MEASURING RATES OF CHLAMYDIA INFECTION AT GENITOURINARY MEDICINE CLINICS IN ENGLAND

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ABSTRACT

This paper aims to calculate the rates of Chlamydia infection at genitourinary medicine (GUM) clinics in England. Data on the number of cases is available from KC60 returns from GUM clinics in the Northwest and Southwest of the country, but the population exposed to risk is required in order to calculate rates of infection. This study tests three different methods of deriving the exposed to risk: Thiessen polygons, 15 mile boundaries, and 30 minute drive-times. It was found that the method of deriving the population exposed to risk did not significantly affect the Chlamydia rates. Thus the best choice of method was deemed to be the simplest approach, the Thiessen polygons. The 15 mile and 30 minute drive-time models did, however, highlight substantial differences in the accessibility of GUM services between the Southwest and the Northwest.

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Abstract

This paper aims to calculate the rates of Chlamydia infection at genitourinary medicine (GUM) clinics in England. Data on the number of cases is available from KC60 returns from GUM clinics in the Northwest and Southwest of the country, but the population exposed to risk is required in order to calculate rates of infection. This study tests three different methods of deriving the exposed to risk: Thiessen polygons, 15 mile boundaries, and 30 minute drive-times. It was found that the method of deriving the population exposed to risk did not significantly affect the Chlamydia rates. Thus the best choice of method was deemed to be the simplest approach, the Thiessen polygons. The 15 mile and 30 minute drive-time models did, however, highlight substantial differences in the accessibility of GUM services between the Southwest and the Northwest.

1. INTRODUCTION

Chlamydia trachomatis is the most prevalent sexually transmitted disease (STD) in the Western world[1] and the most commonly diagnosed STD at genitourinary medicine (GUM) clinics in the UK[2]. In about 75% of infected women and 50% of infected men, it is asymptomatic[3] but the long-term effects of infection can be serious, including chronic pain, ectopic pregnancy and infertility, as well as being the most frequent cause of pelvic inflammatory disease[1]. Although uncomplicated Chlamydia infection can usually be cured with a single short course of antibiotics, individuals can be re-infected.

It is estimated that Chlamydia trachomatis costs the NHS up to £100 million each year both in treating the infection and in addressing the long-term consequences. And according to the Health Protection Authority (HPA), Chlamydia diagnoses have been rising steadily since 1995[4]. However, these statistics are based on a count of the number of individuals infected with Chlamydia. This approach is widely used because the data to calculate it are easily available. GUM clinics submit returns to the HPA which provide data on the number of Chlamydia diagnoses they have made.

However, technological developments have changed our ability to diagnose and report the presence of disease. New initiatives, such as the National Chlamydia Screening Programme and the “Condom Essential Wear” campaign, are encouraging more people to get tested. The rise in disease diagnoses may reflect

these changes. Without knowing the size of the population from which these individuals come, it can be difficult to compare meaningfully between groups or over time.

The ideal measure of Chlamydia infection would be a rate – the number of infected individuals divided by the total population at risk of infection. However, identifying the population at risk is not straightforward. The current approach taken by the Health Protection Authority in their calculations is to aggregate the returns made by the GUM clinics in each Strategic Health Authority (SHA) and then to divide by the total population in that SHA[2]. However, this measure includes a number of individuals who are not at risk of Chlamydia, such as children. It also includes individuals who would not have attended the clinic because it is too far away from their home. Moreover, much of the detail of the differences between regions has been lost because the data for the clinics have been aggregated.

This study will explore alternative methods of deriving the population exposed to risk of Chlamydia and will use this population to calculate rates for each clinic. There are a number of techniques using a Geographic Information System (GIS) which can help us to allocate populations to clinics and improve upon the rates that are currently provided by the HPA.

With accurately calculated rates, we can begin to compare across locations in the UK. In an era of limited resources, it is important to know which areas to target in order to ensure that measures to reduce disease incidence are implemented

where they are most needed. This may mean sending extra resources to places with high rates or alternatively, it may mean asking questions about why some areas have much lower rates than their neighbours. Do these areas have genuinely lower rates and if so, why? Or do they represent areas where GUM services are being under-utilised and where additional efforts are needed to encourage individuals to attend for testing? It is only once we have reliable measures of Chlamydia infection that we can begin to think about tackling these questions.

The objectives of this study are:

- To derive the population for whom each clinic is the nearest GUM service using Thiessen polygons
- To derive the population for whom each clinic is "accessible" – i.e. within 15 miles
- To derive the population for who live within 30 minutes driving time of each clinic
- To compare these populations to explore whether GUM clinics suffer from accessibility problems which warrant the additional complexity of the drive-time model
- To calculate prevalence rates of Chlamydia for each clinic in the Northwest and Southwest of England using as a denominator each of the populations described above..
- To explore whether there are any spatial clusters of Chlamydia rates

2. DATA

The data have been taken from KC60 returns made by GUM clinics in the Northwest and Southwest Strategic Health Authority Regions of England. The KC60 return was conceived primarily as a way to measure the workload of GUM clinics but actually provides the main source of data on sexually transmitted diseases[5]. All GUM clinics have a statutory responsibility to provide information via the KC60 form on all clinic attendees each quarter. The limited data reported include:

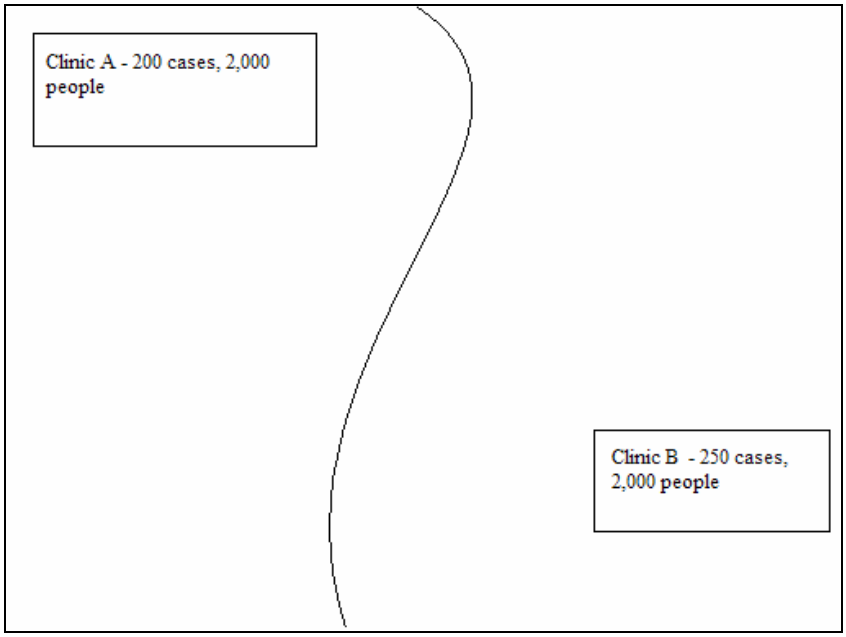
- condition;
- sex;
- number of male cases which were homosexually acquired; and
- age group.[6]

We will use the data reported in 2001, as they were provided for the majority of clinics in the Northwest and Southwest regions and, as this paper's main aim is to look at the feasibility of different approaches to deriving rates, the actual timeframe of the data is not particularly relevant.

The study will concentrate on the Northwest and Southwest regions because the decision to publish the information disaggregated by clinic is made at the local HPA level and we were able to obtain data only for the Northwest and Southwest regions.

The clinic data were cross-checked against the list of clinics in the HPA audit of GUM clinic waiting times[7] in order to ensure that no clinics were excluded from the study because of failure to provide permission for their KC60 data to be reported at the clinic level. If any clinics are missed, the effect would be to underestimate the rates in the surrounding clinics. To see this, imagine a region with 4,000 people and two clinics, A and B. These clinics have reported 200 and 250 cases respectively on their KC60 returns and there are 2,000 people in the catchment area of each clinic (see Figure 1)

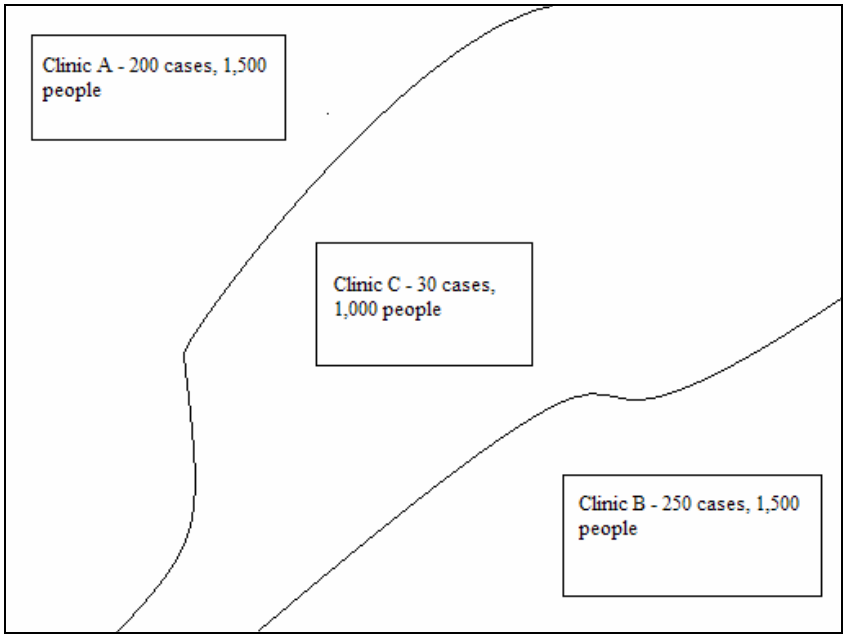
Figure 1. Example catchment area with two clinics



Now imagine that there is actually a third clinic, C, which was excluded from the original analysis. Some of the people from both clinic A and clinic B actually should be in the catchment area of clinic C, as in Figure 2. The result is that the catchment areas for clinics A and B get smaller, meaning that they have a smaller

population than they did before we included clinic C but the same number of cases reported. This would mean a smaller denominator when calculating the rate and hence a higher rate. We have done our best to ensure that we have included all GUM clinics in the Northwest and Southwest in order to avoid this sort of underestimate.

Figure 2. Example catchment area for 3 clinics.



We have been able to identify two clinics as part of this cross-checking process, Westmorland General Hospital and Furness General Hospital, which chose not to allow their numbers of diagnoses to be released in 2001. We have still computed the exposed to risk for these clinics and thus ensured that the denominators for the clinics around them are not distorted in the way illustrated in the example above. However, without knowing how many people have been diagnosed with Chlamydia, it has not been possible to compute rates for these clinics.

The GUM clinic is not the only setting in which individuals can seek diagnoses and treatment for sexually transmitted diseases. Family planning clinics and General Practitioners' (GP) surgeries also offer these services. For approximately 40% of individuals who eventually attend a GUM clinic, their GP will be their first point of contact[8].

