

A standardized methodology for the surveillance of antimicrobial prescribing linked to clinical indications in primary care

Sue Smith¹, Jeremy I. Hawker², Gillian E. Smith¹, Roger Morbey¹, Alan P. Johnson³, Douglas M. Fleming⁴, Laura Shallcross⁵, Andrew C. Hayward⁵

¹Real-time Syndromic Surveillance Team, Centre for Infectious Disease Surveillance and Control, National Infection Service, Public Health England, Birmingham B3 2PW, UK

²Field Epidemiology Service, National Infection Service, Public Health England, Birmingham B3 2PW, UK

³Healthcare Associated Infection Surveillance, Centre for Infectious Disease Surveillance and Control, National Infection Service, Public Health England, London NW9 5EQ, UK

⁴Department of Clinical and Experimental Medicine, School of Biosciences and Medicine, University of Surrey, Guildford GU2 7XH, UK

⁵UCL Institute of Health Informatics, London NW1 2DA, UK

Address correspondence to Sue Smith, E-mail: sue.smith@phe.gov.uk

ABSTRACT

Background A key component of strategies to reduce antimicrobial resistance is better antimicrobial prescribing. The majority of antibiotics are prescribed in primary care. While many existing surveillance systems can monitor trends in the quantities of antibiotics prescribed in this setting, it can be difficult to monitor the quality of prescribing as data on the condition for which prescriptions are issued are often not available. We devised a standardized methodology to facilitate the monitoring of condition-specific antibiotic prescribing in primary care.

Methods We used a large computerized general practitioner database to develop a standardized methodology for routine monitoring of antimicrobial prescribing linked to clinical indications in primary care in the UK. Outputs included prescribing rate by syndrome and percentages of consultations with antibiotic prescription, for recommended antibiotic, and of recommended treatment length.

Results The standardized methodology can monitor trends in proportions of common infections for which antibiotics were prescribed, the specific drugs prescribed and duration of treatment. These data can be used to help assess the appropriateness of antibiotic prescribing and to assess the impact of prescribing guidelines.

Conclusions We present a standardized methodology that could be applied to any suitable national or local database and adapted for use in other countries.

Keywords primary care, public health

Introduction

Antibiotic resistance poses a major threat to clinical medicine and public health, not only in the UK but internationally.^{1–5} It is recognized that overprescribing of antibiotics generates a strong selective pressure for the emergence and spread of antibiotic resistance. Hence, promotion of antibiotic stewardship programmes, comprising activities aimed at optimizing prescribing so as to improve clinical outcomes while minimizing the selective pressure for resistance engendered by antimicrobial use, is increasingly being advocated as a major intervention for trying to reduce levels of antimicrobial resistance. For example, optimizing prescribing

practice through implementation of antimicrobial stewardship programmes is one of the seven key areas for action highlighted in the UK 5-Year Antimicrobial Resistance Strategy.⁵

Sue Smith, Health Protection Scientist

Jeremy I. Hawker, Consultant Epidemiologist

Gillian E. Smith, Consultant Epidemiologist

Roger Morbey, Statistical Project Lead

Alan P. Johnson, Consultant Clinical Scientist

Douglas M. Fleming, Visiting Professor

Laura Shallcross, Clinical Lecturer

Andrew C. Hayward, Professor

Assessing the implementation and impact of antibiotic stewardship programmes requires a better understanding of antimicrobial usage, both in primary and secondary care. Indeed, both the European Commission⁴ and the UK's Chief Medical Officer have highlighted the importance of surveillance of antimicrobial consumption. However, while available data on antibiotic use show trends in drug usage by class^{6–8} information on why the drug was prescribed is frequently lacking, making it difficult to assess whether or not prescribing is appropriate or to monitor the effectiveness of prescribing guidelines. Our previous work has shown how general practitioner (GP) databases can be used to look at prescribing for specific conditions and to assess the impact of published prescribing guidance.^{9–11} As an aid to investigators wishing to use such data sources to develop on-going surveillance systems at a national or local level, we present here the development of a standardized methodology designed to enable the establishment of a system for monitoring antimicrobial prescribing linked to clinical indications in primary care. The formulation of the standardized methodology was based on our experience of conducting a study to assess trends in compliance of antibiotic prescribing in the community with national guidance.¹¹

Methodology

The methods presented describe and set out the different components of the standardized methodology, describing the various elements required to establish an antimicrobial prescribing surveillance system.

