**Bird L, Landes D, Robson T, Sturrock A, & Ling J. (2018). Higher antibiotic prescribing propensity of dentists in deprived areas and those with greater access to care in the North East and Cumbria: A population-based exploration of prescribing variations. *British Dental Journal* *225*(6):517-524.**

**ABSTRACT**

**Background**

Primary dental practitioners prescribe approximately 10% of all prescriptions.In 2016 NHS England launched a national program to combat antibiotic over-usage; the main contributing factor to antimicrobial resistance. The aim is to identify prescribing habits in the North East and Cumbria in October 2016

**Method**

The Business Services Authority were commissioned to undertake a survey of prescriptions during this time frame. Data collected included the antibiotic name, dose, frequency, duration, practice contract number and location.

**Results**

The rate of prescriptions issued per 1,000 population reported ranged from 7.02 in Middlesbrough to 0.77 in Eden (Cumbria), with deprived areas showing higher prescribing rates. Prescriptions issued per 1,000 UDAs commissioned per practice ranged from 0.02 to 16.6 per thousand. Prescription rates were highly correlated with higher dental access rates. The number of urgent care episodes and prescribing rates showed a negative correlation. Eleven different antibiotics were prescribed.

**Discussion**

The variability of rates of antibiotic prescribing in areas of similar deprivation indicated practitioner bias/preferences influenced rates significantly. Education on antibiotic prescribing guidelines would be of benefit.

**Conclusion**

We recommend all dentists regularly undertake self-audit to assess their own prescribing habits and a peer review assessment and/or mentored support groups be established to support colleagues that demonstrate outlying prescribing patterns.

**Background**

In 2016 NHS England launched a national program to combat antibiotic over usage which is the single most important contributing factor to Antimicrobial Resistance (AMR). Currently it is estimated that up to 50% of antibiotics are not being prescribed optimally whether this be in type, dose or duration or the prescription is unjustified(1); cycle 1 of a recent 3-year clinical audit of dental prescribing in Wales showed this figure to be as high as 79.2% of prescriptions failing to meet these set standards(2). The World Health Organisation (WHO) estimates AMR is currently responsible annually for 50,000 deaths across Europe and the United States of America; with a review estimating this could rise to an extra 10 million deaths a year from drug-resistant infections worldwide unless prompt action is taken to tackle the risk (3). Public Health England have introduced an initiative to reduce inappropriate antibiotic prescribing in an attempt to reduce the development of resistance to antimicrobials. The three aims of this initiative are 1) to improve the knowledge and understanding of AMR; 2) conserve and steward the effectiveness of existing treatment and 3) stimulate the development of new antibiotics, diagnostics and novel therapies (4).

It was believed that the discovery of Penicillin in 1928 by Alexander Fleming would help create an infection-free future. But as Fleming explained in his Nobel Prize acceptance speech, bacterial resistance was a possibility (5). AMR is a global problem which results in the ‘ability of microbes to resist the effects of drugs’(1) so that treatment of these microbes becomes ineffective and ‘with few new antimicrobial classes being introduced since the 1980s it is crucial we act promptly to tackle this (1,4,6) and therefore, ‘tackling antimicrobial resistance is rightly a national and international priority’(7). One key action to slow resistance growth is to ensure all antibiotics are appropriately prescribed and these prescriptions are regularly reviewed’ (7). Management of acute dental problems in general practice currently often involves the prescription of antibiotics for reasons which include time constraints, patients unwilling to undergo treatment and acute periodontal problems. These were found in 57.4% of patients with acute dental problems in a 2016 cross-sectional study in Wales were prescribed antibiotics and only 19% of these prescriptions were clinically justified (8).

In 2013 PHE established the English Surveillance Programme for Antimicrobial Utilisation and Resistance (ESPAUR) which, amongst other things, ‘aims to develop, maintain and disseminate robust data relevant to antimicrobial use (AMU), AMR and antimicrobial stewardship’ (7,9). The 2016 report found that between 2014 and 2015 there was a 4.3% reduction in total antibiotic consumption, measured as defined daily dose (DDD).

