Do Doctors Listen?

Prescribing Rates of NSAIDs as influenced by the National Health Service of the UK

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1 Introduction

The National Health Service (NHS) of the United Kingdom is the world's largest publicly funded health service; it is directly funded by taxation and provides health care to any resident of the United Kingdom, currently 63.2 million people [1]. The NHS is concerned with how well all of their doctors, physicians and employees are providing health care, so they release directives about prescribing to make sure health care is provided well and efficiently. They also keep track of all of the drugs prescribed by all of the practices. As part of their transparency agenda, they have been publishing this data on the web for several years.

In this analysis, we're using the NHS Open Data to look at how NHS directives relate to actual prescribing practice. Specifically, we'll be looking at how prescribing rates of diclofenac and naproxen, two popular NSAIDs, relate to two events that happened during our data set. This first event is a directive stating that because diclofenac has negative side effects, practices should prescribe naproxen in its place. This directive was originally issued several years before our data set, but was re-issued in October 2012.

The second event is a reorganization of the NHS. Currently, all of the practices in Britain are divided into governing bodies called CCGs (Clinical Commissioning Groups). These CCGs are responsible for "commissioning the vast majority of NHS services" [2]. But these CCGs were only formed in April 2013. Before this the governing bodies were PCTs (Primary Care Trusts). The reorganization left many boundaries intact, but split up or merged some PCTs to form CCGs.

We're asking how directive(s) and reorganization of the NHS influences the prescribing behavior of the country as a whole, how this varies between CCGs, and if there is geographic clustering in how CCGs respond.

2 Question 1

How did the directive released in October 2012 and the reorganization of the NHS governing structure influence prescribing rates of diclofenac and naproxen across the country?

2.1 Methodology

Most of our data was gathered from NHS Open Data [3]. Every month, the NHS publishes a file containing the amount of every drug that each individual practice prescribes. These are provided to the public approximately four months after the fact. In our analysis, we used data from January 2012 until October 2013. The values we used in this analysis were:

DATE: Month and year data was taken.

BNF: Code for the drug, which also identifies the chemical make-up.

QUANTITY: Amount of drug dispensed measured in units matching the formulation of the product.