Because the KC60 data are clinic-specific, the outcome measure will be the rate of Chlamydia diagnosed at clinics rather than the rate of the disease in the general population. To address this problem, we would have preferred to use a data source which included diagnoses in all healthcare settings but no such data source currently exists. Some other sources that we considered were:

- The National Chlamydia Screening Programme (NCSP). The NCSP was launched in England in 2003 and it is hoped that it will cover the whole of the country by the end of 2007[9]. It offers screening to 16-25 year olds in settings outside of the GUM clinics, such as local pharmacies. However, whilst this age group represent the largest number of cases diagnosed each year[10], people aged over 25 are still regularly diagnosed with Chlamydia and should be included in both the count of individuals infected and the total population at risk of infection.

  Although the NSCP is likely to represent a significant source of data on Chlamydia diagnoses in the future, it currently does not cover the whole

country and data are not available even for those areas which are covered. The data collected are detailed, including an individual's postcode of residence, but it is unclear whether these data will be made available to researchers given concerns regarding confidentiality.

- The General Practice Research Database (GPRD). The GPRD includes anonymised records for 3.4 million active patients[11]. It allows researchers to analyse sexually transmitted disease rates as diagnosed within general practice. But policies vary by locality and many GPs' surgeries will recommend that an individual goes to a GUM clinic for testing, confirmation of a result and/or treatment[12]. As a result, the actual diagnosis may be made and recorded outside of the general practice setting. It is estimated that only 25% of women and 5.1% of men receive treatment from their GP[13].

- Microbiology laboratory reports. All laboratories in England and Wales were invited to report on sexually transmitted diseases which they diagnose and the results were published quarterly in Communicable Disease Report (CDR) Weekly, now published as the Health Protection Report. These reports provide data on all tests carried out. This means that they cover all healthcare settings, however there can be double counting, such as when an individual is initially tested at a GP's surgery but then referred to GUM clinic and retested to confirm the result. Moreover, since reporting is voluntary, a number of laboratories do not report.[4]

It is believed that GUM clinic data captures the largest number of cases, since most cases are thought to present at a GUM clinic at some stage[14], and KC60 is certainly the most widely used in the ongoing discussion about trends in STD incidence in the UK. For the purposes of this study we have therefore chosen to use these data in spite of their limitations.

3. METHODS

3.1 DERIVING THE POPULATION EXPOSED TO RISK – THE THEORY

In calculating rates, it is vital that we do not violate the principle of correspondence – i.e. we must ensure that events included in the numerator correspond with the exposed to risk in the denominator[15]. Our numerator includes all Chlamydia cases diagnosed at a particular GUM clinic. Therefore our denominator should only include those people at risk of being included in the numerator. This is not simply the total population in a given area. Some people, for example very young children, have a virtually non-existent risk of contracting the disease. Chlamydia is almost exclusively sexually transmitted so the population at risk should exclude those who are not sexually active. Moreover, the denominator for each clinic should only include those individuals who, were they to suspect an STD, would attend that clinic.

Taking the first consideration, we find that some simplifying assumptions are required. There is no dataset available which provides a count of the total number of sexually active individuals in each region. The National Survey of Sexual Attitudes and Lifestyles II (NATSAL II), a nationally representative survey of sexual behaviour in Britain, was interested primarily in the behavioural correlates of HIV transmission[16]. It defined the sexually active population was defined by an age interval. Those under 16 and over 44 years old were considered to be at minimal risk of STD transmission and were therefore excluded from the study. The

National Chlamydia Screening Programme also sets the lower age band at 16. In both cases this is likely to be because 16 is the age of consent, below which sexual activity is not legally permitted.

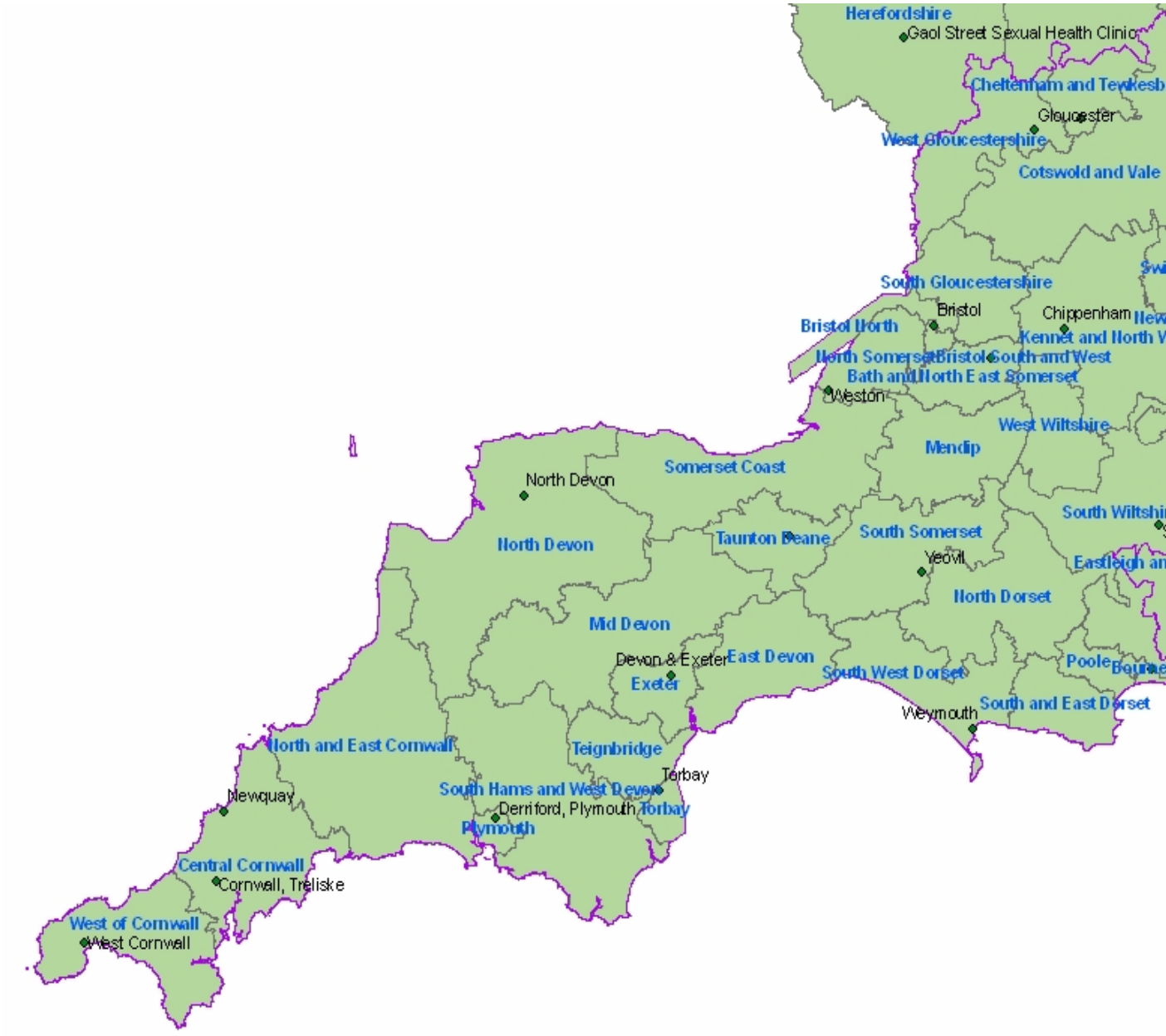
It is well known that sexual activity does begin earlier. A study by Stone and Ingham[17] found that the median age at which young people accessed sexual health services for any reason as 15 years. But those under 16 represented approximately 2% of all Chlamydia cases in 2006 and those over 45 accounted for 1%[18]. Choosing the age range 16-44 means that we will account for the vast majority of the population at risk, and by maintaining consistency with the NATSAL data we will be able to compare the rates that we derive with data on the prevalence of certain sexual behaviours derived from NATSAL II.

Our numerator data are taken from GUM clinics. To derive an appropriate denominator we still need to determine which individuals would attend which clinics. One approach would be to assume that people attend the clinic in their Primary Care Trust (PCT) or to use some other similarly convenient administrative boundary. However, a number of PCTs contain more than one clinic. In these areas, data would have to be aggregated. We would lose some of the detail that might tell us about differences between clinics that share an administrative area. For example, as shown in Figure 3, Newquay and District Hospital and Royal Cornwall Hospital at Treliske were both part of the Central Cornwall PCT. However, our calculations found that the lowest rates of Chlamydia were at the Newquay clinic whilst some of the highest were at the Royal Cornwall clinic. Why

two clinics located so close to one another should have such different rates is an interesting question which we would have missed had we simply aggregated their data because they were in the same PCT.

Similarly, in PCTs without a GUM clinic, we would have to assume that people do not access any GUM services. However this assumption is likely to be false. A PCT is an arbitrary administrative border and there is no reason why people would not cross it to access nearby services. For example, Teignbridge PCT has no GUM clinic. However, Torbay Hospital lies very close to its border. It might be reasonable to suppose that if people from Teignbridge suspect they have an STD, they travel to Torbay.

Figure 3. Southwest clinics and Primary Care Trusts



A more realistic assumption might be that people attend the clinic located nearest to them. When a sexually transmitted disease is suspected an individual can attend a GUM clinic directly, or may be referred by a GP. Attending a clinic has a cost in terms of time and expense so it might be reasonable to assume that each

patient chooses to attend their nearest clinic. But “nearest” can mean a lot of different things. It can refer to distance or to the time taken to travel there. This paper will explore a variety of different ways of measuring a patient’s nearest clinic.

The simplest way or measuring, or identifying, a patient’s nearest clinic is called a Thiessen (or Voronoi) polygon. A Thiessen polygon demarcates an area around each clinic. Within this area lie all the locations for which the Euclidean distance (i.e the distance “as the crow flies”) to this clinic is less than the Euclidean distance to any other clinic[19]. Thiessen polygons can be drawn by hand by connecting each clinic to all the surrounding clinics. The lines connecting the clinics are then perpendicularly bisected. The smallest area enclosed by joining the perpendicular bisectors is the Thiessen polygon. If any place is equidistant from two clinics, it will lie on the boundary of the polygon. If it is equidistant from three or more points, it will form one of the vertices of the polygon. In practice, these polygons are more usually constructed using a computer program.

A problem with the Thiessen polygons is that although they assign everyone to a clinic, there will be people who simply live too far away from a clinic for it to be practical for them to attend. In this case, it is likely that they will seek treatment in an alternative setting, such as a GP surgery or family-planning clinic. So these people should not be included in the denominator for their nearest GUM clinic because they are not at risk of attending any GUM clinic.