Monitoring of antimicrobial prescribing is likely to increase in the future. The methodology given here is one such example of how prescribing could be assessed and analysed to reduce inappropriate prescribing in dental practice. Dental practitioners should be aware of how data are collected and the importance of reducing and monitoring their own prescribing habits.

**Aims**

This paper aims to first, identify prescribing habits in NHS practice in a defined region of the UK - Cumbria and the North East. Second, we will examine associations between prescribing rates and socioeconomic status, rural-urban classification, dental disease, population size, access to dental care and the number of urgent claims for dental treatment.

**Methods** (10)

The Business Services Authority (BSA) were paid to extract data from community pharmacy payments for issuing dental prescriptions. Data on the antibiotic name, dose, frequency and duration of course, practice contract number and address was gathered. This was achieved by manual recording of scanned prescriptions. There were challenges with this process as on some scripts it was not possible to retrieve all the data. The problems with data capture resulted in three data sets: a) all defined variables fully captured; b) limited information was available but identification of the prescribing dental practice was issued; c) limited information available but impossible to determine fully which practice issued the prescription. The postcode of each issuing practice or salaried services (which are dental services that the Primary Care Trust commission and include, amongst others, Dental Access Centres, Paediatric, Orthodontic and special care dental services (11)) was used as the most stable descriptor to identify the population for which the prescription was issued(10).

Dental disease rates by local authority were obtained from the report in decay and dental disease in 5-year-olds children by PHE(12). Using these data and that of prescription rates issued per 1,000 population in these areas, no identifiable relationship between increased prescribing in areas of increased dental disease (Figure 5). Gray et al (1991) reported that caries present in 3 or more deciduous molars in a 5 year old was an indicator of likely caries in first permanent molars (13).

The BSA extracted the NHS dental antibiotic prescribing data from Durham, Darlington and Tees, Cumbria, Northumberland and Tyne and Wear for all NHS community pharmacies for October 2016. It is worth noting some dental prescriptions may have been dispensed by another area as well as prescriptions from outside the area being dispensed inside the area.

Practice postcode was used to classify areas in accordance with nationally recognised descriptions for urban and rural areas and also to link to index of multiple deprivation (IMD) 2015 score for the lower super output area (LSOA) allowed for determination of socio-economic status of the practice(16). The IMD ‘is an overall relative measure of deprivation constructed by combining seven domains of deprivation according to the respective weights’. The seven domains and their weighting are; income deprivation (22.5%); employment deprivation (22.5%); education, skills and training deprivation (13.5%); health deprivation and disability (13.5%); crime (9.3%); barriers to housing and services (9.3%); and living environment deprivation (9.3%)’ (16). LSOAs are ‘small areas designed to be of similar population size, with an average of approximately 1,200 residents of 650 households; produced by the office of national statistics for reporting of small area statistics (16,15). The number of Units of Dental Activity commissioned from a practice defined by its postcode was used as a proxy for population size; 1,000 UDAs provides 460 separate treatment courses on average (17) and factoring in local authority population data allowed for approximation of prescriptions per 1,000 of the population (15,16).

Correlation tests were completed using the Excel Correlation Statistical Package (18))as seen in Figure 6.

**Results** (10)

A total of 13,565 prescriptions were identified for this one month period. Of these, 98% were for three main antibiotics amoxicillin, metronidazole and erythromycin. The remaining 2% was made up of 10 less commonly prescribed antibiotics (Appendix 1).

Of the three data sets outlined above; 63% of records captured all defined variables; 36% captured limited information but identified the prescribing dental practice and 1% had limited information available but it was impossible to determine fully which practice issued the prescription.

Prescriptions per 1,000 of the population

Prescriptions originated from across the North East and Cumbria, the North West and North Yorkshire by local authorities, as shown in the table below.