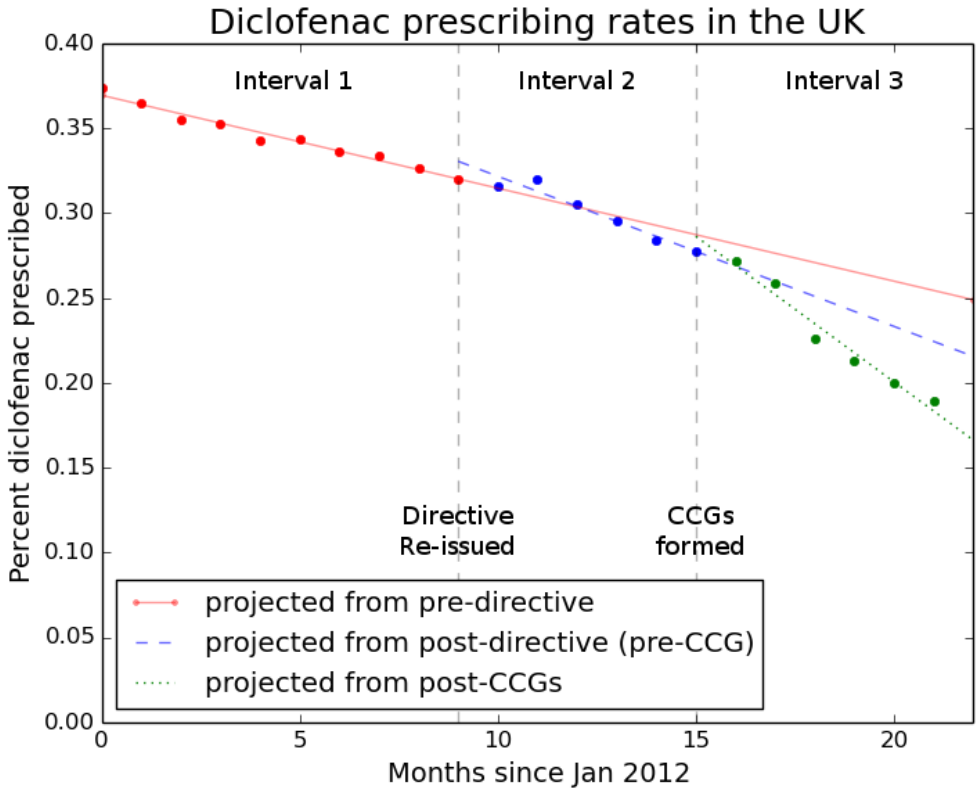

Figure 1: The Percent Diclofenac prescribed across our entire dataset for each month.

We also received supplemental information from a physician in the NHS with information on dosing schedule:

Dosing Schedule: Quantity taken per day for each preparation of naproxen and diclofenac.

We calculated the daily dose equivalent of naproxen and diclofenac prescribed each month by dividing the quantity of each prescribed by the quantity in its daily dose, to get days prescribed. The percent diclofenac was calculated out of the total number of days of diclofenac and naproxen prescribed. The metrics that we calculated in this analysis were:

Prescribed: Quantity / Dosing Schedule

Percent Diclofenac: Days Prescribed Diclofenac / (Days Prescribed Diclofenac + Days Prescribed Naproxen)

2.2 Data and interpretation

Looking at diclofenac prescribing rates across the UK, we can see that the total rate of diclofenac prescriptions filled has been decreasing steadily for the entirety of our observation period, as shown in Figure 1.

To determine the rate of change in the percentage of diclofenac prescribed, we divided the data into months before October 2012 (when the directive was re-issued), between October 2012 and April 2013 (after the directive, but before the formation of CCGs), and after April 2013 (after the formation of CCGs), which are Interval 1, 2 and 3 respectively. Since the data is approximately linear within intervals, we determined the rate of change in each interval using a linear least squares fit.

Using a line fit to Interval 1, we find that the rate of change of diclofenac prescription is -0.55 percentage points per month. If we do the same with Interval 2, we see the rate of change of diclofenac is -0.88 percentage points per month. With Interval 3, the rate of change is -1.7 percentage points per month.

To check whether these differences actually indicate a meaningful change, we compare the magnitude of the change to the standard deviation of the data. The standard deviation around the line is 0.7 percentage points for the first two intervals, and 0.9 percentage points for Interval 3. Since the changes in slope from interval to interval are 0.3 percentage points and 0.8 percentage points, it takes several months for the trend to move more than one standard deviation away from the previous interval's prediction, but as these changes in slope are sustained over multiple months, they eventually lead to substantial changes in amount prescribed.

If we use data from Interval 1 to project the rate of diclofenac prescription in October 2013, we expect a 25% diclofenac prescribing rate. Using data from after the directive, but before CCGs, we expect a 22% diclofenac prescribing rate. In reality, both of these are higher than the observed rate of 19%. Using the average slope in Interval 3, however, we actually underestimate the prescribing rate at October 2013, indicating that the effect from the switch to CCGs may be a one-time drop, rather than a sustained increase in the rate of decrease.

Since the rate at which diclofenac prescribing is decreasing is 60% better in the interval after the directive than before the directive, it appears the directive did have some effect. However, if we project out to 2013, the re-issuance of the directive can only account for part of the difference between the prescribing rate projected from before the directive and the actual prescribing rate. It also appears that the reorganization into CCGs had a substantial role in decreasing the amount of diclofenac prescribed.

3 Question 2

How did the directive released in October 2012 and the reorganization of the NHS governing structure influence prescribing rates of diclofenac and naproxen across CCGs? Does the distribution of responses lead us to believe that governing body or geographic region has a substantial effect on the behavior of the constituent practices?

