiotics compared to for instance countries in southern Europe, and general knowledge of proper antibiotics use is comparatively high. Still 27 percent of the population in Sweden believes antibiotics can be used to cure virus infections, and 19 percent believes antibiotics are effective against common colds (André et al, 2010). Excess demand translates into excess consumption even in Sweden. Mölstad and Cars (1999) show that physicians in Sweden prescribe antibiotics more often than public policy recommends them to in the case of upper respiratory tract infections among other diagnoses.

Patients therefore demand antibiotics not only because they do not internalize negative externalities associated with antibiotics, but also because they are poorly informed or unable to evaluate their own medical condition (Ong et al., 2007). Antibiotics tend to be associated with few side effects, they are a relatively cheap medicine and most patients have previous experiences of being successfully treated with antibiotics. This makes them an attractive precaution. There is also a natural asymmetric information situation between a patient and a physician where the physician is better educated to evaluate the patient's health and the quality of the healthcare given. Previous studies have shown that willingness to prescribe antibiotics can in this situation be perceived by the patient as a signal of quality of healthcare provided or of concern for the patient's welfare (Avorn and Solomon, 2000). Explaining to a patient why antibiotics may not be an appropriate treatment takes time for the physician and may still not convince the patient.

Finally, in many cases there exists a medical uncertainty of whether use of antibiotics is appropriate or not, and costly tests might be needed to determine proper treatment. In such situations non-medical factors such as economic incentive structures will influence the physician's choice of whether to prescribe antibiotics or not (Mölstad and Cars, 1999). [4]

[4] See also Wickström Österwall (2014) for how reminders directed at physicians and patients affect antibiotic prescription in Sweden.

3. Healthcare organization and reform

The Swedish government decided in 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 their 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 the 290 assigned municipalities. 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 (OECD, 2013).

The individual county councils were assigned responsibility for making changes deemed necessary for the competition inducing reform. Common features were that there should be free entry for healthcare providers into the market and that healthcare providers should be compensated according to number of patient visits and number of patients “listed” with the healthcare provider, that is, a form of capitation. Before the reform healthcare providers were compensated according to location (and indirectly by the expected number of patients), poverty and health of the region etc. Patients have had since the early 1990’s some possibility to choose their healthcare provider, but there was no compensation directly connected to individual patients and healthcare providers had weak financial incentives to attract new patients (Anell, 2011).

After the reform there was a much clearer incentive to maximize the actual number of visits from patients and the number of patients listed. Competition increased with the reform both because of new healthcare providers that established themselves on the market, that is, the number of healthcare providers increased, and because of the change in compensation rules for already established providers. Section 8 in this paper investigates the effect of the reform on market structure in terms of newly established healthcare providers, share of private providers and number of patient visits. The purpose is to try to disentangle the effect of market structure change on antibiotic prescription from the effect of a change in financial compensation rules.

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 percent of patients' medicine costs. 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 by prescribing more medicine. Even when it comes to relatively cheap medicine a responsibility for medicine costs might function as a reminder for the physician to limit less motivated prescriptions. In the regression effects for counties that receive a pure competition shock are therefore separated from counties where both increased competition and cost responsibility matters. Henceforth the different effects will be referred to as "pure competition effect/pure treatment effect" and "mixed incentives effect" respectively.

The number of listed patients determines the majority of the income for healthcare providers in all treated counties, including counties where formally a high share of income is determined by number of patient visits. There is a clear advantage for the patient 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. After a patient lists themselves at a particular healthcare provider that healthcare provider is then compensated with a fixed amount every year. Thus, healthcare providers 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 prescription of antibiotics 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, a modified difference-in-differences estimation is used in the paper. The estimation strategy is discussed more in detail in section 5.