There is no established definition of “remoteness” from health services. We have chosen to classify those who live more than 15 miles from a GUM clinic as being remote from this service. This is based on the NHS policy of reimbursing travel costs to those who live more than this distance from the clinic[20].

Both the Thiessen polygon and the boundary approaches are distance-based – “nearness” is defined based on the straight-line or “crow-fly” distance between the clinic and the individual’s address. Crow-fly distances have a distinct advantage of being simple to measure. However, they may not correspond very well to the routes that people take in the real world. The nearest clinic might be only 2km away but if you have to cross a river and there is no bridge you may have to travel much further to reach the clinic than a crow-fly distance would predict.

It is possible instead to base our model on the amount of time which it takes to travel from a given point to the nearest clinic. Individuals who live in locations where the travel time to the nearest clinic is considered too long should be excluded from the denominator. As with those for whom the journey is too far, it is likely that they would seek treatment in an alternative location.

Much like “remoteness” there is no established duration that is considered “too long” to expect individuals to travel. A number of studies of the accessibility of NHS services have used a drive time of more than 30 minutes[21,22,23] and this paper will follow that convention, though we will also examine the population distribution of drive times in 10 minute intervals.

3.2 DERIVING THE POPULATION EXPOSED TO RISK – METHODS

The starting point for all the calculations was to geo-reference each clinic based on its postcode. The clinic location would provide the starting point from which all other calculations of distance would be made. Northing and Easting grid references were obtained for each clinic based on the postcode. This was done using the 2000 Postcode Directory, made available by UKBORDERS.

Each clinic was then mapped in ARCMap onto an administrative map of England, showing the country divided into Lower Super Output Areas (LSOA) from the 2001 Census, which was also provided by UKBORDERS. LSOAs are a geography created for the 2001 Census. They have a minimum population of 1,000 people, a mean population of 1,500 and are generally made up of 4 to 6 census Output Areas, the smallest census geography unit[24]. We chose to work with LSOAs rather than Output Areas for two reasons. Firstly as there are fewer LSOAs than Output Areas, the computing power required is reduced and secondly, due to disclosure requirements, data are readily available for LSOAs from Neighbourhood Statistics (provided by the Office for National Statistics) but not for Output Areas. Using data from the 2001 Census available from Neighbourhood Statistics, we obtained the population aged 16-44 years for each LSOA.

Both the Thiessen polygons and the 15 mile boundaries around each clinic were drawn using ArcMap. These figures were “clipped” to the LSOA map. “Clipping” these figures ensures that the polygons and boundaries correctly trace the

coastline of the UK and that they maintain the same projected coordinate system as the other data layers. The total population aged 16-44 for each polygon was obtained by selecting within ARCMap the LSOAs which had their population centres within that polygon. The population figures for the selected LSOAs were then summed to give a total population for each polygon. When the population was to be restricted to the 15 mile boundary, LSOAs were only selected if their population centre fell within that distance.

The population has been allocated to clinics on the assumption that people travel to the clinic closest to their address on the date of the 2001 census. In practice, this is unlikely to be true for all attendees. The most common reason for this is that clinics tend to have limited opening hours, restricted to the times when many people are at work. A clinic in the town where an individual works may be more convenient than one near his or her home. In large urban areas where many people work but fewer people live, we may thus under-estimate the population at risk and hence over-estimate the rate. Similarly, in suburban areas, we may over-estimate the population at risk and under-estimate the rate.

There are several different approaches to creating a drive-time model. The simplest is to use some of the readily available internet trip planning software such as www.multimap.com or Google Maps. They have excellent data on the road network and provide good travel time estimates for single trips. However, these are less useful when the travel time must be computed from a large number of starting points as each one has to be manually inputted.

A vector-based model extends the theory used by this approach to a more general model. The model estimates the time that it will take to travel a particular road segment between nodes, or intersections of roads[25]. Figure 4 below illustrates how the vector model operates. Imagine that the blue square is the postcode centroid in a particular region, the boundaries of which are represented by the blue lines. The model then calculates the time taken to travel from the blue point to the road (the first red point), the time between each of the road intersections (the other red points) and the time between the road and the clinic (the green point). Added together, these times give the total travel time.

Figure 4. Path-finding example in the vector model

However, this is just one possible path. Another route, following the orange lines, could involve turning left onto Fulton Street, whilst still another involves a left onto Dey Street. The vector model evaluates all possible paths between all the start points and end points which you specify and finds the shortest travel times. For example, in the Northwest, the model would work out all the possible paths between approximately 4,500 LSOA centroids and the 25 GUM clinics and select the shortest. The results would be returned in a 4,500 x 25 matrix of travel times.

Such an approach is computationally intensive. Moreover, because the calculations are done from centroids, there can be distortions. For example, the blue point was the centroid for this particular area and from this point it might be quickest to travel to clinic A. But for someone living on Wall Street (at the purple point in Figure 4, for example), clinic B is probably closer. This will not be reflected in the calculations since all calculations will be done from the centroid. For these reasons, the vector model is usually more suited to calculations where we have a fixed set of start points, such as patient addresses, rather than being interested in travel times over a region more generally.

So we have opted instead for a surface model. The surface model is a raster-based approach which involves creating a more generalised surface of drive times to each clinic by representing these as a continuous cost-surface[26]. First, we obtained a representation of the UK road network from the Ordinance Survey Digimap Collection (1:50,000 scale). This includes 4 classifications of road types: motorway, A-road, B-road and minor road. Each road type was then assigned a

background speed. This required us to make some assumptions about how quickly traffic moves along each road type. A car's speed, and hence the time taken to complete a journey, varies by time of day, by region and even by driver.

The speeds we assigned to the roads in our model, shown in the table below, were based on the average road speeds reported by the Department of Transport[27] and upon empirical work to verify travel times to health services done by Haynes et al[28]. Roads in urban LSOAs were slowed to a speeds half of those in rural LSOAs to take into account the time-cost of traffic congestion in urban areas. The designation of an LSOA as urban or rural was based on classifications made by the Rural and Urban Area Classification Project, a joint project sponsored by the Countryside Agency, the Department for the Environment, Food and Rural Affairs, the Office for National Statistics, the Office of the Deputy Prime Minister and the Welsh Assembly Government[29]. In areas where there are no roads, it was assumed that individuals could cross the land to the nearest road at a background walking speed.

Table 1. Travel speeds

Road type	**Rural Speed (miles per hour)**	**Urban Speed (miles per hour)**
Motorway	65	33
A-road	45	23
B-road	30	15
Minor road	20	10
Walking	4	4

It is important to note that our calculation of travel time will actually be a measure of estimated drive-times. It will not include other activities which effect the overall travel time, such as the time spent trying to park at the clinic. Nor does it represent the time taken to get to a clinic by individuals who do not have access to a car and who therefore rely on public transport. Therefore these calculations will only represent an approximation of the true time taken for an individual to get to the clinic.

Both the road network and the land area maps were then rasterised, turning the UK map into a grid of 100 metre squares in ARCMap. The travel time to cross each square is calculated based on the background speeds assigned to each road type, creating a travel-time raster. The Cost Distance function in the Spatial Analyst toolpack then uses this raster to calculate a value for each square which represents the least cost in terms of travel time between that square and nearest endpoint (clinics). The travel times were used to trim the area around the clinics so that persons living more than 30 minutes away are not included in the exposed to risk.

The road network will include 100 metre squares in which, for example, a motorway bridges a minor road. The model does not realise that the motorway cannot be joined at this point and will calculate the travel time assuming that the individual joins the motorway. The tendency of the model to ignore how the features of the road network actually interact is a small weakness in regional

calculations such as ours which is interested in travel times over the whole of the Northwest and Southwest areas. However if this method were to be applied to local area calculations, such as transit through Southampton, the problem could be substantial.

3.3 SPATIAL CLUSTERING

Once we have derived appropriately calculated rates of Chlamydia infection, we might be interested to know whether these rates conform to any patterns. Do high rates cluster together? Does the rate at one clinic seem to depend on the rates at other, surrounding clinics? Spatial autocorrelation is a measure of the extent to which data exhibit this sort of clustering. When high values are generally located near to other high values or low values near to other low values, the data are said to show positive spatial autocorrelation. When it is distributed so that high values are generally next to low values, the data show negative spatial autocorrelation[30].

In addition to providing us with information about the patterns of Chlamydia distribution, identifying any spatial autocorrelation is vital because most statistics, particularly in regression analyses, are based on the assumption that values are independent of one another. The presence of spatial autocorrelation violates this assumption and so spatial dependence must be specifically controlled for in statistical calculations[31].

Spatial autocorrelation can be measured in a number of ways but the classic measure is Moran's *I*. It compares the value at one location with the value at all the other locations. When *I* approaches 1, there is evidence of strong positive spatial autocorrelation, whilst an *I* approaching -1 shows evidence of strong negative spatial autocorrelation. We can also obtain a Z-test statistic which tests the null hypothesis that the observed values are the result of a random process (no spatial autocorrelation) against the alternative hypothesis that there is spatial correlation. These calculations have been done using GeoDa, a program created specifically for the analysis of spatial data.

4. RESULTS

4.1 NUMBER OF CASES

The numbers of cases reported at each clinic are presented in Tables 2 and 3 below. The highest numbers of cases in the Northwest were diagnosed in Liverpool and Manchester, which is unsurprising as these are the two largest cities in the region. In the Southwest, the highest numbers of cases are diagnosed in Bristol and Bournemouth.

Table 2. Chlamydia cases diagnosed at Northwest clinics

Clinic	**Chlamydia cases**
Ormskirk	92
Workington Community Hospital	99
Halton General Hospital	109
Royal Albert Edward Infirmary, Wigan	116
Burnley General Hospital	125
St Helens and Knowsley Hospital	130
Hope Hospital	138
Cumberland Infirmary	144
Chorley and South Ribble District General Hospital	144
Warrington and District General Hospital	164
Trafford General Hospital	191
Macclesfield District General Hospital	201
Leighton Hospital	208

Clinic	Chlamydia cases
Fairfield General Hospital	235
Ashton Community Care Centre	235
Southport District General Hospital	279
Royal Oldham Hospital	312
Tameside and Glossop Centre for Sexual Health	328
Royal Blackburn Hospital	364
Royal Preston Hospital	393
Stepping Hill Hospital	408
Countess of Chester Hospital	415
North Manchester Hospital	420
Victoria Hospital, Blackpool	425
Arrow Park Hospital	471
Baillie Street Health Centre, Rochdale	528
Royal Bolton Hospital	581
Withington Hospital	706
Manchester Royal Infirmary	758
Royal Liverpool Hospital	1130

Table 3. Chlamydia cases diagnosed at Southwest clinics

Clinic	Chlamydia cases
Newquay and District Hospital	35
West Cornwall Hospital, Penzance	47
Chippenham Community Hospital	50
Weston General Hospital	59
Yeovil District Hospital	99
Royal Devon and Exeter Hospital	109
Torbay Hospital	136
North Devon District General Hospital	192
Salisbury District Hospital	194
Cheltenham General Hospital	197
Weymouth and District Hospital	214
Royal Cornwall Hospital, Treliske	225
Taunton and Somerset Hospital	239
Royal United Hospital, Bath	279
The Great Western Hospital, Swindon	406
Gloucester Royal Hospital	520
Derriford Hospital Level 5, Plymouth	531
Royal Bournemouth Hospital	700
Bristol Royal Infirmary	881

4.2 THIESSEN POLYGONS

Using the Thiessen polygon approach we can begin to see how the measures of disease incidence change once we control for the population exposed to risk. The rates for each clinic, using the Thiessen polygon as the catchment area, are presented in Tables 4 and 5 below. The 95% confidence intervals are based on the Poisson distribution and have been calculated in STATA. Figures 4 and 5 below show quartile maps of the rates in each Thiessen polygon for the Northwest and Southwest regions.