3.1 Methodology

In this analysis, we use two additional fields from the NHS data set:

PRACTICE: Code for the individual practice.

CCG: NHS group of practices.

Before April 2013, the "CCG" field actually refers to the PCT code a given practice belongs to. In order to maintain consistent groups throughout the duration of the analysis, we determined which CCG each practice belonged to in April 2013 and used that CCG to group it in the months before April 2012. So current CCGs may have actions ascribed to them which happened before they were actually constituted - these are, instead, actions performed by the group of practices which eventually constituted the CCG, and which were generally in the same PCT before the transition.

3.2 Data and Interpretation

3.2.1 CCG Impact

Figure 2 is a scatter plot that compares the rate of change of diclofenac prescriptions from the practices within a CCG before the directive was released (Interval 1) to the rate of change after the directive but before the CCGs were formed (Interval 2). We can see that the majority of CCGs cluster below the identity line, meaning they are decreasing their diclofenac prescriptions more rapidly after the directive than before it. CCG groups above the dashed line are decreasing less after the directive than before, while those below the dashed line are decreasing more after the directive.

In Figure 3, we compare the rate of change of diclofenac prescriptions after the directive but before the CCGs were formed (Interval 2) to the rate of change after the CCGs were formed (Interval 3) in order to look at the effect of the formation of CCGs. We, again, see that most CCGs decrease their diclofenac prescriptions more rapidly after the reorganization. CCG groups above the dashed line are decreasing less after forming CCGs, while those below the dashed line are decreasing more after forming CCGs.

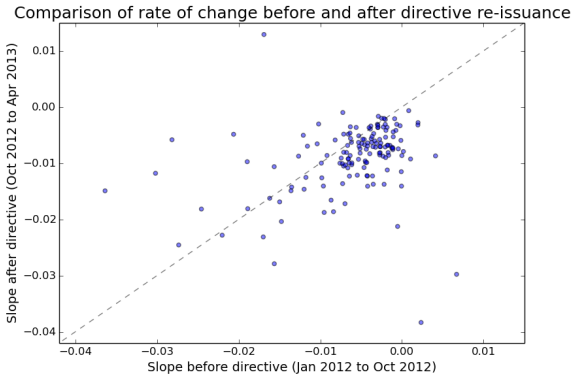

Figure 2: The rate of change in diclofenac prescriptions after the directive versus the rate of change before the directive for each CCG group.

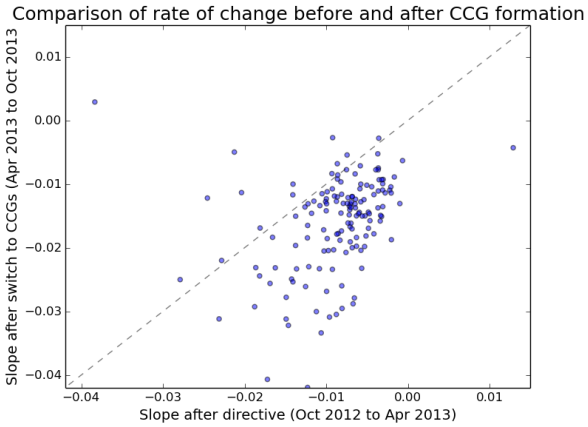

Figure 3: The rate of change in diclofenac prescriptions after the switch to CCGs versus the rate of change before the switch to CCGs for each CCG group.

It is unclear from only these plots, however, whether which CCG a practice belongs to actually effects its behavior, or if the variance we see is just due to random variance between practices. We theorize that if the CCGs have an effect on practice behavior, then practices within a CCG will tend to be similar along metrics like percent diclofenac prescribed and rate of change in diclofenac prescriptions. If this is the case, then the distribution of these metrics across the CCGs will have a higher variance than if CCGs had no effect, since they will tend to either have all practices below the mean or all practices above the mean. We used the percentage of diclofenac prescribed in the last month of our data set for this analysis. We computed the actual variance, then repeatedly simulated data under the null hypothesis to find the probability of observing a variance at least this high if CCGs were uncorrelated with prescribing behavior.