Data requirements

The key requirement for an antimicrobial prescribing surveillance system is access to a large computerized database of GP data that records both clinical indicators and prescribing data using validated medical coding systems (e.g. Read Codes, SNOMED, ICD10).^{12,13} The computerized system should be capable of linking consultations and prescribing data (e.g. by consultation/prescribing date) so that it is possible to determine the condition for which an antimicrobial was prescribed. The database should provide appropriate geographical coverage and data quality indicators should show when practices meet recording standards.^{14,15} Demographic data should be available to allow surveillance of prescribing trends by age, region or sex. Finally the database should be regularly updated to allow surveillance of prescribing trends over time.

In the UK suitable databases include the Health Improvement Network (THIN),¹⁶ the Clinical Practice

Research Datalink (CPRD),^{17,18} and the Royal College of General Practitioners Research Surveillance Centre database (RCGPRSC).^{19,20} The THIN database collects consultation data from 587 general practices with 3.6 million active patients, comprising 5.7% of the UK population¹⁶ while CPRD has 674 practices with 4.4 million active patients, representing 6.9% of the UK population.²¹ There is an overlap between THIN and CPRD with some practices contributing to both systems and similar data available in both.²² The RCGPRSC is slightly smaller covering 230 practices and 1.5 million patients that also allows analysis of prescribing rates for infections.^{19,20}

Clinical indicators

When considering which clinical indicators to monitor it is preferable to choose conditions commonly recorded in general practice for which clear recommendations regarding the appropriateness of antibiotic prescribing are available. In the UK, prescribing recommendations have been made to primary care physicians by a number of authorities including: the RCGP;²³ National Institute for Health and Care Excellence (NICE);²⁴ the Department of Health's Standing Medical Advisory Committee (SMAC) Sub-Group on Antimicrobial Resistance;²⁵ Public Health England²⁶ (whose guidelines are endorsed by the Royal College of General Practitioners) and the British National Formulary.²⁷ Other countries will have their own recommendations that could be used to set appropriate indicators.

Methods of data extraction and analysis

It is important that methods of data extraction and analysis are properly recorded, especially if the intention is to set up an on-going surveillance system where analysis will be repeated at regular intervals. An example of suitable software is STATA,²⁸ which is able to handle very large datasets. STATA queries are written as program 'do files' that provide a permanent record of what was done so that queries can be repeated at a later date, making it particularly suitable for on-going surveillance.

Data quality

The quality of GP data depends on the thoroughness of data recording within the individual practice. Some databases (e.g. RCGPRSC and THIN) have on-going training in data recording for participating GPs, while all will carry out data validation checks and may provide quality indicators for each practice to show when they reached an acceptable level of data recording.^{15,29} The databases should also carry out

data validation checks on patient records to check that data on age, sex and other important variables are recorded.^{29,30}

Data extraction

Episodes of the condition of interest can be extracted by merging patient records with the list of codes chosen to define that condition (which may include signs and symptoms). Episodes can then be linked to antibiotic prescribing using the appropriate drug code list. However, there can be more than one consultation (when antibiotics may or may not have been prescribed) associated with the same episode of illness, and many conditions can occur more than once. If possible, initial and new consultations from an illness episode should be pooled for inclusion in the analysis to assess whether an antibiotic was or was not prescribed for that episode. Given there may be uncertainty as to whether a new consultation is related to a given episode of illness, inclusion/exclusion periods can be set after the initial consultation to help standardize the criteria for defining episodes in a given study, particularly if trends in prescribing are being monitored. Only episodes with a single condition and a single prescription issued within the same consultation or on the same day should be included to be reasonably confident that the antibiotic was prescribed for the condition monitored.