*Insert Table 1*

Overall, 13,529 prescriptions dispensed could be ascribed a postcode. This allowed for calculation of prescriptions issued per practice postcode location for October 2016; with the majority issuing 40 or fewer; with a range of 1 to 286 as shown in the following histogram (Figure 1).

*Insert Figure 1 here*

From the data, we were able to identify locations of 97% (or 13,126) of prescriptions; some prescriptions were prescribed from areas outside of the North East and Cumbria; namely North Yorkshire and Lancashire. Rate of prescriptions per 1,000 population ranged from 7.02 per thousand in Middleborough to 0.77 per thousand in Eden (Cumbria).

Relationship between number of prescriptions and socio-economic status

Data showed dental practices in more deprived areas prescribed a higher number of antibiotics, as represented in Figure 2. Overall levels of deprivation in the North East and Cumbria described in national deciles were then compared with this.

*Insert Figure 2 here*

Further analysis of prescribing patterns showed generally minimal difference in prescriptions from different geographical locations; with a minor indication that those practices in major conurbations, urban cities and towns had a slightly increased prescribing rate(10,19).

Number of prescriptions per 1,000 UDAs

The number of prescriptions provided per 1,000 UDAs commissioned for each postcode location ranged from 0.02 prescriptions per 1,000 UDAs commissioned to 57,000 per 1,000 from a salaried service with a single UDA contract who had delivered 57 prescriptions. The majority of practices issued fewer than 4 prescriptions per 1,000 UDAs commissioned during this one month period. Figure 4 shows the distribution spread for the 329 postcode locations, with the exclusion of the two highest practices.

Figure 3– Ratio of dental prescriptions issued per 1,000 UDA commissioned from NHS dental practices identified by postcodes.

*Insert Figure 3 here*

Figure 4 (20)– Prescribing rates against UDA commissioned each year by practice postcode (excludes the outlier of 57,000 prescriptions per 1000 population). Standard deviations (SD) represent the spread of data around the average results. For normal distribution, 68.27% of data in within 1 SD of the mean. The data, as represented by the diamonds, is predominantly within two standard deviations of the average, though some results are outside of 3 standard deviations as represented by the most outer lines on the graph.

*Insert Figure 4 here*

Relationship between population dental disease levels and prescriptions rates

No identifiable relationship between increased prescribing in areas of increased dental disease (Figure 5).

Figure 5– Relationship between prescription rates per 1,000 population of local authorities and districts in the North East and Cumbria and oral heath using the oral health of 5-year-old children as a proxy measure with r2=0.16. r2 is the coefficient of determination; a statistical measure of proximity of data to the regression line.

*Insert Figure 5 here*

Relationship between access to dental care and prescription rates

A significant positive correlation as seen in Figure 6 was identified between increased prescribing rates and increased access to dental services in the North east and Cumbria using BSA data on dental access rates when compared to prescribing rates of the local authorities.

Figure 6– Relationship between access to NHS dental services by populations in the North East and Cumbria and antibiotic prescriptions rates for populations and r2=0.66.

*Insert Figure 6 here*

**Discussion**

Analysing prescriptions within a region allows for the identification of inconsistent and anomalous prescribing habits. This is important as primary dental care is responsible for approximately 10% of all prescribing and as such unjustified prescribing can impact upon AMR. By assessing the impact of different factors on prescribing habits it can help to further target and focus education and resources.

We aimed within this paper to identify the prescribing habits of Cumbria and the North East and possible associations to socioeconomic status, dental disease, population size, access to dental care and the number of urgent treatment claims

The data showed that overall prescription rates were higher for people living in more deprived areas of the North East and Cumbria. One possible explanation is that areas of higher deprivation were shown to have higher levels of decay and dental disease (22) or as these locations were also identified as having greater access to dental services it may be that patient attendance occurs more often when the patient is in pain or that dentists in these more deprived areas have a greater tendency to prescribe. … It is worth considering that 40% of the North East has fluoridated water. The 2015 Cochrane review into water fluoridation to prevent tooth decay reviewed 155 studies which concluded fluoridation reduced decayed, missing and filled teeth in children by 35% in primary teeth and by 26% in permanent teeth. The authors however highlighted that 71% of the included studies were conducted prior to 1975 which is before the general introduction of fluoridated toothpaste and therefore ‘may not be applicable today’ (24). There is however need explore how fluoridation affects those with the highest caries rates (25).