The rates in the Northwest range from 1.12 per 1,000 at the Royal Albert Edward Infirmary in Wigan up to 8.56 per 1,000 at the Baillie Street Health Centre in Rochdale. Although Liverpool had by far the most cases diagnosed, it only had the sixth highest rate. And similarly though Southport was towards the middle of the table in terms of number of cases diagnosed, it has the fourth highest rate.

In the Southwest, the rates range from 0.67 per 1,000 at Newquay and District Hospital up to 5.12 per 1,000 at Weymouth and District Hospital. As in the Northwest, the position of many clinics in the table changed substantially when we controlled for the population exposed to risk. Weymouth, for example, was in the middle of the table in terms of cases diagnosed but has the highest Chlamydia rate.

The rates in the Southwest are much lower than were observed for the Northwest region. The average Chlamydia rate for the whole Southwest using this method is

2.67 per 1000 population aged 16-44. For the Northwest, the rate is 3.90 per 1000 population aged 16-44. The Health Protection Agency (HPA) estimates for these regions similarly show the Southwest rates as lower than those in the Northwest, with a rate of 1.45 per 1000 for the Northwest compared with 1.03 per 1000 for the Southwest[32]. These rates are calculated using a different exposed to risk, i.e. per 1000 resident population rather than per 1000 population aged 16-44. When we recalculated our average rates using the same population exposed to risk as the HPA, we were able to replicate their rates.

The HPA estimated rate for all of England was 1.38 per 1000.[33] Although the Southwest region has much lower rates on average than the rest of the country and the Northwest has somewhat higher rates, the tables below show that this varies considerably by clinic.

Table 4. Chlamydia rate for Northwest clinics - Thiessen polygon catchment areas

Clinic	**Chlamydia rate per 1,000 population**	**95% Confidence Interval**
Royal Albert Edward Infirmary, Wigan	1.12	(0.92, 1.35)
St Helens and Knowsley Hospital	1.22	(1.02, 1.45)
Burnley General Hospital	1.53	(1.28, 1.83)
Halton General Hospital	1.62	(1.33, 1.95)
Ormskirk	1.71	(1.38, 2.10)
Workington Community Hospital	1.98	(1.61, 2.41)
Warrington and District General Hospital	2.05	(1.75, 2.39)

Clinic	Chlamydia rate per 1,000 population	95% Confidence Interval
Hope Hospital	2.45	(2.05, 2.89)
Leighton Hospital	2.46	(2.14, 2.82)
Cumberland Infirmary	2.47	(2.08, 2.90)
Tameside & Glossop Sexual Health Centre	2.75	(2.46, 3.07)
Chorley and South Ribble District General Hospital	2.96	(2.46, 3.07)
Stepping Hill Hospital	3.16	(2.83, 3.52)
Fairfield General Hospital	3.28	(2.88, 3.73)
Trafford General Hospital	3.36	(2.90, 3.87)
Macclesfield District General Hospital	3.73	(3.23, 4.28)
Royal Blackburn Hospital	3.79	(3.41, 4.20)
Royal Bolton Hospital	3.86	(3.55, 4.19)
Royal Oldham Hospital	3.96	(3.53, 4.43)
Ashton Community Care Centre	3.97	(3.48, 4.51)
Victoria Hospital, Blackpool	4.16	(3.77, 4.57)
Royal Preston Hospital	4.20	(3.80, 4.64)
Arrow Park Hospital	5.22	(4.76, 5.72)
North Manchester Hospital	5.28	(4.79, 5.81)
Royal Liverpool Hospital	5.54	(5.27, 5.81)
Countess of Chester Hospital	5.99	(5.47, 6.94)
Southport District General Hospital	6.17	(5.47, 6.94)
Manchester Royal Infirmary	6.23	(5.80, 6.69)
Withington Hospital	7.35	(6.82, 7.92)

Clinic	Chlamydia rate per 1,000 population	95% Confidence Interval
Baillie Street Health Centre, Rochdale	8.56	(7.85, 9.32)

Table 5. Chlamydia rate for Southwest clinics - Thiessen polygon catchment areas

Clinic	Chlamydia rate per 1,000 population	95% Confidence Interval
Newquay and District Hospital	0.67	(0.47, 0.93)
Chippenham Community Hospital	0.73	(0.54, 0.96)
Weston General Hospital	0.84	(0.64, 1.08)
Royal Devon and Exeter Hospital	0.95	(0.78, 1.14)
Yeovil District Hospital	1.27	(1.03, 1.54)
Torbay Hospital	1.56	(1.31, 1.84)
West Cornwall Hospital, Penzance	1.72	(1.27, 2.29)
Royal United Hospital, Bath	2.33	(2.06, 2.62)
Cheltenham General Hospital	2.40	(2.07, 2.76)
The Great Western Hospital, Swindon	2.60	(2.35, 2.86)
Taunton and Somerset Hospital	2.86	(2.51, 3.25)
Bristol Royal Infirmary	2.97	(2.77, 3.17)
Derriford Hospital Level 5, Plymouth	3.31	(3.03, 3.60)
North Devon District General Hospital	3.52	(3.04, 4.06)
Royal Bournemouth Hospital	3.67	(3.40, 3.95)

Salisbury District Hospital	3.69	(3.19, 4.24)
Royal Cornwall Hospital, Treliske	3.98	(3.48, 4.54)
Gloucester Royal Hospital	4.35	(3.99, 4.74)
Weymouth and District Hospital	5.12	(4.45, 5.85)

Figure 4. Map of rates in the Northwest

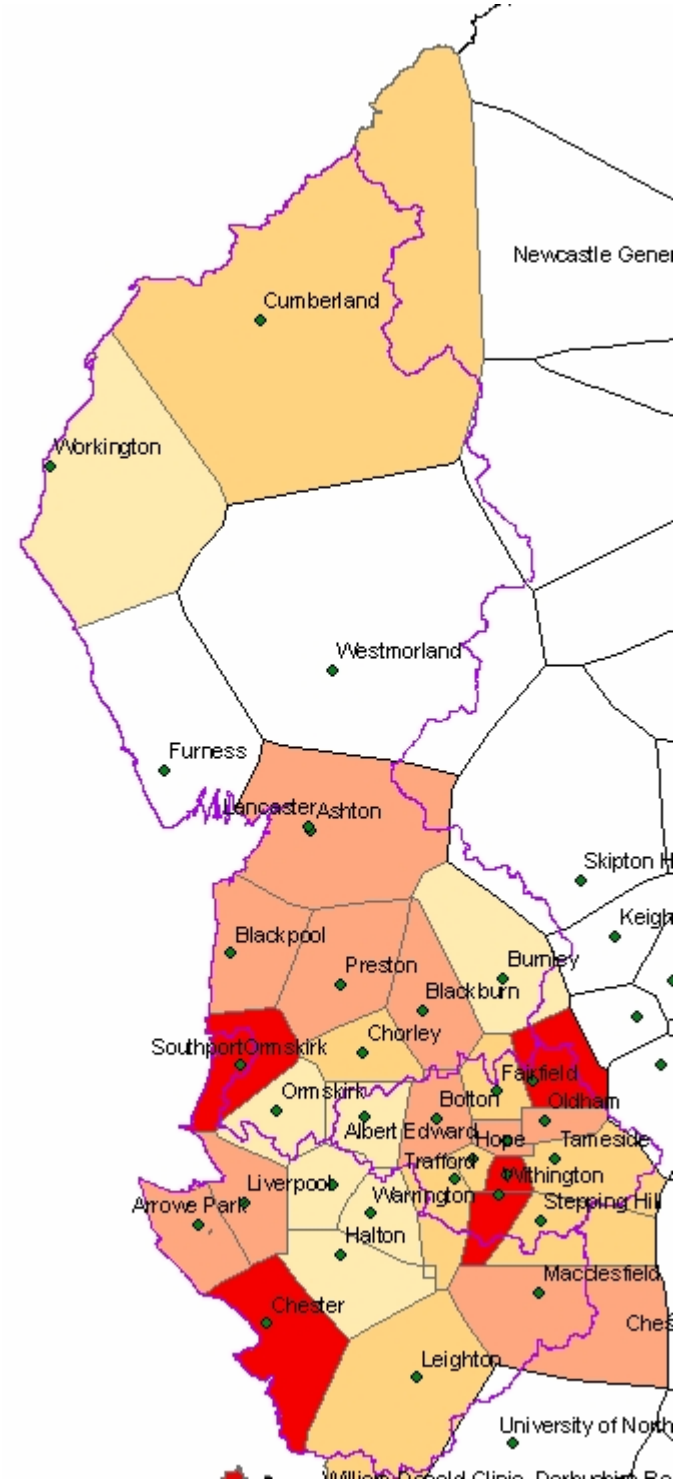
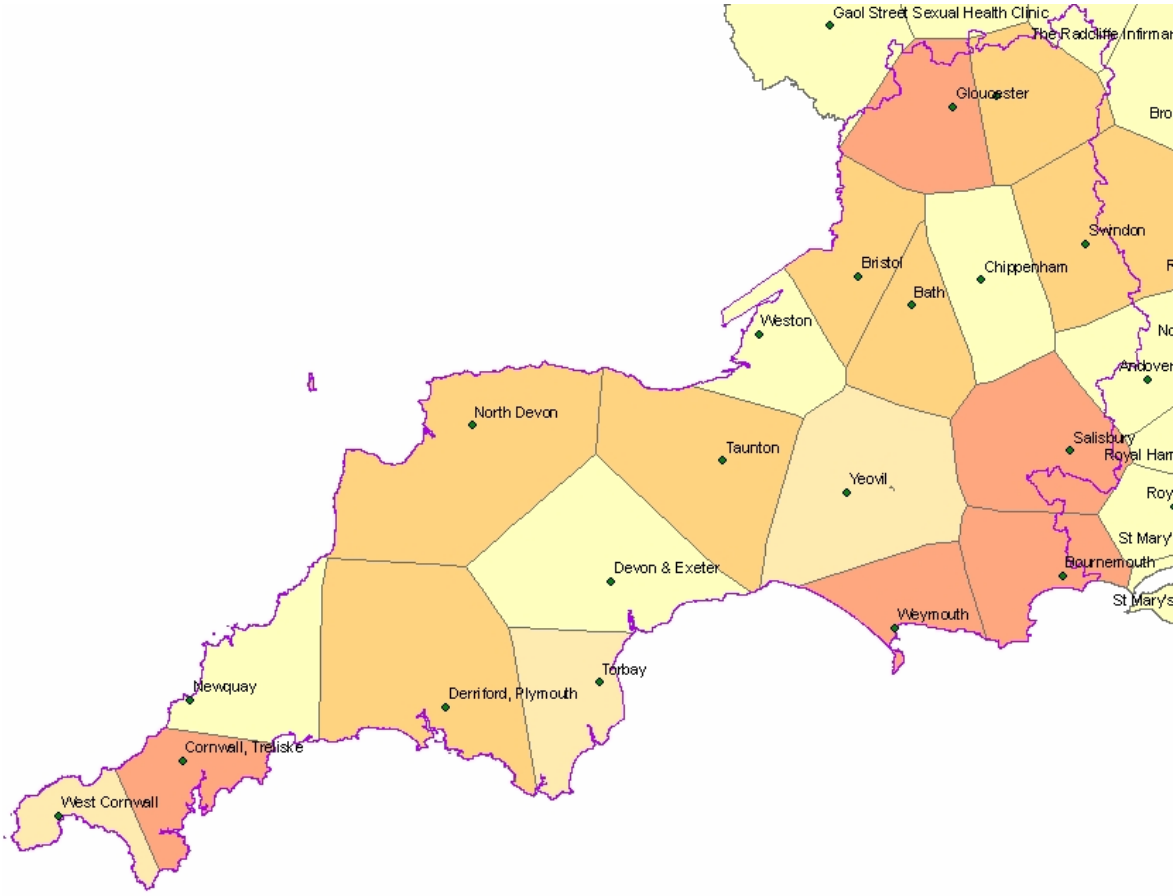