4. 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 antibiotic types in each definition have been selected by medical expertise at the Swedish Institute for Communicable Disease Control. Narrow spectrum antibiotics are antibiotic types that kill a small segment of bacteria, meaning that potential problems with development of multi-resistant bacteria are smaller for this antibiotics type. Conversely, broad spectrum antibiotics kill a large segment of bacteria, and hence are associated with higher risks. Together the antibiotic types in the broad spectrum variable and narrow spectrum variable account for a clear majority of all prescribed antibiotics in Sweden. A description of the antibiotic types 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 results using prescriptions are used but using defined daily dosages gives very similar results.

An underlying assumption of this paper is that there exists a “grey zone” in which antibiotics might be more or less appropriate medically. If it is true that the increased leverage of the patient make physicians more willing to prescribe antibiotics this should be especially true for cases where it is ambiguous whether antibiotics are motivated or not. A high share of the narrow spectrum antibiotics consists of antibiotics for upper respiratory tract infections. Antibiotics might be motivated in case the infection is bacterial and severe, but in most cases such infections are instead caused by viruses, which makes antibiotics use redundant. Since it is often hard to judge whether antibiotics is motivated or not one can expect an increased leverage of patients 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.

Data on market characteristics, that is, data on the number of healthcare providers, share of private healthcare providers and patient visits comes from SKL (Sveriges Kommuner och Landsting). The data is on yearly and county basis and has been extrapolated to be consistent with the antibiotics data.

To enable a discussion on welfare effects, treatment effects of the reform are estimated on sick leave decisions made by physicians. The treatment effects are estimated for all sick leave decisions, sick leave decisions due to infections, circulatory issues and for psychiatric disorders. It is possible that the competition inducing reform had a direct impact on sick leave decisions since increased patient leverage may impact physicians' decisions the same way it might impact their decision when it comes to antibiotic prescriptions. This means that an absence of negative effect on sick leave due to the reform can not directly be interpreted as that increased antibiotics use had no effect on sick leave. In such case it will be known however that a possible negative effect on sick leave because of increased antibiotics use did not dominate a positive direct effect on sick leave from the reform. Data for the sick leave decisions come from the Swedish social insurance agency and has the same structure as the antibiotics data. The sick leave data is however censored whenever less than 10 individuals in a particular municipality in a particular month get a specific diagnosis.

Summary statistics for all outcome variables can be found in table A3, A4 and A5 in the appendix.

5. Econometric strategy

In order to isolate the effect of the reform on prescription of antibiotics, a model with the following structure is estimated:

$$Antibiotics_{it} = \alpha + \alpha_1 Pure\_Reform_{it} + \alpha_2 Mixed\_Reform_{it} + \beta_1 PRP_{it} + \beta_2 PRM_{it} + \lambda_t + \mu_i + \varepsilon_{it}$$

The variable $Antibiotics_{it}$ 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. $Pure\_Reform_{it}$ and $Mixed\_Reform_{it}$ are dummy variables taking the value one the year of the reform in treated areas and zero otherwise. The difference between

Pure_Reform$_{it}$ and *Mixed_Reform*$_{it}$ is that *Pure_Reform*$_{it}$ 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_Reform*$_{it}$ instead measures the effect of competition combined with medicine cost responsibility. In treated areas 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 are included. Municipalities located right next to a big city arguably share healthcare market with the big city municipality.

PRP$_{it}$ and *PRM*$_{it}$ are post reform dummy variables taking the value one for all years after the reform for the pure reform and mixed reform areas respectively. λ_t and μ_i are 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 model. The used model is chosen in order to capture the pro-competition incentive shock that the reform triggers on the reform years, 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 in this paper the effects for treatment and years post treatment are separated. This is necessary since politicians evaluated effects of the reform on prescription of antibiotics after reform and issued counter measures where prescriptions had increased. A standard difference-in-differences model will hence not capture a pure competition effect. Another reason to why this specification is better for the purpose in this paper is that most of the listings took place during the reform years and it is reasonable to assume that the reform years are the years where the competition effect would matter most. The specification used captures this competition shock better than a standard difference-in-differences model. Results from a classic difference-in-differences set up can be found in Table A1 in the appendix.