For the percentage of diclofenac prescribed at October 2013, the probability of observing a variance as high as we do is less than .001. In Figure 4, we can see the actual distribution of this metric and an example distribution of this metric under the null hypothesis. We can compare the actual distribution of this metric to one under the null hypothesis and see that in reality CCGs display more variance than can be explained by random assignment. On the basis of this result we can feel relatively confident moving forward under the assumption that prescribing practice is related to CCG membership.

3.2.2 Geographic Correlation

To visualize the decrease in diclofenac by governing body over time, we created a series of maps showing the percent diclofenac prescribed by each PCT or CCG every month from January 2012 until October 2013. In Figure 5 are several key frames from this graphic. Between the first two, before the release of the directive, little change can be observed. Between August 2012 and March 2013, however, the directive is released, and a noticeable decrease in diclofenac prescribing occurs. Between March 2013 and September 2013, CCGs are created, and diclofenac prescribing drops remarkably. Throughout the entire time series, specific PCTs/CCGs and entire geographic regions seem to maintain higher or lower prescribing rates than the median, even as everyone increases or decreases.

To further clarify how each CCG group responded to the directive, we created Figure 6, which shows the difference in the slope of each CCG before and after the directive. For example, a CCG group with a slope difference of 0.01 might have gone from decreasing its prescribing by 0.5 percentage points per month before the directive to decreasing its prescribing by 1.5 percentage points per month after the directive (changing from a slope of -0.005 to -0.015). Clearly, some CCG groups reacted more than others (some even went the opposite directions), and there appears to be some geographic connection to it.

However, this metric does not take into account the total number of diclofenac prescriptions that a CCG group is filling. If a CCG group is already prescribing a very low amount of diclofenac and decreasing them

Actual distribution of percent diclofenac prescribed compared to distribution with no CCG correlation

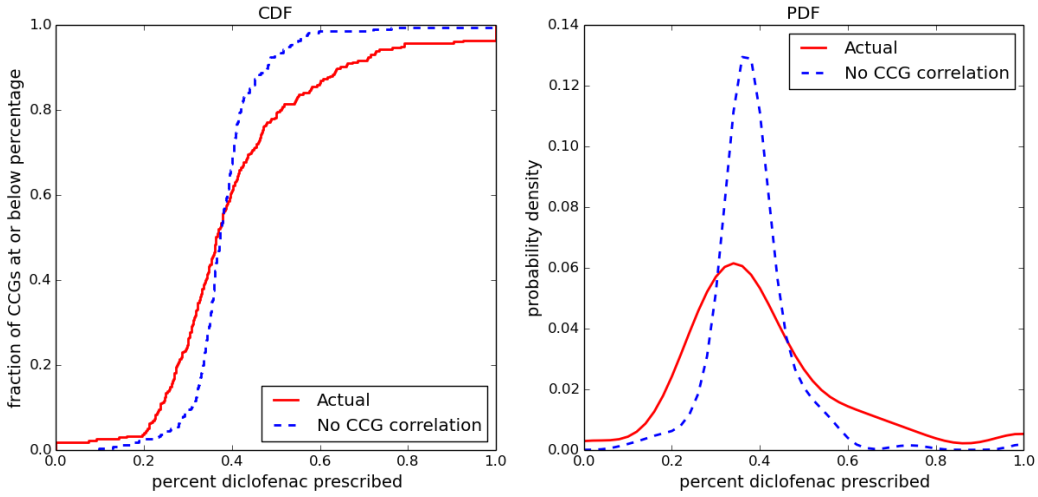

Figure 4: CDF and smoothed PDF of the actual distribution of diclofenac prescribing in October 2013 among CCGs versus an example distribution if practice behavior were totally uncorrelated with CCG affiliation. The actual distribution shows a noticeably higher variance than would be expected with no correlation. The probability that is effect is due to chance is less than 0.1%, leading us to believe that CCG affiliation is related to prescribing behavior.