Figure 5. Map of rates in the Southwest

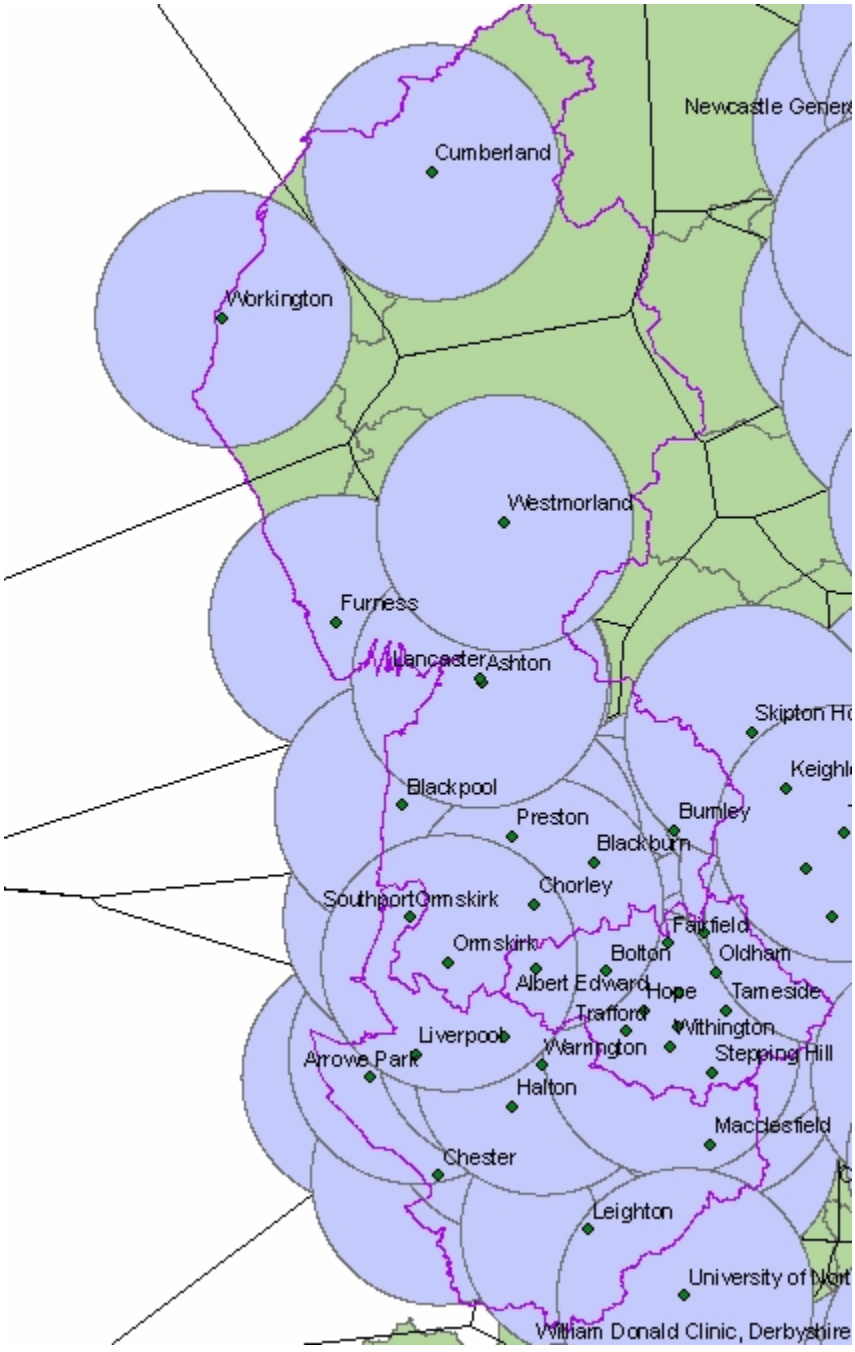


4.3 15 MILE BOUNDARIES

When we change the catchment area to exclude those individuals who live more than 15 miles from the clinic, as shown in Figures 4 and 5, we begin to see differences in the accessibility of clinics in the Northwest compared to the Southwest.

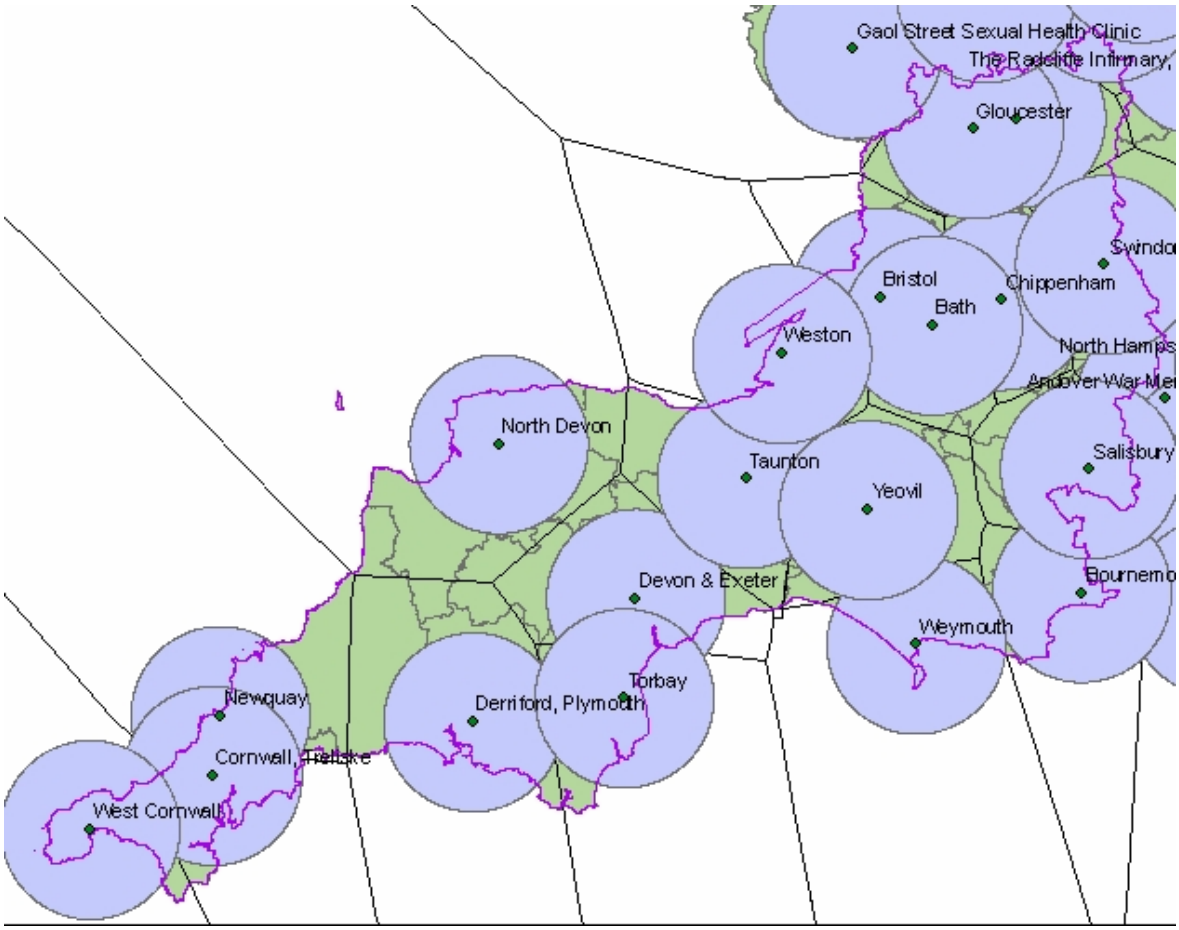
Figure 6 shows that very little of the Northwest is not covered by one of the 15 mile boundaries (in purple). The areas that are excluded, in the northern-most region of Cumbria, are relatively unpopulated and account for only 2% of the Northwest population aged 16-44 years. These individuals were originally allocated to one of four clinics: Westmorland and Furness General Hospitals (which are not included above as they have chosen not to report their figures as discussed in Section 2), Cumberland Infirmary and Workington General Hospital. The rates for Cumberland Infirmary and Workington General Hospital can be adjusted to exclude those who live outside the 15 mile boundary but it can be seen that even for these two clinics, the change is very small (From 2.47 to 3.18 for Cumberland and from 1.98 to 2.14 for Workington). Remoteness with respect to distance from a clinic does not seem to be an issue in this region.

Figure 6. Northwest clinics with 15 mile boundaries



In contrast, the map (Figure 7) of the Southwest shows far more polygons containing areas that were classed as more than 15 miles from a clinic. Virtually every clinic includes at least a small area that was deemed to be remote on this measure. However, these areas were relatively sparsely populated and overall only about 6% of the population aged 16-44 years was affected.