The model looks 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[5], the underlying assumption being that effects of a competition reform should only matter in regions where a choice of healthcare provider is feasible. As a robustness test a regression on treated

[5] 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.

counties rather than municipalities with a big city is also run. In this specification only include Halland, Stockholm and Västmanland can be included 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.

6. Results

The results shown in Table 1 indicate that the effect of competition on prescription of antibiotics is positive. 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 percent and as predicted the effect on narrow spectrum antibiotics was the largest at 7 percent. Broad spectrum antibiotics show the smallest effect at 3 percent.

Table 1: Results from the difference-in-differences regressions on the three antibiotics outcome variables. The dependent variables are logged.

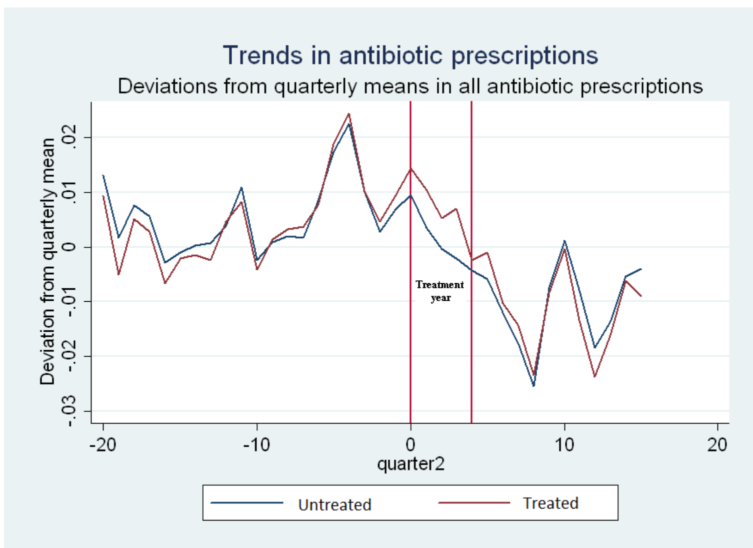
	All antibiotics	Broad spectrum antibiotics	Narrow spectrum antibiotics
Pure treatment areas	0.05*** (0.01)	0.03** (0.01)	0.07*** (0.01)
Mixed incentives treatment areas	-0.01** (0.01)	-0.03** (0.01)	-0.00 (0.01)
Number of obs.	31,320	31,320	31,320
R^2	0.72	0.73	0.59

Note: Standard errors within brackets. P-values indicated with stars where 0.1=*, 0.05 = ** and 0.01= ***.

Interestingly, all positive significant effects on prescription of antibiotics in association with the reform disappear when healthcare providers are held responsible for medicine costs. Broad spectrum antibiotics have a significant effect at -3 percent for this treatment whereas there is no effect on narrow spectrum antibiotics. One explanation might be that broad spectrum antibiotics are on average more expensive than narrow spectrum antibiotics.

Below Figure 1 illustrates the pure treatment effect for all antibiotics. The figure 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. To deseasonalize the trends, quarterly means for the different seasons have been subtracted.

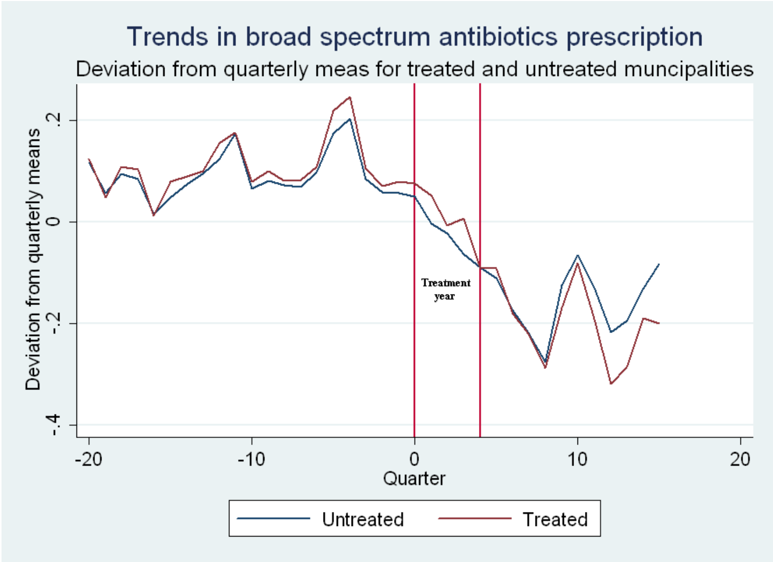
Figure 1: Pooled trends in all antibiotic prescription for treated and untreated areas.