Data analysis

For data analysis, STATA survival analysis commands were used to calculate incidence rates for total episodes and for episodes where antibiotics were prescribed over a 16-year period. In addition annual rates were calculated by sex, age band and Townsend score,³¹ a composite measure of social deprivation linked to UK Census data by patient post code that is included in the THIN dataset. Data were also presented as the percentage of episodes where antibiotics were prescribed. For urinary tract infections (UTIs), for which current UK prescribing guidelines recommend three day courses of nitrofurantoin (or trimethoprim if low risk of resistance) for adult women,²⁶ course lengths were calculated by dividing the number of tablets prescribed by the daily dosage. Daily dosage is often recorded as free text but in THIN this has been converted to a numeric quantity.³²

The conditions were defined as groups of clinical codes. Since THIN records consultations using the Read Clinical Classification version 2, the conditions were defined as lists of Read codes, but other medical coding systems such as SNOMED or IDC10 could be used. We conducted an initial broad search of the Read code dictionary using methods previously described.³³ For each condition, a list of search

terms (key words and synonyms) was produced and used to search the descriptions in the Read code dictionary to produce a comprehensive code list from which the final codes to be included were chosen. It is helpful if the codes can be linked to counts to see how often they are used to ensure that the most commonly used codes are included. The selected groups of clinical codes can be chosen to maximize sensitivity (to include all possible cases) or specificity. Our aim was to make the groups of clinical codes as near to the condition that was subject to a recommended action as possible and so the following criteria were applied:

- High specificity of code for clinical condition: e.g. tonsillitis was included in the sore throat indicator, but not influenza, even though it may present with a sore throat, since many cases of influenza will not have a sore throat.
- Exclusion of codes that indicated a clear bacterial aetiology for recommendations that related to viral upper respiratory tract infection (URTI) (e.g. exclusion of ‘bacterial sore throat’ and ‘streptococcal sore throat’, but not excluding a generic ‘sore throat’).
- Exclusion of specific codes for which the relevant recommendation is not appropriate (e.g. the UTI recommendation was for women with uncomplicated infection, so infections recorded as recurrent or associated with pregnancy or kidney infection were excluded).

A more sensitive, less specific list could also be analysed to check that any improvement is not due to ‘diagnostic transfer’³⁴ to more severe clinical codes to justify a prescription.

Drug code lists included all antibiotics in chapter 5.1 of the British National Formulary²⁷ excluding chapters 5.1.9 (antituberculosis drugs) and 5.1.10 (antileprotic drugs). Additional code lists were developed for antibiotics specified in UK treatment guidelines.²⁶

Resources required for a surveillance system

When setting up a surveillance system it is important to consider cost as this is likely to have a substantial impact on the feasibility of any project. In the UK most providers meet the costs of maintaining large GP datasets by charging those who use the data. The fees vary depending on the level of access to the data.

At the beginning of a project, staff time is required to produce code lists, set up and check queries for data extraction and develop surveillance reports. Clinical/Consultant Epidemiologist input may be required to agree the final code lists for the indicators and drug code lists, and it can be helpful if GPs with expertise in GP data or antimicrobial

resistance are available to comment on these. Someone with a thorough knowledge of statistical packages is necessary, to check the data queries and oversee the statistical outputs. Once the initial work is complete, an on-going surveillance system would require the analysis to be repeated at regular intervals, probably either annually or quarterly.

Results

Example of use of the standardized methodology for analysis of THIN data

We present here specific details of use of the standardized methodology based on our experience of conducting a pilot UK study of community prescribing for cough/cold, sore throat, URTI, otitis media and UTIs, using data from the THIN database.^{11,16} These conditions were chosen as they covered recommendations for infections for which antibiotic prescribing should be avoided, conditions when specific antibiotics should be given and one instance (UTIs) of a recommendation for short-course prescribing.²⁶

Data outputs

Outputs for selected clinical syndromes have been reported elsewhere.¹¹ Four types of indicator were produced:

- Prescribing rate by syndrome.
- Percentage of consultations for the condition that resulted in an antibiotic prescription.
- Percentage of antibiotic prescriptions for the condition that were for one of the recommended antibiotics.
- Percentage of antibiotic prescriptions for the condition that were of the recommended treatment length.

These indicators can be analysed by:

- Time trends.
- Variation by individual primary care practice.
- Age-group.
- Socio-economic group.