Figure 7. Southwest clinics with 15 mile boundaries



Because the virtually every clinic has been affected, we recalculated the rates for the Southwest excluding those individuals for whom the clinic was considered to

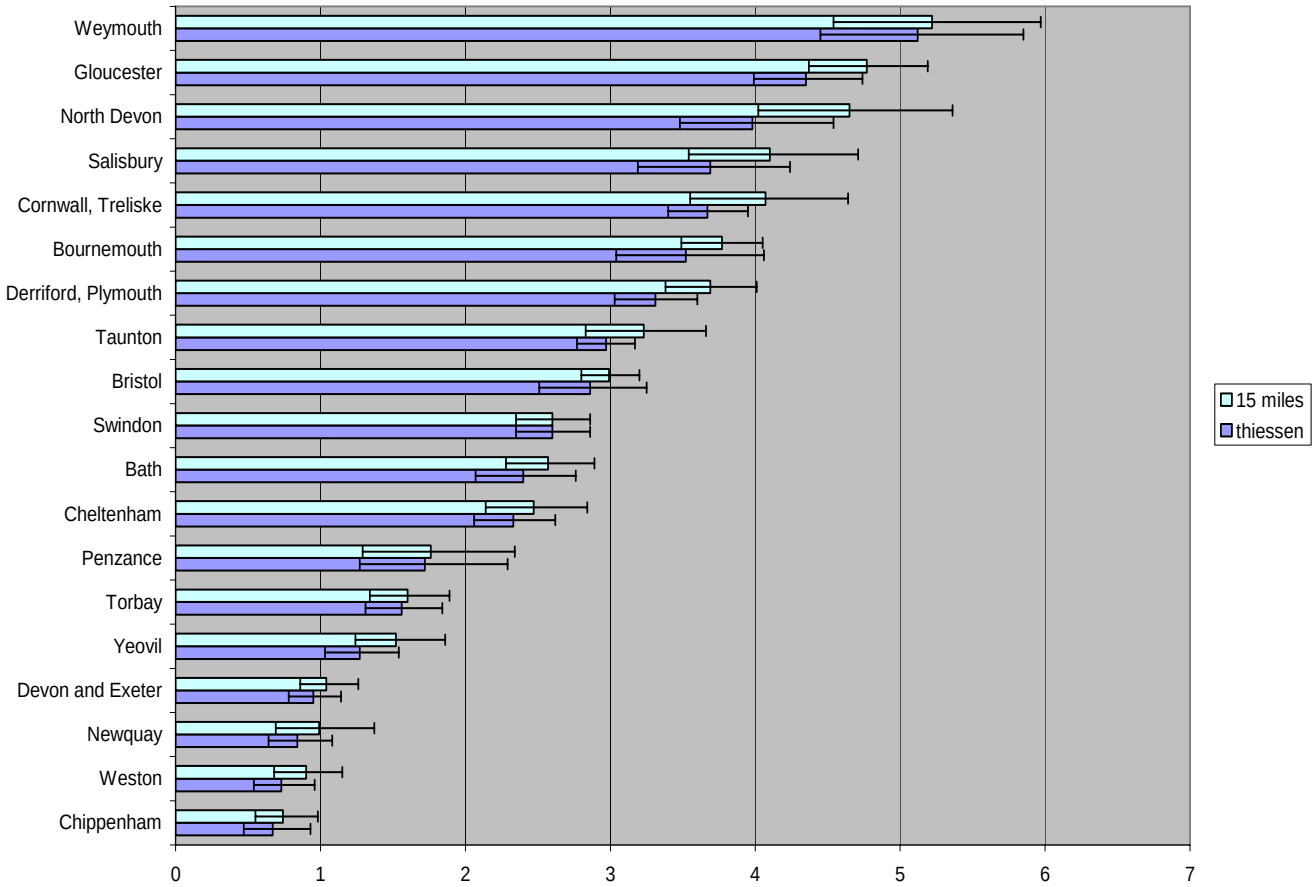
be remote. This reduces the population exposed to risk (i.e. the denominator) and correspondingly increases the rates. But these changes are spread across the clinics such that the changes to the rates are relatively small. The new rates shown in Table 6 differ little from those derived using the Thiessen polygon method and the differences are not statistically significant, as illustrated by the overlapping 95% confidence intervals in Figure 8 below.

Table 6. Chlamydia rate for Southwest clinics - 15 mile boundaries

Clinic	**Chlamydia rate per 1,000 population**	**95% Confidence Interval**
Chippenham Community Hospital	0.74	(0.55, 0.98)
Weston General Hospital	0.90	(0.68. 1.15)
Newquay and District Hospital	0.99	(0.69, 1.37)
Royal Devon and Exeter Hospital	1.04	(0.86, 1.26)
Yeovil District Hospital	1.52	(1.24, 1.86)
Torbay Hospital	1.60	(1.34, 1.89)
West Cornwall Hospital, Penzance	1.76	(1.29, 2.34)
Cheltenham General Hospital	2.47	(2.14, 2.84)
Royal United Hospital, Bath	2.57	(2.28, 2.89)
The Great Western Hospital, Swindon	2.60	(2.35, 2.86)
Bristol Royal Infirmary	2.99	(2.80, 3.20)
Taunton and Somerset Hospital	3.23	(2.83, 3.66)
Derriford Hospital Level 5, Plymouth	3.69	(3.38, 4.01)
Royal Bournemouth Hospital	3.77	(3.49, 4.05)

Clinic	Chlamydia rate per 1,000 population	95% Confidence Interval
Royal Cornwall Hospital, Treliske	4.07	(3.55, 4.64)
Salisbury District Hospital	4.10	(3.54, 4.71)
North Devon District General Hospital	4.65	(4.02, 5.36)
Gloucester Royal Hospital	4.77	(4.37, 5.19)
Weymouth and District Hospital	5.22	(4.54, 5.97)

Figure 8. Comparison of rates in the Southwest derived using the Thiessen and 15 mile methods (bars denote 95 percent confidence intervals)



4.4 DRIVING TIMES

Remoteness with respect to the driving time is not much of an issue in the Northwest. Table 7 below shows the percentage of the population that lives within a given drive-time of a GUM clinic. Only 2% of the population lives more than 30 minutes from a clinic and only 6% more than 20 minutes.

Table 7. Travel time to the nearest clinic in Northwest

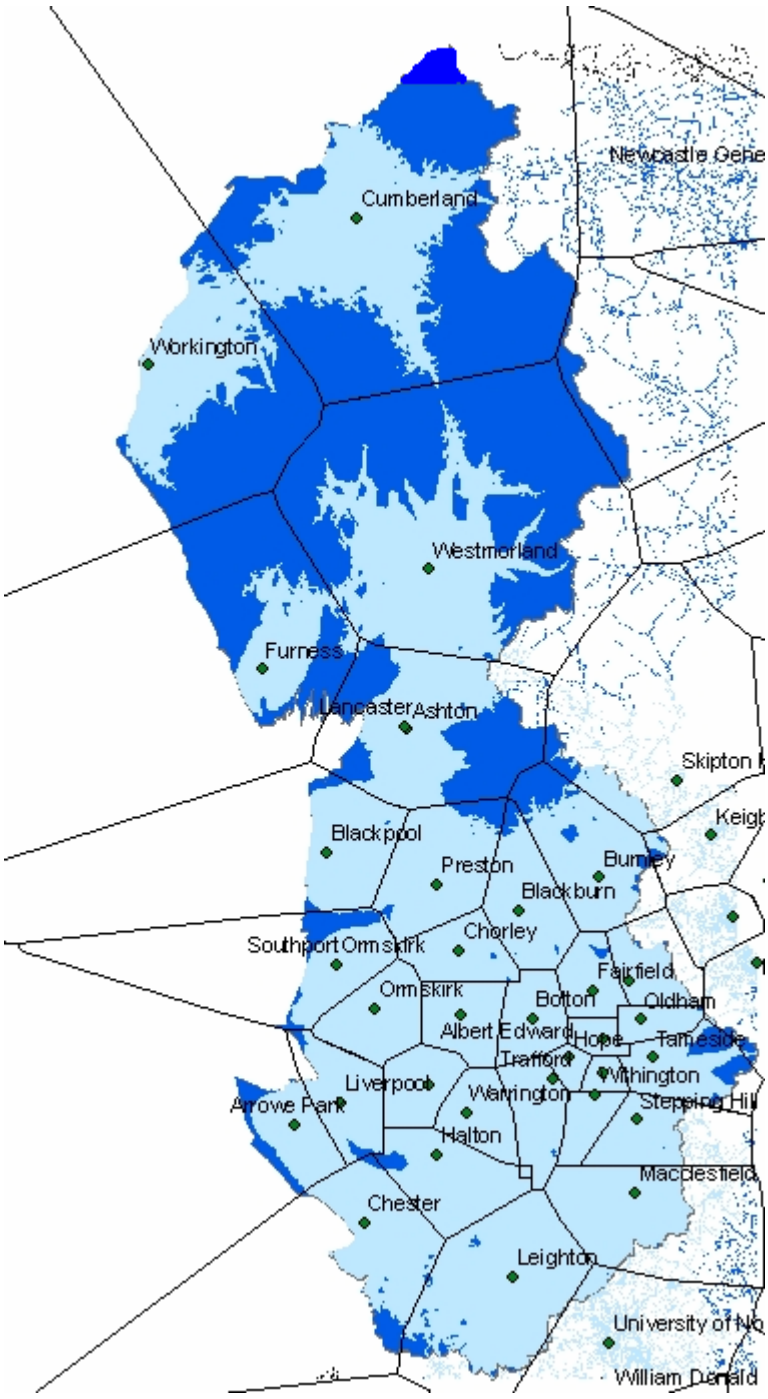
Time to nearest clinic	**% of population living within this travel time to nearest clinic**	**Cumulative % of population living within this time to nearest clinic**
0 – 5 minutes	20%	20%
5 – 10 minutes	39%	59%
10 – 15 minutes	25%	85%
15 – 20 minutes	9%	94%
20 – 25 minutes	3%	97%
25 – 30 minutes	1%	98%
30 – 35 minutes	1%	99%
35 – 40 minutes	0%	99%
40 – 60 minutes	1%	100%
60 minutes plus	0%	100%

Although some areas (shown in dark blue on Figure 9 below) are clearly less accessible they are mainly in the less populated, more rural areas which do not have easy access to the motorways and A-roads. The same clinics are affected

by this remoteness as when measured with the crow-fly distance approach, though the travel time model does manage to give further refinement. For example, although the individuals in the vicinity of the Burnley clinic were all within 15 miles, a number were found by the travel-time model to live more than 30 minutes away.

For the Northwest, it seems that we add very little by moving away from the Thiessen approach. Most people are able to easily access their nearest clinic and so the added complexity of the distance and travel time models are not needed.