Note: The trends have been deseasonalized to smooth the graph.

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.

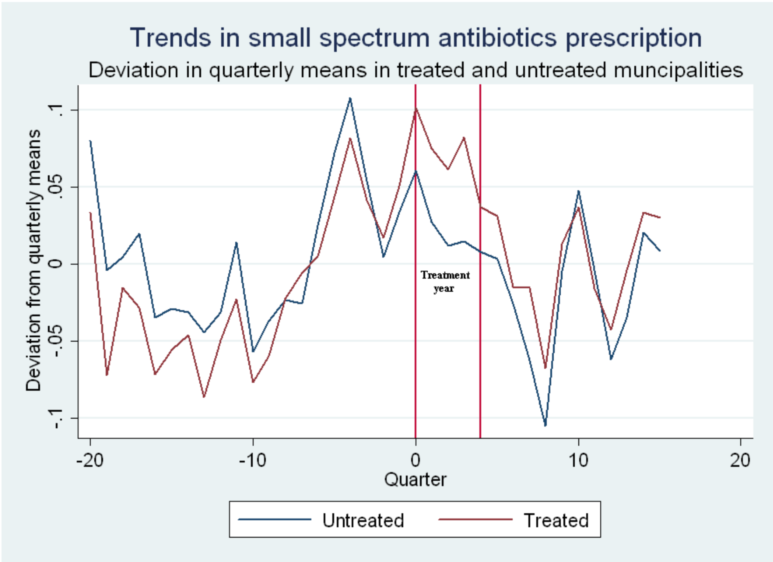
Figure 2: Pooled trends in broad spectrum antibiotics prescription for treated and untreated areas.



Note: The trends have been deseasonalized to smooth the graph.

Finally in Figure 3 we see that narrow spectrum antibiotics follow the same trends as all antibiotics. The treatment effect for narrow spectrum antibiotics is however more pronounced.

Figure 3: Pooled trends in narrow spectrum antibiotics prescription for treated and untreated areas.



Note: The trends have been deseasonalized to smooth the graph.

7. Robustness checks

In this section I want to test the robustness of the results for the big-city specification and find a lower bound for the general effect of the competition reform. Rather than defining treated as being a municipality with a big city (or being next to a big city), here all municipalities located in a county that implemented the reform are defined as treated. In this specification only Halland, Stockholm and Västmanland can be included since the reforms in the other counties occurred in the last six months of 2009 or in 2010 and hence these counties 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 regressions on the three antibiotics outcome variables where the effect is estimated for municipalities in treated counties. The dependent variables are logged.

	All antibiotics	Broad spectrum antibiotics	Narrow spectrum antibiotics
Reform effect	0.04*** (0.01)	0.04*** (0.01)	0.05*** (0.02)
Number of obs.	31,320	31,320	31,320
R^2	0.51	0.52	0.43

Note: Standard errors 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 percent instead of 7 percent. It is interesting to note however that the R^2 falls dramatically in this specification compared to the big-city specification.

The assumption of parallel trends is tested for by creating placebo reform dummies for years when treatments were not carried out in Table 3. This means that the same estimations as in

Table 1 are carried out, but instead of assigning the right years for when the reforms were introduced, the reform years are lagged one step behind in time. For “2004-2007” for instance it is assumed that the reform was carried out 2004 in Halland, 2005 in Stockholm and Västmanland, and so forth. If the parallel trend assumption holds placebo treatment effects should be insignificant or substantially smaller in magnitude than actual treatment effects.