	Slope After Directive	
Total percent in Jan2012	Small ($> -.01$)	Large ($< -.01$)
High ($> .33$)	Incorrigible	Compliant
Medium (.33% - .25%)	Non-compliant	Compliant
Low ($< .25$)	Good	Angels

Table 1: Classification scheme used for breaking CCG groups into classes based on compliance.

rapidly, it would be difficult for the slope to decrease by much more. This is why in the next two figures we take as factors in the classification the total amount of diclofenac prescribed and the absolute, rather than relative, slope.

To capture differences between CCG groups, we classified each CCG group according to its behavior before and after the directive. We used two metrics, the total percentage of diclofenac prescribed in January 2012 and the rate of decrease of diclofenac prescriptions in Interval 3. The values we used for classification were chosen solely to divide the CCGs into reasonably sized groups. Figure 7a shows the percent of diclofenac prescribed by each CCG in January of 2012. The CCGs are classified into three groups: high, medium and low. Those who had a percentage above .33 were assigned high, between .33 and .25 were assigned medium and below .25 was assigned low.

Figure 7b displays the slope of the percentage of diclofenac in Intervals 2 and 3. Those with the classification of small are decreasing their diclofenac prescriptions by less than 1 percentage point per month, and those with the classification large are decreasing their diclofenac prescriptions by more than 1 percentage point per month.

Since there are many different metrics to evaluate the CCGs on, to create a general classification we combined the two attributes discussed above (percent prescribed at the beginning of the data set and slope in Interval 2 and 3). The classifications for each CCG group to describe their level of compliance with the directive are shown in Table 1. In Figure 8, those CCG groups which started out with a low prescribing rate and continued to decrease it after the directive, are “Angels” colored yellow. Those which started out with a medium or high prescribing rate but were decreasing rapidly after the directive are “Compliant”, colored