Figure 9. Northwest clinics with 30 minute drive-time catchment areas



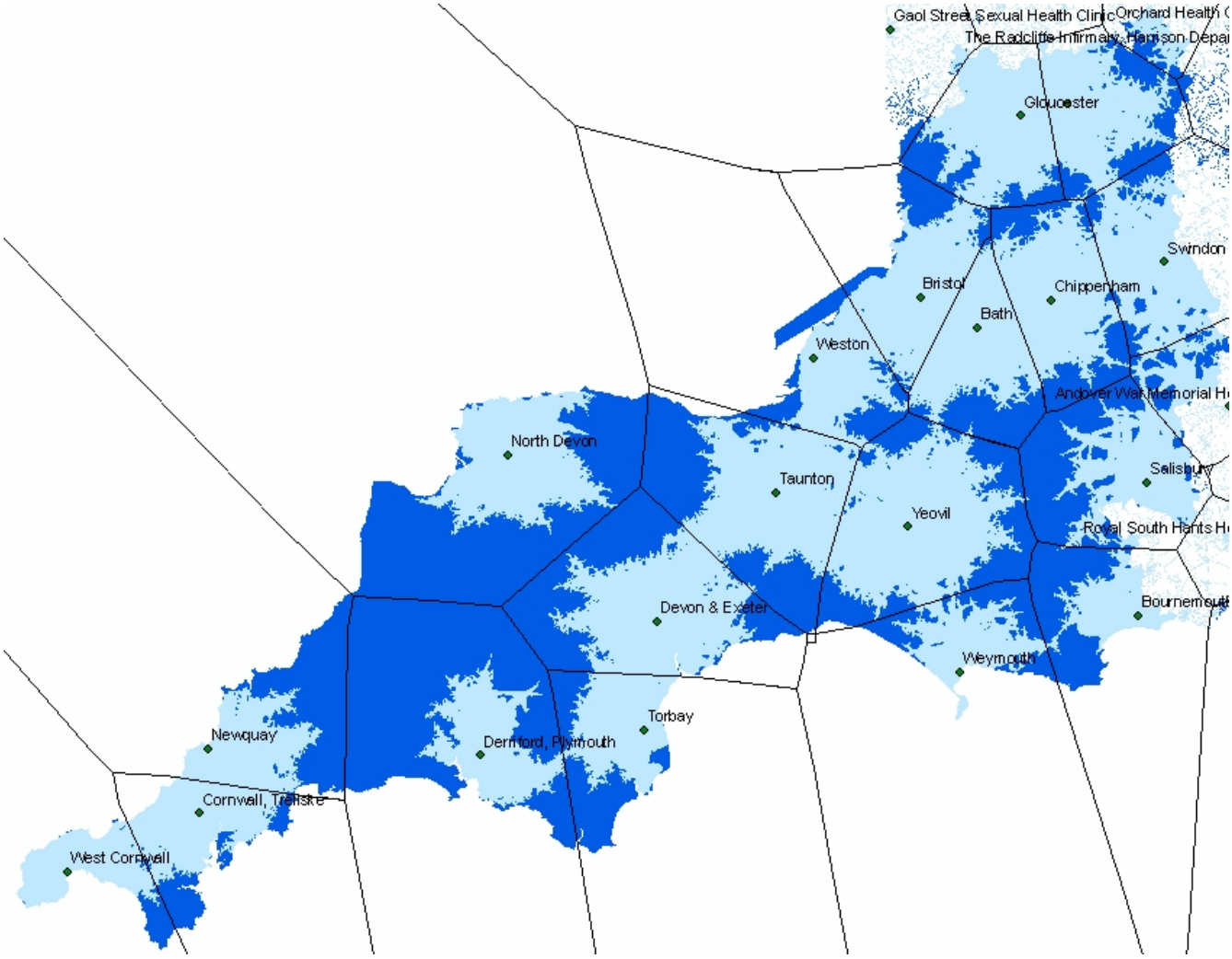
The situation in the Southwest is very different. The travel time analysis also shows a number of areas where clinic access is problematic. As shown in Table 8

below, 10% of the population live more than 30 minutes away from a clinic and almost one in three live more than 20 minutes away. Much like when we drew the 15 mile boundaries, Figure 10 shows that virtually every clinic's catchment area contains an area which is considered remote, denoted by a dark blue patch, from which the trip will take more than 30 minutes.

Table 8. Travel time to the nearest clinic in Southwest

Time to nearest clinic	**% of population living within this travel time to nearest clinic**	**Cumulative % of population living within this time to nearest clinic**
0 – 5 minutes	16%	16%
5 – 10 minutes	23%	39%
10 – 15 minutes	17%	56%
15 – 20 minutes	14%	70%
20 – 25 minutes	11%	81%
25 – 30 minutes	9%	90%
30 – 35 minutes	4%	94%
35 – 40 minutes	3%	97%
40 – 60 minutes	3%	100%
60 minutes plus	0%	100%

Figure 10. Southwest clinics with 30 minute drive-time catchment areas

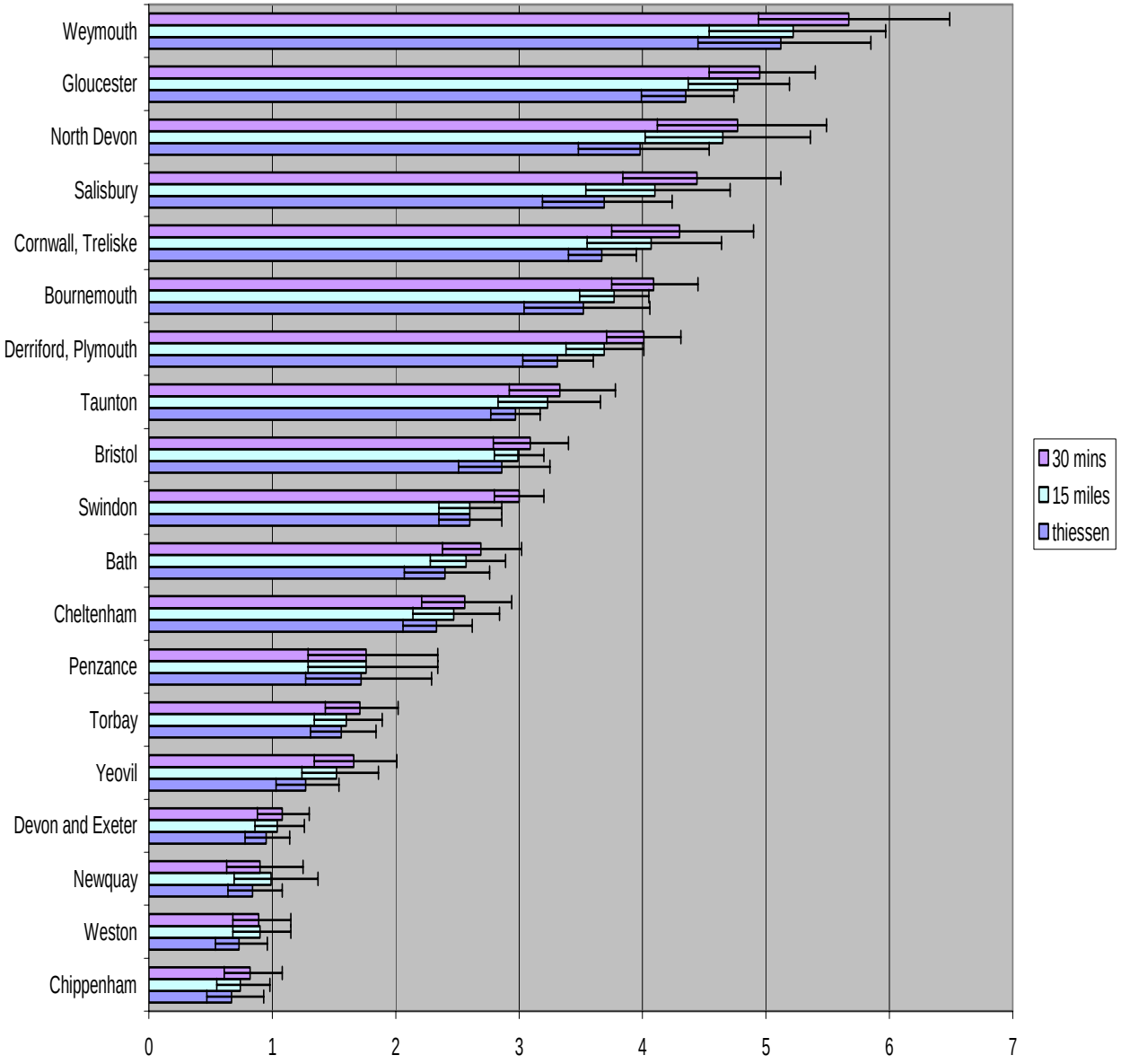


However, the impact on the rates is once again very limited (Table 9). For most clinics, they increase compared to both the rates calculated using the Thiessen and the crow-fly distance methods. This reflects the further reduction in the denominator as we exclude those individuals who live more than 30 minutes away. But the increases are modest and again, as shown in Figure 11 below, not statistically significant as the 95% confidence intervals overlap.

Table 9. Chlamydia rate for Southwest clinics – 30 minute drive time

Clinic	Chlamydia rate per 1,000 population	95% Confidence Interval
Chippenham Community Hospital	0.82	(0.61, 1.08)
Weston General Hospital	0.89	(0.68, 1.15)
Newquay and District Hospital	0.90	(0.63, 1.25)
Royal Devon and Exeter Hospital	1.08	(0.88, 1.30)
Yeovil District Hospital	1.66	(1.34, 2.01)
Torbay Hospital	1.71	(1.43, 2.02)
West Cornwall Hospital, Penzance	1.76	(1.29, 2.34)
Cheltenham General Hospital	2.56	(2.21, 2.94)
Royal United Hospital, Bath	2.69	(2.38, 3.02)
Bristol Royal Infirmary	3.00	(2.80, 3.20)
The Great Western Hospital, Swindon	3.09	(2.79, 3.40)
Taunton and Somerset Hospital	3.33	(2.92, 3.78)
Royal Bournemouth Hospital	4.01	(3.71, 4.31)
Derriford Hospital Level 5, Plymouth	4.09	(3.75, 4.45)
Royal Cornwall Hospital, Treliske	4.30	(3.75, 4.90)
Salisbury District Hospital	4.44	(3.84, 5.12)
North Devon District General Hospital	4.77	(4.12, 5.49)
Gloucester Royal Hospital	4.95	(4.54, 5.40)
Weymouth and District Hospital	5.67	(4.94, 6.49)

Figure 11. Comparison of rates in the Southwest on all three methods



However, if we calculate the rates using a drive time of less than 20 minutes, rather than 30 minutes, the change to the rates is substantial as shown in Figure 12. This is because 30% of the population in the Southwest must travel for more than 20 minutes to access their nearest GUM clinic. Excluding these individuals

from the calculations means very large reductions to the exposed to risk. Some clinics are more affected than others. The population exposed to risk in Swindon reduces by only 8% in comparison with the population used in the Thiessen polygon approach. In contrast the population exposed to risk in Newquay reduces by 69%. Although 30 minutes has been used in a number of previous studies, clearly areas of the Southwest are very sensitive to the threshold chosen. There is little empirical evidence about the amount of time individuals are willing or able to spend travelling in order to access sexual health services. Further research in this area is needed in order to assess whether there is a significant problem with accessibility in the Southwest.