A large range in the rate of prescriptions issued per 1,000 population was noted. This figure is the DDD (defined daily dose) of antibiotics prescribed in the region; this is the number of patients per 1,000 population who are taking antibiotics at any one time. National average DDD was 23 in 2014. DDD is the currency against which prescribing is measured. Figures from PHE, have indicated that the Durham, Darlington and Tees region (taking into account general medical practice, hospital and dental use) has the second highest DDD in England of 26.5 (27). The 10% figure that is the often-quoted rate of dental prescribing and the DDD of 2.11 represents approximately 10% of all antibiotic prescribing in the locality.

From the statistical review, there is clear evidence that rate of antibiotic prescribing in some instances cannot be explained by deprivation solely. Further work needs to be undertaken to explore the variation between different practices within similar levels of deprivation. This is currently difficult to understand and highlighted that different practitioners have a different propensity to prescribe. It is worth noting that an antibiotic prescribing audit undertaken to specifically identify prescribing outliers within this same area of Cumbria and the North East did not yield any significant discrepancy in prescribing habits; this may be due to the voluntary participation in the audit and prescribing outliers may have not taken part in the project. It is clearly important to identify the appropriateness of these individuals prescribing habits.

No definitive conclusions can be drawn regarding the rural/urban geography of populations and prescriptions as the data showed only a very minimal correlation indicating slightly higher rates in urban areas. Those of lower socio-economic areas may have limited means of transport and as such this would support the findings, however rurally residing patients would, in most circumstances, have to travel greater distances to attend a practice.

These data have allowed the identification of prescribing habit trends within the region which allows practioners to audit their own prescribing and compare with the data shown above. A clinical audit into prescribing by dentists in Wales identified 21.8% did not meet the advised guidelines for dose, frequency or duration of prescription (2) and from our results, we identified that certain practices were also prescribing at rates far higher than the average and as such education can be targeted towards this.

We should however be aware that the data available is limited for several reasons therefore care must be taken when drawing conclusions from it. The main issue with the data is that it is based on prescribing practice locations and not on patient addresses. The practice postcodes are unfortunately not evenly distributed around the North East and Cumbria as a result, the data obtained only accounts for prescribing habits of population characteristics in relation to practice postcode and not from the population in which the patient lives.

In addition, the data reflects only prescriptions issued by general dental practitioners for dental problems and not those issued by general medical practitioners to whom patients with dental issues may have visited and as such risks not accounting for a possible additional population of individuals. However, with the resources available it does provide a general overview.

Monitoring and auditing our own prescribing habits will ensure appropriate prescribing is being carried out. The Dental Antimicrobial Stewardship Toolkit is one such self-audit toolkit (29) that could be used to achieve this. The results of these self-audits could then be compared with area or regional data in the future.

**Conclusions**

Penicillin’s accounted for 69% of antibiotics prescribed which is consistent with findings in practices in East England with 63.4% (30) and Wales where penicillins accounted for 67% of prescriptions (31). There was no apparent link between population dental disease and prescribing patterns but patients in more deprived areas received a higher rate of prescriptions, as did those with greater access to dental care.

Primary dental practitioners in England prescribed over 3.5 million antibiotics in 2014 (32) and we therefore have the ability to contribute to the campaign against antimicrobial resistance. In order to furnish practitioners with the relevant individual and benchmarked prescribing activity, consideration should be given to routine reporting of antibiotic prescribing rates by individuals by the BSA as a part of the NHS England assurance framework. This would facilitate individual self-identification of aberrant prescribing rather than regulatory performance management.