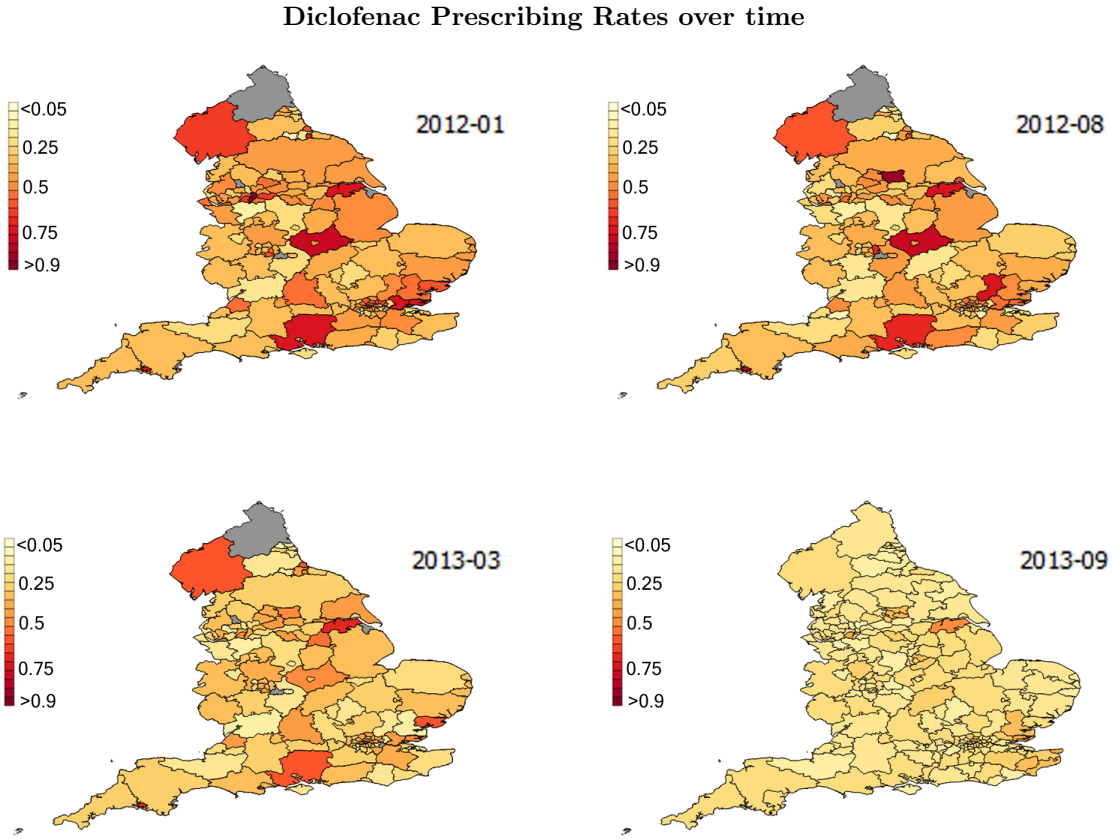

Figure 5: KeyFrames of a time-series plot of the percentage of diclofenac prescribed by each CCG. Months shown are January 2012, August 2012 (one month before the directive is re-released), March 2013 (one month before CCGs are formed), and September 2012. Red indicates a high rate of diclofenac prescription, while white indicates a low rate. Grey indicates missing data.

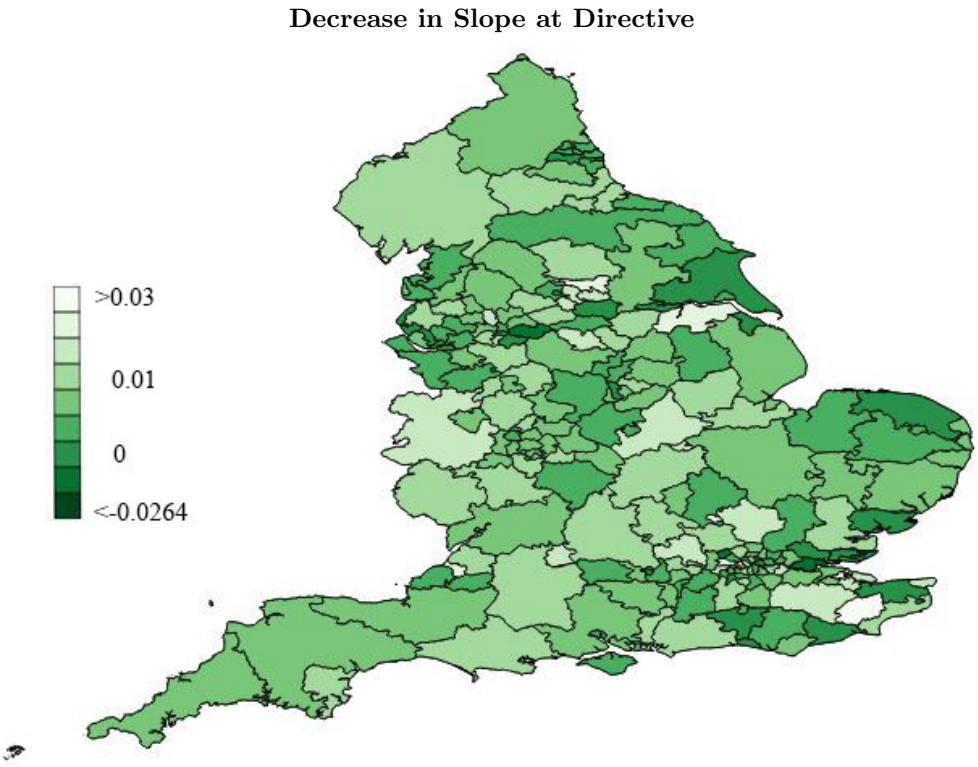

Figure 6: Decrease in slope of the percentage points of diclofenac prescribed from before the directive and after the directive, separated by CCG that a practice belongs to.