Table 10 shows the rates using the 20 minute drive time model. Comparing this to Table 9, which shows the results of the 30 minute model, shows that there is little change in the order in which the clinics occur. Those with the lowest rates in the 30 minute model are also those with the lowest rates in the 20 minute model. Although the rates may be higher using a 20 minute threshold, and although some clinics may be more affected than others, overall the areas that we have identified as areas with high rates remain areas of high rates regardless of the method chosen.

Figure 12. Comparison of rates in the Southwest, including 20 minute drive-time threshold

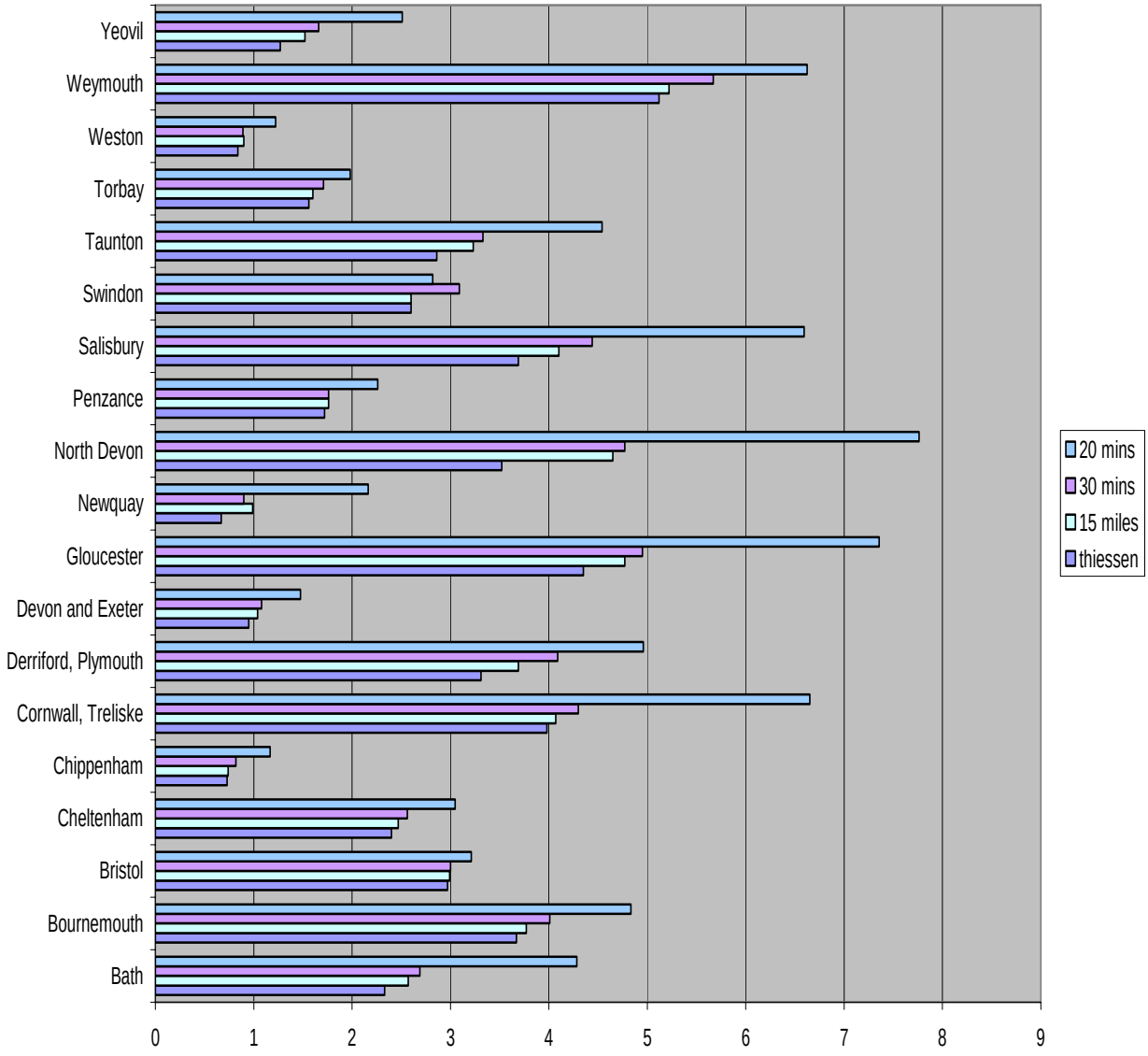


Table 10. Chlamydia rate for Southwest clinics – 20 minute drive time

Clinic	Chlamydia rate per 1,000 population
Chippenham Community Hospital	1.17
Weston General Hospital	1.22
Royal Devon and Exeter Hospital	1.48
Torbay Hospital	1.98
Newquay and District Hospital	2.16
West Cornwall Hospital, Penzance	2.26
Yeovil District Hospital	2.51
The Great Western Hospital, Swindon	2.82
Cheltenham General Hospital	3.05
Bristol Royal Infirmary	3.21
Royal United Hospital, Bath	4.28
Taunton and Somerset Hospital	4.54
Royal Bournemouth Hospital	4.83
Derriford Hospital Level 5, Plymouth	4.96
Salisbury District Hospital	6.59
Weymouth and District Hospital	6.62
Royal Cornwall Hospital, Treliske	6.65
Gloucester Royal Hospital	7.36
North Devon District General Hospital	7.76

4.5 CONCLUSION

The method used to calculate the denominator made very little difference to the rates that we obtained. The impact of trying to account for crow-fly and travel time measures of distance was greater in the Southwest than in the Northwest and it resulted in marginally higher rates. However, this change to the rates was not statistically significant. Using the simple Thiessen polygon approach seems to be as good in both regions as using more complex models.

Having said that, further research is required in order to determine whether the thresholds that we have chosen to use here are the most appropriate to measure accessibility of clinics. Results in the Southwest, for example, are particularly sensitive to whether a 20 or 30 minute drive-time is used and the more complex drive-time model may be justified should further studies show that a 20 minute threshold is more representatives of the journeys that individuals actually make.

But if the primary interest is not the point estimate of the rates but their magnitude, i.e. which areas have relatively higher or lower rates, then the method chosen seems to make little difference.

4.6 SPATIAL CLUSTERING

In the quartile maps of the rates using the Thiessen polygon approach (Figures 4 and 5), there did not seem to be any initial evidence of clustering. Moran's *I* for the Northwest was 0.051 (p value = 0.20) showing no evidence of spatial

autocorrelation. In the Southwest, Moran's *I* was -0.26 (p value=0.12) which also showed no evidence of spatial autocorrelation. We can therefore conclude that the rates are spatially independent of one another.

5. DISCUSSION

This study has shown that it is possible to calculate rates of Chlamydia infection for individual GUM clinics in the Northwest and Southwest region of England. Were the data available, it would be possible to extend the methods used here to calculate rates for all UK clinics based on their KC60 returns. Rates were found to be higher in the Northwest than in the Southwest. The average rate for the whole of the Northwest region was found to be higher than the English national average whilst the average for the Southwest region was substantially lower than the national average. However considerable variation existed between clinics within regions. Further research is needed in order to establish why such variations occur.

Our calculations were based on the application of three different techniques of varying complexity to derive the population exposed to risk. It was found that the technique selected had little impact on the results and therefore we recommend that future studies use the simplest method of calculation, i.e. the Thiessen polygon approach. This is especially true if we are mainly interested in identifying areas which are Chlamydia “hot spots”. Although the point estimates of the rates changed depending on the method used, the clinics with higher rates calculated on one method tended to be also have high rates when calculated using the other methods.

However, the drive-time model highlighted issues surrounding the accessibility of GUM clinics in the Southwest. Point estimates of the rates in the Southwest region were very sensitive to the drive-time threshold used. Approximately 10% of the population lives more than 30 minutes from their nearest clinic and the exclusion of these individuals from the exposed to risk did not affect the rates in a statistically significant way. But if a 20 minute threshold is used, the changes to the rates were much more substantial, as 30% of the population live more than 20 minutes from their nearest clinic. We have used the 30 minute threshold in this paper, as this threshold has been used in previous research. However, its selection seems to have little basis in empirical evidence and it seems that further research is required to confirm how individuals access sexual health services.

Where there are issues of accessibility, such as in the Southwest, it is possible that people who do not live near to a clinic would be more likely to call upon other local services, such their GP, for treatment. This problem has been acknowledged by the South West Health Protection Authority which writes, “It is still apparent that a large proportion of diagnoses are being made by GPs or in other clinical settings. This has implications for commissioning services as most data released are based on KC60 returns and therefore may vastly underestimate the burden of disease in the wider community.”[34]

However, the currently available data leave administrators little choice other than to base service allocations and commissions on KC60 data. The Health Protection Authority and the Department of Health are looking at ways of ensuring

that data collected about sexually transmitted diseases are more accurate and more readily available. The Common Data Set for Sexual Health (CDSSH) is currently in its second pilot stage[35]. Once released, it will provide information on diagnoses from a variety of healthcare settings including both GP surgeries and GUM clinics. It will record patient demographic information, including postcode of residence, and a full sexual history[36].

But as yet, there is no final release date for the CDSSH and it remains unclear who will have access to the data. In the interim, deriving rates calculated using a sound methodology represents the first step in getting more out of the existing data available from the KC60 returns. Although these data cannot provide information on service settings other than GUM clinics, it does represent the best data currently available and allows us to explore differences in rates of sexually transmitted disease between groups, locations or over time. Moreover for areas such as the Northwest, where accessibility is generally good, the additional call on GP and other services is likely to be limited, making GUM clinic rates a more valid estimate of the true population rates.

Sexual health was highlighted as one of the key target areas in “Choosing Health” White paper in 2004. Making progress on tackling sexually transmitted diseases will therefore require that we analyse existing data to help us to answer such fundamental questions as “Why are Chlamydia rates higher in some areas than in others?”. We hope in a future paper to explore some possible explanations for this, exploring correlations between the rates derived here and data on sexual

behaviour and patterns of diagnosis and referral for treatment. Such analyses will assist us in targeting interventions so that they not only reach the locations and individuals who most need them, but also address the underlying reasons for the higher risk to these populations.

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