**Recommendations**

Future studies should therefore look to develop more robust reporting data in more areas of the country. Further work should be undertaken to identify and support practitioners that have a greater propensity to prescribe antibiotics and consideration should be given to routine reporting of antibiotic prescribing rates by the BSA to NHS England for identification of aberrant prescribing patterns.

The Department of Health in conjunction with PHE and the Royal Colleges introduced the antibiotic guardian initiative (33,34) whereby individuals, currently over 47,000, can pledge to consider local measures such as drainage for dental infections before issuing antibiotics and to discuss with patients the importance of antimicrobial resistance by encouraging them to take the Antibiotic Guardian quiz. As part of this initiative, practitioners make a pledge to become antibiotic guardians or discuss methods of controlling symptoms rather than prescribing antibiotics as a first course of action (33,34). There are many resources available to GDPs regarding appropriate management of dental emergency patients as well as antibiotic prescribing; Scottish Dental Clinical Effectiveness Programme (SDCEP) website or app and Faculty of General Dental Practitioners (FGDP) website are two of the available resources (35,36). There is now a new toolkit available for self-audit available on the FGDP or BDA websites (37).

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**Appendix 1** (10)

**Table showing number and description of antibiotic prescriptions from dental practices dispensed by pharmacies with contracts in the North East and Cumbria**.