Table 3: Placebo test where the same regressions as in Table 1 are carried out but with placebo treatment years. This table shows the results for the “pure treatment effect” areas. Dependent variables are logged.

	All antibiotics	Broad spectrum antibiotics	Narrow spectrum antibiotics
2004-2007	-0.01** (0.01)	0.00 (0.01)	-0.01 (0.01)
2005-2008	0.00 (0.01)	0.00 (0.01)	-0.00 (0.01)
2006-2009	0.01*** (0.01)	0.00 (0.01)	0.02** (0.01)

Note: Standard errors within brackets. P-values indicated with stars where 0.1=*, 0.05 = ** and 0.01= ***. Number of observations are 31,320 in all regressions.

The same placebo test for treatment effects in municipalities where healthcare providers are responsible for medicine costs can be seen Table 4 below.

Table 4: Placebo test where the same regressions as in Table 1 are carried out but with placebo treatment years. This table shows the results for the "mixed incentives treatment effect" areas. Dependent variables are logged.

	All antibiotics	Broad spectrum antibiotics	Narrow spectrum antibiotics
2004-2007	0.01 (0.01)	0.03** (0.01)	-0.01 (0.01)
2005-2008	0.00 (0.01)	0.01 (0.01)	-0.01 (0.01)
2006-2009	0.00 (0.01)	0.01 (0.01)	0.01 (0.01)

Note: Standard errors within brackets. P-values indicated with stars where 0.1=*, 0.05 = ** and 0.01= ***.
Number of observations are 31,320 in all regressions.

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 positive point estimate of 3 percent in broad spectrum antibiotics in 2004 for counties with responsibility for medicine costs. 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 pure treatment effect placebo test reported in Table 3.

8. Change in market structure as a consequence of the reform

In this section results are presented from regressions on market structure variables corresponding to the regressions reported in Table 1. Since the reform used in this paper affected both establishment of new healthcare providers and the incentives faced by healthcare providers it is important to see how the reform affected new establishment and patient behavior in the different treatment areas. In Table 5 results for patient visits, healthcare providers and share of private providers are reported.

Table 5: Results from difference-in-differences regressions on market structure outcomes. The dependent variables are logged. Same specification as in Table 1.

	Patient visits	Healthcare providers	Share of private providers
Pure treatment areas	0.15*** (0.00)	0.09*** (0.00)	0.09*** (0.00)
Mixed incentives treatment areas	0.00 (0.00)	0.01** (0.01)	0.03 (0.00)
Number of obs.	31,320	31,320	31,320
R^2	0.90	0.89	0.89

Note: Standard errors within brackets. P-values indicated with stars where 0.1=*, 0.05 = ** and 0.01= ***.

It is clear from Table 5 that more new healthcare providers established themselves in the pure treatment effect areas than in the mixed treatment effect areas during the reform years. The number of healthcare providers increased with 9 percent in the pure treatment areas, and only increased with 1 percent in the mixed treatment areas. This means that the effect of newly established healthcare providers is comparatively more important in the pure treatment effect areas compared to the mixed treatment areas. All of the counties in the pure treatment effect areas except for Gotland are early adopters of the competition inducing reform which might explain this difference. Stockholm, Halland and Västmanland, all early adopters, together account for approximately 30 percent of the Swedish population and a wish for increased entry into the healthcare market was a major reason the reform came early in these counties.

In Stockholm increased accessibility was an important motivation for the reform and in Halland and Västmanland entry of new providers closer to patients was considered important (Anell, 2011). Since the share of private providers increased substantially in the pure treatment areas it is reasonable to assume that many of the newly established healthcare providers were private providers. Number of patient visits also increased substantially in the pure treatment effect areas. This is most likely because of increased accessibility in Stockholm, Halland and Västmanland. It is also likely an effect of that compensation in Stockholm is highly dependent on number of patient visits after the reform was introduced. In Stockholm 50 percent of the compensation to healthcare providers come from number of patient visits, which is the highest share in any county.