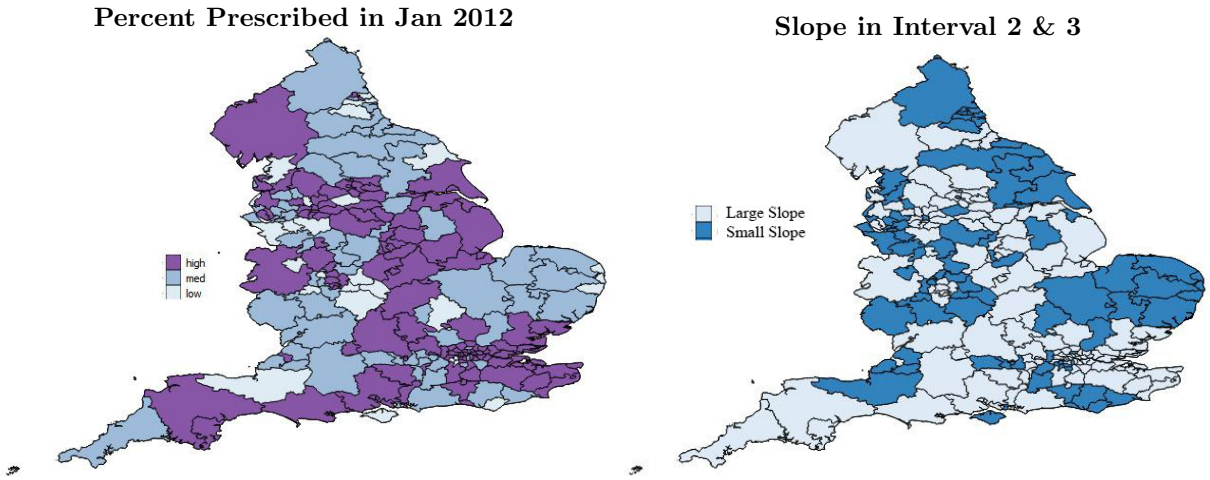

Figure 7: Maps of CCG groups classified according to Table 1

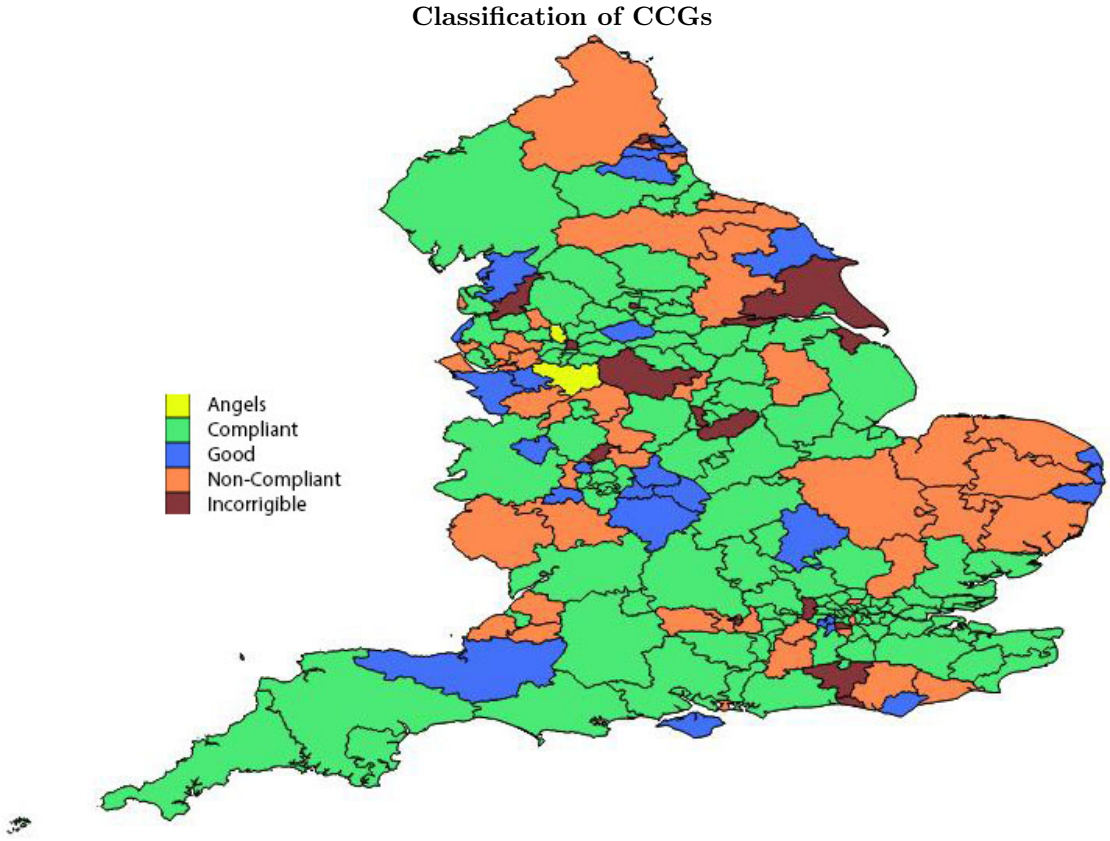

Figure 8: Displays the CCGs with their classifications that were derived from Figure 7.

green (this category makes up the majority of England). Those which started out with a low prescribing rate but were decreasing slowly after the directive are "Good", colored blue. Those which started out medium and showed no signs of decreasing substantially are "Non-compliant", light brown, and those which started out high and showed no substantial decrease are 'Incorrigible", dark brown.

Looking at Figure 8, there appears to be some geographic clustering of responses. Particularly, East Anglia appears to be almost entirely non-compliant - those practices in the region which are not non-compliant are "good", meaning that while they started with a relatively low prescribing rate they are not decreasing very quickly. Yorkshire and the Northeast also appear to have clusters of low compliance. Based on this we believe there are correlations to be drawn here, but we leave further theorizing to someone more familiar with England's geopolitics.

4 Conclusion and Future Work

The rate of diclofenac prescriptions has been decreasing steadily across the UK since at least January 2012. However, both the re-issuance of the directive, which instructed practices to prescribe naproxen instead of diclofenac and the formation of CCGs coincide with a greater rate of decrease in diclofenac prescriptions across the entire country. The actual effect of the directive varied substantially across CCG groups, and it appears that either the CCG or geographic region a practice belongs to has a substantial effect on its prescribing behavior. Both the amount of diclofenac a CCG prescribes and its compliance with the directive appear to display some clustering geographically, especially around East Anglia, Yorkshire and the Humber, and the Northeast. Th which should be investigated further by someone with more knowledge of England's geopolitics.

5 Limitations

Our research, and the data collected, has some limitations. We are only looking at one directive for one drug, and not any other set of drug groups. While practices acted a certain way for this drug group, that doesn't mean they act is consistently for all of the drugs. Our data also starts in January 2012 and goes until October 2013, so long term effects can not be observed. Also, many outside factors could change the prescription behavior of practices in a single CCG.

We are also limited by the events that occurred within our data set, specifically the governing switch from PCT to CCG. This forced us to make some generalizations. Anytime we refer to a CCG and are observing data from before October 2013, the practices are organized by the CCG they eventually end up in. While these often correspond directly with the PCTs they occupied at the time, this does mean that actions taken by CCG groups cannot always be ascribed to the current CCG governance.

6 References

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