|  |  |
| --- | --- |
| **Description of antibiotic** | **Number of prescriptions issued** |
| Amoxicillin 125mg/1.25ml oral suspension paediatric (20) | 2 |
| Amoxicillin 125mg/5ml oral suspension (100) | 164 |
| Amoxicillin 125mg/5ml oral suspension sugar free (100) | 188 |
| Amoxicillin 125mg/5ml oral suspension sugar free [A A H Pharmaceuticals Ltd] (100) | 1 |
| Amoxicillin 250mg capsules (15) | 435 |
| Amoxicillin 250mg capsules (21) | 717 |
| Amoxicillin 250mg capsules [Alliance Healthcare (Distribution) Ltd] (21) | 3 |
| Amoxicillin 250mg/5ml oral suspension (100) | 221 |
| Amoxicillin 250mg/5ml oral suspension [A A H Pharmaceuticals Ltd] (100) | 1 |
| Amoxicillin 250mg/5ml oral suspension [Kent Pharmaceuticals Ltd] (100) | 1 |
| Amoxicillin 250mg/5ml oral suspension sugar free (100) | 282 |
| Amoxicillin 250mg/5ml oral suspension sugar free [A A H Pharmaceuticals Ltd] (100) | 2 |
| Amoxicillin 250mg/5ml oral suspension sugar free [Kent Pharmaceuticals Ltd] (100) | 1 |
| Amoxicillin 3g oral powder sachets sugar free (2) | 69 |
| Amoxicillin 500mg capsules (15) | 3134 |
| Amoxicillin 500mg capsules (21) | 4098 |
| Amoxicillin 500mg capsules [A A H Pharmaceuticals Ltd] (15) | 3 |
| Amoxicillin 500mg capsules [A A H Pharmaceuticals Ltd] (21) | 5 |
| Amoxicillin 500mg capsules [Almus Pharmaceuticals Ltd] (21) | 6 |
| Amoxicillin 500mg capsules [Kent Pharmaceuticals Ltd] (15) | 1 |
| Amoxicillin 500mg capsules [Teva UK Ltd] (21) | 1 |
| Amoxil 500mg capsules [GlaxoSmithKline UK Ltd] (21) | 1 |
| Augmentin 375mg tablets [GlaxoSmithKline UK Ltd] (21) | 1 |
| Azithromycin 250mg capsules (6) | 2 |
| Cefalexin 250mg capsules (28) | 3 |
| Cefalexin 250mg tablets (28) | 2 |
| Cefalexin 500mg capsules (21) | 12 |
| Cefalexin 500mg tablets (21) | 4 |
| Clarithromycin 250mg tablets (14) | 17 |
| Clarithromycin 250mg/5ml oral suspension (70) | 1 |
| Clarithromycin 500mg tablets (14) | 12 |
| Clindamycin 150mg capsules (24) | 23 |
| Co-amoxiclav 250mg/125mg tablets (21) | 31 |
| Co-amoxiclav 250mg/62mg/5ml oral suspension (100) | 1 |
| Doxycycline 100mg capsules (8) | 14 |
| Erythrocin 250 tablets [AMCo] (100) | 3 |
| Erythrocin 500 tablets [AMCo] (100) | 13 |
| Erythromycin 250mg gastro-resistant tablets (28) | 365 |
| Erythromycin 250mg gastro-resistant tablets [A A H Pharmaceuticals Ltd] (28) | 2 |
| Erythromycin 250mg gastro-resistant tablets [Medreich Plc] (28) | 1 |
| Erythromycin ethyl succinate 125mg/5ml oral suspension (100) | 7 |
| Erythromycin ethyl succinate 125mg/5ml oral suspension sugar free (100) | 5 |
| Erythromycin ethyl succinate 250mg/5ml oral suspension (100) | 8 |
| Erythromycin ethyl succinate 250mg/5ml oral suspension sugar free (100) | 4 |
| Erythromycin ethyl succinate 500mg tablets (28) | 5 |
| Erythromycin ethyl succinate 500mg/5ml oral suspension sugar free (140) | 1 |
| Erythromycin stearate 500mg tablets (100) | 4 |
| Erythroped A 500mg tablets [AMCo] (28) | 1 |
| Erythroped Forte SF 500mg/5ml oral suspension [AMCo] (140) | 1 |
| Metronidazole 200mg tablets (21) | 1439 |
| Metronidazole 200mg tablets [A A H Pharmaceuticals Ltd] (21) | 1 |
| Metronidazole 200mg tablets [Almus Pharmaceuticals Ltd] (21) | 1 |
| Metronidazole 200mg/5ml oral suspension (100) | 64 |
| Metronidazole 200mg/5ml oral suspension [A A H Pharmaceuticals Ltd] (100) | 2 |
| Metronidazole 200mg/5ml oral suspension [Zentiva] (100) | 1 |
| Metronidazole 400mg tablets (21) | 2116 |
| Metronidazole 400mg tablets [A A H Pharmaceuticals Ltd] (21) | 2 |
| Metronidazole 400mg tablets [Almus Pharmaceuticals Ltd] (21) | 1 |
| Metronidazole 500mg tablets (21) | 4 |
| Oxytetracycline 250mg tablets (28) | 3 |
| Phenoxymethylpenicillin 125mg/5ml oral solution (100) | 5 |
| Phenoxymethylpenicillin 125mg/5ml oral solution sugar free (100) | 3 |
| Phenoxymethylpenicillin 250mg tablets (28) | 35 |
| Phenoxymethylpenicillin 250mg/5ml oral solution (100) | 1 |
| Tetracycline 250mg tablets (28) | 8 |
| **Grand Total** | **13565** |