Figure 1 shows an example output from using the standardized methodology, illustrating trends in both incidence and in prescribing for one of the selected conditions and shows the importance of considering both sets of data together. This example shows a marked decline in the rate of antibiotic prescribing for episodes of URTI between 1995 and 2000, but also shows a similar decline in incidence of URTI, suggesting that this decrease could be due to less morbidity presenting to the physician, rather than a change in

prescribing behaviour. It is therefore useful to also look at the percentage of episodes with an antibiotic prescribed. When the data are presented in this way there remains a significant decline in the percentage of episodes with a prescription from 64% in 1996 to 49% in 1999 (Fig. 2) but there is also a dip to 47% in 2009, the year of the influenza A(H1N1)pdm09 ‘swine flu’ pandemic, that is not obvious in Fig. 1.

The standardized methodology enables data to be further stratified by age band and socio-economic group to examine variations in prescribing. The example in Fig. 3 shows that the 0–4 years age group are far less likely to be prescribed an antibiotic for URTI than other age groups, while those 65 years and over had the highest percentage of antibiotics prescribed. There was little difference in prescribing by socio-economic group although the most deprived patients (group 5) were slightly less likely to be prescribed antibiotics (Fig. 4). Example outputs from the final two types of indicator are provided in Supplementary material (Figs S1 and S2).

Using the standardized methodology it is also possible to look at the individual drugs prescribed for a condition to see if they are in line with the recommendations in current prescribing guidance. For example, although 60% of otitis media cases should resolve in 24 h without antibiotics, where they are prescribed UK treatment guidelines recommend amoxicillin, or erythromycin for those with penicillin allergy.²⁶ Although the percentage of episodes of otitis media with an antibiotic remained stable, there was an increase in the percentage of prescriptions for a recommended antibiotic from 77% in 1995 to 85% in 2011 (data not shown). This approach could also be adapted to examine prescribing of an inappropriate antibiotic, e.g. prescribing of broad-spectrum cephalosporins may be discouraged in some countries to reduce *Clostridium difficile* infections.²⁶

To assess whether this dataset could produce useful data to help monitor recommendations for short-course therapy in certain syndromes, we looked at course length for trimethoprim or nitrofurantoin in UTIs. Although there was no specific data field for course length, we were able to calculate this from the ‘quantity prescribed’ field divided by the ‘calculated daily dosage’ field for 81 and 70%, respectively, of episodes for which these antibiotics were prescribed. This showed a significant increase in short-course therapy, in line with national recommendations.

Discussion

Main finding of this study

We have developed a standardized methodology for using data from a GP database to monitor trends in antibiotic

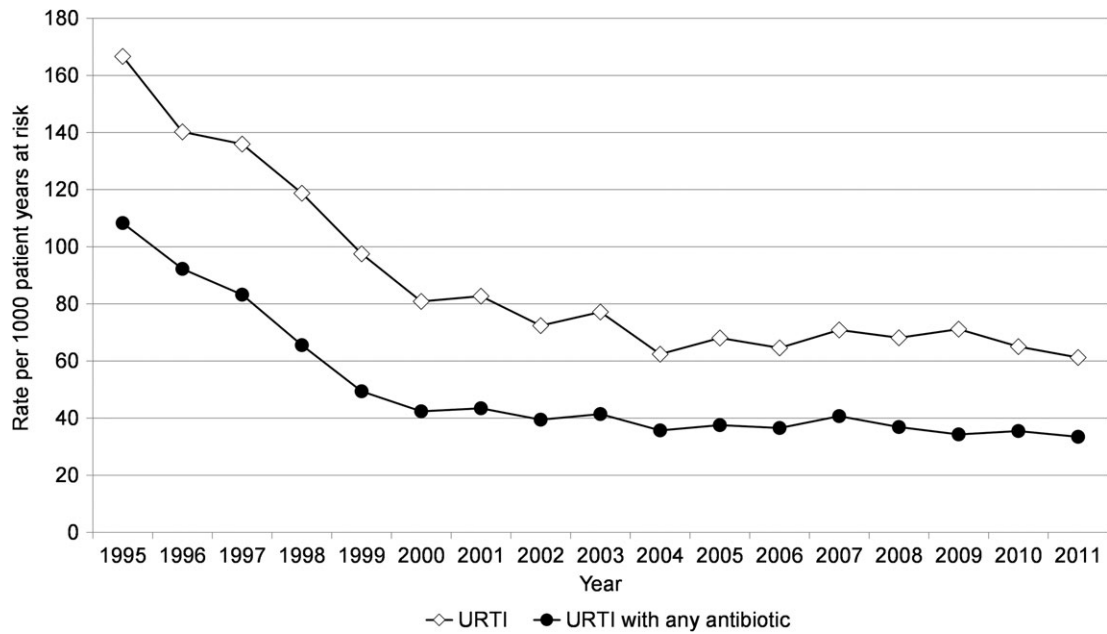


Fig. 1 URTI all episodes and episodes with antibiotic prescribed, 1995–2011.