9. Effects on sick leave

So far in this paper negative externalities associated with prescription of antibiotics have been discussed, that is, development of multi-resistant bacteria. There are however positive effects associated with increased antibiotics use as well, provided that at least some of the extra prescription are for patients that medically need antibiotics. For instance, increased use of antibiotics may lessen need for sick leave or decrease the spread of infectious disease, which may in turn decrease sick leave, suffering and societal costs. These positive effects must be weighed against the negative externality that multi-resistant bacteria constitute.

For several reasons it is not straightforward to compare the positive effects and negative externalities. One reason is the time dimension. To the degree increased prescription of antibiotics will generate positive externalities they will to a large extent be short term, shown in reduced sick leave and reduced spread of disease. Development of multi-resistant bacteria on the other hand potentially has a non-linear development, which makes the negative consequences of prescription of antibiotics harder to predict, especially in the medium to long run. Table 6 shows the treatment effects of the competition inducing reform on sick leave. The big-city specification from the result section is used, effects for mixed incentive areas and pure competition areas are separated since an increase in antibiotic prescription is only observed in the pure treatment effect areas. It is important to note that the competition inducing reform might have a direct impact on sick leave, as well as an indirect effect through increased antibiotics use.

Table 6: Results from a difference-in-differences regressions on sick leave outcome variables. The dependent variables are logged.

	All sick leave	Infections	Psychiatric disorders	Circulatory system disorders
Pure treatment areas	0.04*** (0.01)	0.02 (0.05)	0.02 (0.02)	0.04* (0.02)
Mixed incentives treatment areas	0.01 (0.01)	-0.05 (0.04)	-0.02 (0.02)	-0.05* (0.02)
Number of obs.	34,798	876	21,732	4,752
R^2	0.67	0.81	0.52	0.76

Note: Standard errors within brackets. P-values indicated with stars where 0.1=*, 0.05 = ** and 0.01= ***.

The effects are separated for all sick leave, sick leave as a consequence of infections, psychiatric disorders and circulatory system disorders. The effect for all sick leave is 4 percent and significant for the pure treatment areas. The general effect on sick leave is smaller and insignificant for the mixed treatment areas. This result could potentially be driven by that Stockholm is included in the pure treatment group, and in Stockholm number of visits is important for economic compensation. Sick leave decisions generally require follow-up visits to a high degree. There are no significant effects for infections or psychiatric disorders, and the effects on circulatory system disorders are inconsistent and significant on the 10 percent level.

Since there are generally no consistent treatment effects for sick leave prescriptions it is plausible to interpret the lack of a significant reduction in sick leave for infections for the pure treatment areas as that the increase in antibiotic prescription did not directly affect sick leave. Even if it is argued that increased prescription of antibiotics could have hampered sick leave due to infections, there is no evidence that welfare increased in terms of reduced sick leave as a consequence of the competition inducing reform. If increased prescription of antibiotics did reduce sick leave, there is no evidence that this effect dominated the direct reform effect on sick leave prescriptions.

10. Discussion

The results show that the competition-inducing reform had a positive and significant effect on prescription of antibiotics in areas where healthcare providers do not have to pay for prescribed medicine. Estimated effects are 5 percent for all antibiotic prescriptions, 3 percent for broad spectrum antibiotics and 7 percent for narrow spectrum antibiotics. These increases in prescription of antibiotics did not translate into reduced sickness as measured in sick leave decisions. The treatment effects in areas where healthcare providers do have a medicine cost responsibility are insignificant or negative. The difference in treatment effects between areas with and without a medicine cost responsibility can partly be explained by that the number of healthcare providers increased more in areas with no medicine cost responsibility. The number of healthcare providers increased in the pure treatment areas with 9 percent as compared to 1 percent in the mixed incentives treatment areas. The effect of increased number of healthcare providers can not be separated from the effect of changed rules for compensation. Hence the absence of positive treatment effects in the mixed incentive areas may be a result of either the medicine cost responsibility directly, or it may be an indication that an increase in number of healthcare providers is more important for antibiotic prescription than a change in compensation rules.