# References

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| --- | --- |
| 1. | Centers for Disease Control and Prevention. About Antimicrobial Resistance. [Online].; 2015 [cited 2017 May 20th. Available from: <https://www.cdc.gov/drugresistance/about.html>. |
| 2. | Cope AL BEHERAKAWMLM&CJ. Antimicrobial prescribing by dentists in Wales, Uk: findings of the first cycle of a clinical audit. British Dental Journal. 2016; 221: p. 25-30. |
| 3. | HM Government. Antimicrobial Resistance: Tackling a crisis for the health and wealth of nations. [Online].; 2014 [cited 2017 July 1st. Available from: <https://amr-review.org/sites/default/files/AMR%20Review%20Paper%20-%20Tackling%20a%20crisis%20for%20the%20health%20and%20wealth%20of%20nations_1.pdf>. |
| 4. | Department of Health. UK Five Year Antimicrobial Resistance Strategy 2013 to 2018. , Department of Health and Deparment for Environemnt Food and Rural Affairs; 2013 September. |
| 5. | World Health Organisation (WHO). Antimicrobial Resistance: Global Report on Surveillance. [Online].: World Health Organisation ; 2014 [cited 2017 June 11th. Available from: <http://apps.who.int/iris/bitstream/10665/112642/1/9789241564748_eng.pdf?ua=1>. |
| 6. | Hamilton WL WR. Antimicrobial resistance: a major threat to public health. Cambridge Medicine Journal. 2016 January . |
| 7. | NHS England. NHS England launches national programme to combat antibiotic over usage. [Online].; 2016 [cited 2017 May 20th. Available from: <https://www.england.nhs.uk/2016/03/antibiotic-overusage/>. |
| 8. | Cope AL FNWF&CI. Antibtioic prescribing in UK deneral dental practice: a crss sectional study.. Community Dent Oral Epidemiol. 2016 Apr; 44: p. 145-53. |
| 9. | Public Health England. English suveillance programme for antimicrobial utilisation and resistance (ESPAUR). [Online].; 2016 [cited 2017 May 20th. Available from: <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/575626/ESPAUR_Report_2016.pdf>. |
| 10. | Landes DP. Antibiotic Prescriptions issued by Dentists in the North East and Cumbria: A report for NHS England. Public Health England; 2017. |
| 11. | NHS Primary Care Commissioning. Salaried Primary Dental Care Services: Toolkit for Commissioners. [Online].; 2010 [cited 25th July 2017. Available from: <https://www.pic-cic.org.uk/sites/default/files/articles/attachements/salaried_dental_services.pdf>. |
| 12. | Public Health England. Naitnal Dental Epidemiology Programme for England: oral health survey of five-year-old children 2015, A report on the prevalence and severity of dental decay. [Online].; 2016 [cited 2017 May 21st. Available from: <http://www.nwph.net/dentalhealth/14_15_5yearold/14_15_16/DPHEP%20for%20England%20OH%20Survey%205yr%202015%20Report%20FINAL%20Gateway%20approved.pdf>. |
| 13. | Gray MM MM&AR. The relationship between caries expereince in the deciduous molars at the age of 5 and the first permanent molars of the same child at the age of 8 years.. Community Dental Health 8. 1991; 3-6. |
| 14. | Landes DP. The distance travelled by patients in the North East to access routine NHS dental services. County Durham Primary Care Trust, Durham, UK; 2012. |
| 15. | Office for National Statistics. Population Estimatees for UK, England and Wales, Scotland and Northern Ireland: mid-2015. [Online].; 2016 [cited 2017 May 20th. Available from: <https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/annualmidyearpopulationestimates/latest>. |
| 16. | Department for Communities and Local Government. gov.uk. [Online].; 2015 [cited 2017 June 11th [File 1: index of multiple deprivation ]. Available from: <https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015>. |
| 17. | NHS Digital. NHS Dental Statistics for England 2015-2016, Annual Report. [Online].; 2016 [cited 2016 May 20th. Available from: <http://www.content.digital.nhs.uk/catalogue/PUB21701>. |
| 18. | Microsoft Excel. Excel Correlation Statistical Package.. |