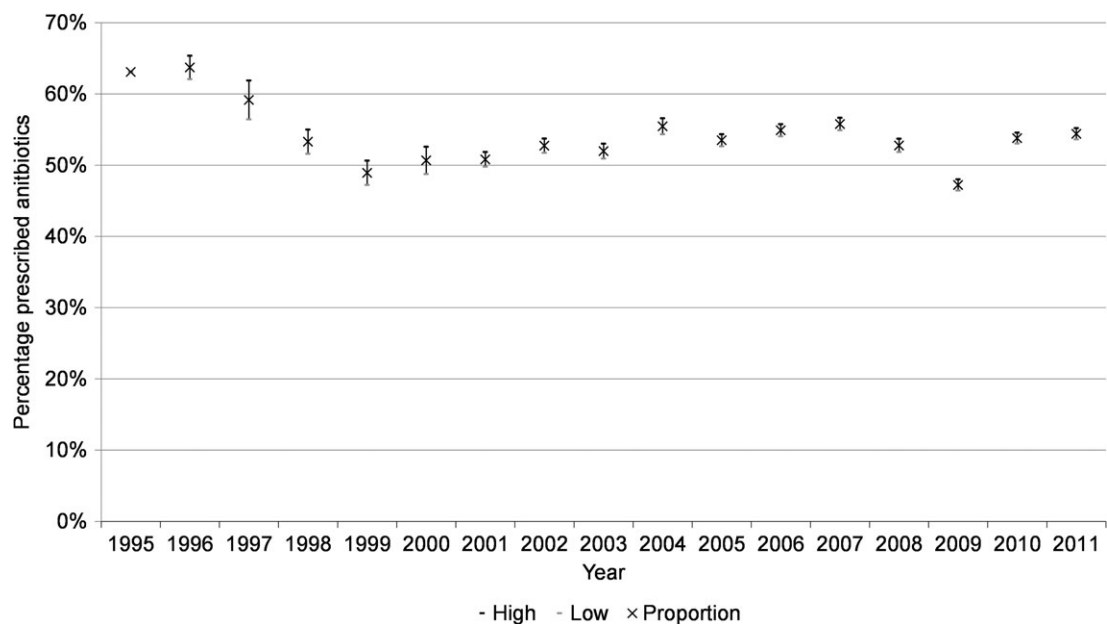


Fig. 2 Percentage of episodes of URTI with antibiotic prescribed, 1995–2011 (with 95% confidence intervals for within practice year on year variation).

prescribing for specific clinical indications, and have given an example of its use to show trends in diagnosis and antibiotic prescribing for a series of chosen conditions over recent years. These data could be regularly updated to provide an on-going surveillance system. While there are a number of surveillance systems that monitor trends in the quantity of antibiotics prescribed in primary care, the lack of information

on the condition for which the prescription was issued makes it difficult to monitor the quality of prescribing. The standardized methodology can monitor trends in prescribing for specific conditions, including looking at specific drugs prescribed and the duration of treatment. The data can be used to help assess the appropriateness of antibiotic prescribing and also to evaluate the impact of prescribing guidelines.