It was proposed in section 4 that if increased patient leverage matters for prescription of antibiotics, the largest impact should be seen on narrow spectrum antibiotics. This is also what is observed. 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 increases quality of healthcare and that more tests are performed. These tests would then be followed by suitable antibiotics which in most cases will be narrow spectrum antibiotics. It is possible that patients respond 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.

The increase in prescription of antibiotics shown in this paper is centered on the actual treatment years, that is, the years the reform was introduced in different counties. The effect on narrow spectrum antibiotics is still positive the years after the treatment years, but the effect on broad spectrum antibiotics is negative. This is most likely a consequence of that many counties evaluated effects on antibiotic prescription following the reform and put in counter measures if needed. Reducing broad spectrum antibiotic prescription was considered most important. Counter measures included information campaigns and fines for prescribing outside a specified range. It is a question for further research to establish whether these measures can continue to counterweight the effect of competition on prescription of antibiotics.

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Appendix

Definition of narrow spectrum antibiotics:

PcV (fenoximetylpenicillin) J01CE02
Nitrofurantoin J01XE01
Pivmecillinam J01CA08
Trimetoprim J01EA01

Definition of broad spectrum antibiotics:

Amoxicillin (J01CA04)
Amoxicillin with clavulanic acid (J01CR02)
Doxycyklin (J01AA02)
Cefalosporiner J01DB+J01DC+J01DC+J01DE
Erytromycin J01FA01
Kinoloner J01MA02+J01MA06

Table A1: Classic difference-in-differences regression results, all treated big cities, dependent variables logged.

	All antibiotics	Broad spectrum antibiotics	Narrow spectrum antibiotics
Pure treatment areas	0.01 (0.01)	-0.04*** (0.01)	0.05*** (0.01)
Mixed incentives treatment areas	-0.01* (0.01)	-0.04** (0.02)	-0.00 (0.01)
N	31,320	31,320	31,320
R^2	0.72	0.73	0.59

Note: Standard errors within brackets. P-values indicated with stars where 0.1=*, 0.05 = ** and 0.01= ***.

Table A2: Post treatment dummies, all treated big cities, dependent variables logged.

	All antibiotics	Broad spectrum antibiotics	Narrow spectrum antibiotics
Pure treatment areas	-0.00 (0.01)	-0.06*** (0.02)	0.04*** (0.01)
Mixed incentives treatment areas	-0.02* (0.01)	-0.04*** (0.02)	-0.01 (0.01)
N	31,320	31,320	31,320
R^2	0.72	0.73	0.59

Note: Standard errors within brackets. P-values indicated with stars where 0.1=*, 0.05 = ** and 0.01= ***.

Table A3: Summary statistics for the antibiotics variables. Number of prescriptions per 10,000 inhabitants.

	Mean	Standard dev.	Min	Max	Observations
All Prescriptions	329	57	160	601	31,320
Narrow spectrum antibiotics	151	28	51	412	31,320
Broad spectrum antibiotics	112	32	34	306	31,320

Table A4: Summary statistics for the sick leave variables. Number of sick leaves per 10,000 inhabitants.

	Mean	Standard dev.	Min	Max	Observations
All sick leave	51.2	13.7	8.3	126.2	34,798
Infections	1.0	0.6	0.2	8.2	876
Psychiatric disorders	9.3	3.0	1.3	56.7	21,732
Circulatory system disorders	2.2	1.3	0.4	17.3	4,752

Table A5: Summary statistics of market structure variables. Statistics based on county observations yearly. Patient visits in thousands.

	Mean	Standard dev.	Min	Max	Observations
Number of patient visits	631.7	809.7	69.5	4138.9	189
Healthcare providers	51.6	49.6	7	225	189
Private healthcare providers	15.8	24.9	0	131	189