| 19. | Department for Environment, Food and Rural Affairs. 2011 rural-Urban Classification of Local Authorities and other geographies. [Online].; 2016 [cited 2017 May 20th. Available from: <https://www.gov.uk/government/statistics/2011-rural-urban-classification-of-local-authority-and-other-higher-level-geographies-for-statistical-purposes>. |
| 20. | Association of Public Health Observatories (APHO). Analytical Tools for Public Health: Funnel plot for rates (including directly standardised rates). [Online].; 2008 [cited 2017 June 11th. Available from: <http://webarchive.nationalarchives.gov.uk/20170106081009/http://www.apho.org.uk/resource/item.aspx?RID=47240>. |
| 21. | Landes DP. Modelling Urgent and Unscheduled Care Demand, County Durham and Tees Valley & Cumbria, Northumberland and Tyne & Wear, NHS England Area Teams. Public Health England, North East Centre ; 2014. |
| 22. | The Information Centre for Health and Social Care. 2: Disease and related disorders - a report from the Adult Denal Health Survey 2009. [Online].; 2011 [cited 2017 May 21st. Available from: <http://content.digital.nhs.uk/catalogue/PUB01086/adul-dent-heal-surv-summ-them-the2-2009-rep4.pdf>. |
| 23. | The Information Centre for Health and Social Care. 1: Oral HEalth and function - a report from the Adult Dental Health Survey 2009. [Online].; 2011 [cited 2017 May 21st. Available from: <http://content.digital.nhs.uk/catalogue/PUB01086/adul-dent-heal-surv-summ-them-the1-2009-rep3.pdf>. |
| 24. | Iheozor-Ejiofor Z WHWTOLCJMRARTPWV&GA. Cochrane Review: Water fluoridation to prevent tooth decay. Cochrane Library. 2015. |
| 25. | Rugg-Gunn AJ SAWHJCBJCPJJKMLMMJODSCHSPTWWS&ZS. Critique of the review of 'Water fluoridation of dental caries' published by the Cochrane Collaboration in 2015. BDJ. 2016; 220: p. 335-340. |
| 26. | Middlesborough Council. Middlesborough Council Website. [Online].; 2015 [cited 2017 May 21st. Available from: <https://www.middlesbrough.gov.uk/open-data-foi-and-have-your-say/about-middlesbrough-and-local-statistics/index-multiple-deprivation-2015>. |
| 27. | Public Health England. New report reveals increase in use of antibiotics linked to rising levels of antibiotic resistance. [Online].; 2014 [cited 2017 July. Available from: <https://www.gov.uk/government/news/new-report-reveals-increase-in-use-of-antibiotics-linked-to-rising-levels-of-antibiotic-resistance>. |
| 28. | Landes DP. Access to Dental care for residents of NHS County Durham and NHS Darlington provided by NHS dentists in the North East 2010-2011. Durham UK: NHS County Durham; 2012. |
| 29. | NICE. Antimicrobial stewarship: systems and processes for effective antimicrotial medicine use. [Online].; 2015 [cited 2017 July 5th. Available from: <https://www.nice.org.uk/guidance/ng15/resources>. |
| 30. | Chate RAC> |
| 31. | Karki AJ HG&TD. Dental prescribing in Wales and assocaited public health issues. BDJ Online. 2010; 210(E21). |
| 32. | The Health and Social Care Information Centre. Prescribing by Dentists. [Online].; 2014 [cited 2017 May 20th. Available from: <http://content.digital.nhs.uk/catalogue/PUB17425/pres_dent_eng_2014_rep.pdf>. |
| 33. | Public Health England. Make your pledge today and join 17,000 Antibiotic Guardians. [Online].; 2015 [cited 2017 June 11th. Available from: <https://www.gov.uk/government/news/make-your-pledge-today-and-join-over-17000-antibiotic-guardians>. |
| 34. | Public Health England. Antibiotic Guardian. [Online].; 2014 [cited 2017 June 11th. Available from: <http://antibioticguardian.com>. |
| 35. | The Faculty of General Dental Practioners, UK. Antimicrobial Prescribing for General Dental Practioners, 2nd Edition. [Online].; 2014 [cited 2017 July 5th. Available from: <http://www.fgdp.org.uk/OSI/open-standards-initiative.ashx>. |
| 36. | Scottish Dental Clinical Effectiveness Programme. SDCEP. [Online].; 2016 [cited 2071July 5th. Available from: <http://www.sdcep.org.uk/wp-content/uploads/2016/03/SDCEP-Drug-Prescribing-for-Dentistry-3rd-edition.pdf>. |
| 37. | New toolkit lets dentists build on antibiotic prescribing success. 2017.. |

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