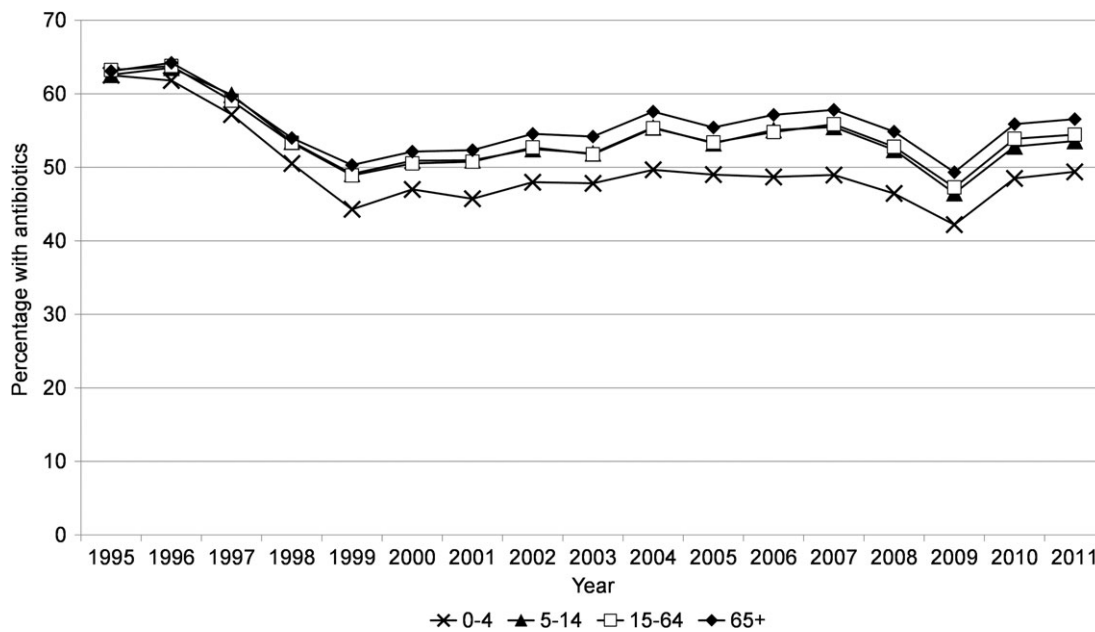


Fig. 3 Percentage of episodes of URTI with antibiotic prescribed stratified by age band (years), 1995–2011.

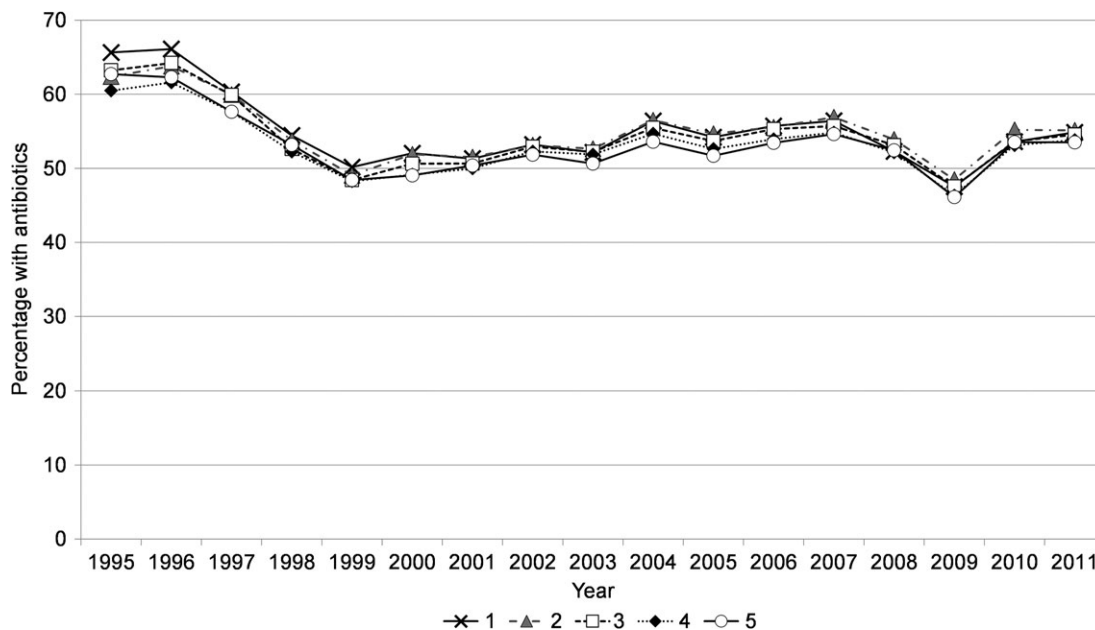


Fig. 4 Percentage of episodes of URTI with antibiotic prescribed stratified by Townsend score, 1995–2011.

What is already known on this topic

Although our pilot study used the THIN dataset available in the UK, similar primary care databases also exist in other European countries, such as the Information System for the Development of Research in Primary Care (SIDIAP) in Catalonia,³⁵ or the Health Search Database (HSD) in Italy.³⁶ Although some of these datasets are smaller than THIN,¹⁶ they are sufficiently large and well-established to be used to

examine national consultation and prescription trends in infectious diseases, offering the potential for a powerful international infectious disease surveillance network.

What this study adds

To aid local antibiotic stewardship programmes, Public Health England has recently extended the range of public

health profiles available on its freely accessible Fingertips web-portal to include antimicrobial resistance.³⁷ This allows local data on antibiotic prescribing (both total and by antibiotic class) to be accessed by Clinical Commissioning Groups, Trusts or GP practices, who can also benchmark their prescribing against the national picture. The value of the standardized methodology reported here is that it can enhance understanding of data available via Fingertips through its ability to link antibiotic prescribing data to clinical indications, thus allowing users not only to monitor trends in prescribing but also the quality in terms of appropriate or inappropriate antibiotic use.

Limitations of this study

There can be limitations to the use of the standardized methodology such as the choice of clinical codes to define the conditions to be monitored. For example, omission of any commonly used codes would result in erroneous incidence rates. Similarly if GPs changed the way that they code conditions over time, possibly to justify issuing prescriptions, this could affect analysis of trends in prescribing.³⁴

When auditing the content of computerized records it is necessary to consider the consistency and comprehensiveness of the record generated. A satisfactory record must always contain the Read codes relevant to the morbidity for which the person consulted and for which the antibiotic or other drug was prescribed linked together on the same date. Prescriptions are routinely issued from (and therefore stored on) computer records but if morbidity details and relevant Read codes are not entered at the same time it may prove impossible to audit prescription linked morbidity. We therefore emphasize the importance of disciplined recording as a prerequisite for audit activities.

Prescribing data are particularly well recorded in THIN because the record in the practice information system directly generates the paper prescription, although there is no way of knowing whether or not the prescription was dispensed. Hence, the system cannot identify cases where the GP has followed guidelines and issued a deferred prescription to be used only if there is no improvement: this could mean that antibiotic usage may be overestimated.

A further limitation of the system is that it would miss prescribing not entered on the practice information system. One of the key areas is the clinical management of patients through GP out of hours (OOH) services. The electronic record of a patient who consults OOH services, and is prescribed an antibiotic, may not be updated with prescribing information that is readily extractable, and therefore not

available for analysis. This could also include prescriptions issued when a GP visited a patient at home.

Finally it is known that some prescribed antibiotics are not linked to a clinical code and therefore the reason for the prescription is unknown (estimated to include ~39% of antibiotics prescribed).³⁸

Conclusion

Monitoring antimicrobial prescribing is a major component of strategies for the control of antimicrobial resistance produced at local, UK,⁵ European⁴ and World² level. We have described a methodology for monitoring antibiotic prescribing using data from a large GP database, which has been put together in the form of a standardized methodology that can be modified to be used in any county that has a suitable database of primary care consultations. The adoption and use of this standardized methodology will contribute to the implementation and monitoring of antimicrobial stewardship initiatives to help deliver these strategies.

Supplementary data

Supplementary data are available at the *Journal of Public Health* online.

Authors' contributions

JH devised the project, obtained funding, co-supervised the project, was part of the Steering Group and contributed to drafting and revision of the article. SS helped develop the methods, undertook the analyses and drafted and revised the article. GS helped devise the project and methods, co-supervised the project, chaired the Steering Group and helped revise the article. RM helped develop the methods, provided statistical analyses and helped revise the article; AJ and DF were part of the Steering Group and helped revise the article. LS assisted with the analyses and helped revise the article. AH helped devise the project and methods, was part of the Steering Group and helped revise the article.

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Transparency declarations

All authors have no conflict of interest related to the submitted work.

Ethical approval

The protocol for this work was approved by the THIN Scientific Review Committee (SRC ref 12-002). No patient identifiable data were used and no new information was collected for this project.

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