At the meeting in March 2001 at the Royal Society of Medicine there was agreement about the need for surveillance of antimicrobial resistance, but a lack of clarity in the objectives. Palmer, in his thought-provoking introduction, made the points that the aims and objectives of a surveillance programme should be clear at the outset, that passive routine surveillance should be simple, with minimal data requirements, and that the programme should be formally evaluated. The CDC have recently published their latest guidelines for evaluating public health surveillance systems. These guidelines include assessment of a number of the attributes of a system, including simplicity, flexibility, data quality, acceptability, representativeness, timeliness and a focus on how well it operates to meet its purpose and objectives. The overall objective of surveillance of antimicrobial resistance is to facilitate control by informing the need to improve prescribing and infection control practices.

It is useful to begin with a definition of population surveillance. Langmuir, one of the originators of the modern concept, defined population surveillance in 1963 as ‘the continued watchfulness over the distribution and trends of incidence through the systematic collection, consolidation and evaluation of morbidity and mortality reports and other relevant data’. He pointed out that intrinsic to the concept of surveillance is the regular dissemination of information derived from the data to all who require it. These objectives are encapsulated today in the CDC definition of surveillance. Because in routine passive surveillance, the involvement and support of a number of personnel is essential, methods are characterized by being simple, descriptive and of necessity incomplete, in that not all available data are collected. Surveillance needs to be continuous (or at least regular) and part of routine practice.

Monitoring trends is the cornerstone objective, in order to alert us to the need for further investigation and if necessary intervention, in an attempt to reverse adverse trends. Surveillance systems can also provide an indication of the success of an intervention, but more detailed active surveillance studies are usually required. It is always desirable to have a clear case definition, and to this end the BSAC standardized susceptibility testing method is one way of introducing uniformity to the definition of microbial resistance, although the NCCLS method is used in many countries. Surveillance data may be collected at various levels: local, regional, national and international; methods and details will vary according to the purpose of surveillance. Several authors have given details of the requirements of antimicrobial resistance surveillance. In this article, surveillance encompassing more than one country, or of resistance in pathogens from animals will not be considered.

A system of routinely collecting data from laboratory computers by automatic download is the most convenient way of retrieving information. This can be performed routinely within the laboratory for its own use or as part of a regional or national data collection system. If the purpose of the surveillance is to provide information about trends at a local level and assist clinicians in the rational choice of antibiotics, the data from such a system, and their interpretation, must be fed back in a timely fashion to the localities providing them. Also, there will not be a requirement for the full identity of all isolates, for example of coliforms from urine specimens, because the aim is to inform the choice of empirical therapy, in this case for urinary tract infections. Such objectives were the basis for the Microbase project in the mid-1980s to 1990s. If surveillance data are to be used to provide guidance for clinicians on the appropriate use of antibiotics, there should be clear decisions, preferably supported by evidence, about what constitutes an unacceptable level of resistance, such that a...
change in empirical therapy is advisable. For example, at what level of resistance of urinary pathogens to trimethoprim should the drug not be recommended? The availability of suitable alternatives will to some extent influence such decisions. Also, the role of sampling bias in routine clinical practice should be assessed and its tendency to result in higher estimates of resistance should be taken into account.

Collection of data at a regional or national level allows some benchmarking of resistance rates to be done, but the reliability of such exercises is questionable because of inter-laboratory variations in practice in areas such as sampling, isolation, identification, testing and reporting. If practice within a laboratory remains constant, surveillance data can be used reliably to assess local trends over time. A current political obsession is to produce performance indicators so that comparisons can be made between hospitals and trusts. The latest examples are in the area of hospital-acquired infection, presumably with the overall objective of bringing about a reduction in nosocomial infection. Routinely generated data can be used for this purpose, but it is essential to select a clinical sample where the reasons for collection have the greatest degree of consistency between hospitals, in order to minimize sampling bias and reduce misinterpretation of data. In this respect, blood culture is the most appropriate sample, albeit imperfect. For example, in one study of invasive pneumococcal infections the prevalence of bacteraemia may have been underestimated because of sampling bias.

Isolates from the sentinel laboratories could be submitted to a central laboratory for susceptibility testing to obtain uniformity. Alternatively, the peripheral laboratories could perform the testing, but this would require extremely tight quality assurance. The whole programme should be coordinated nationally. Currently the BSAC and PHLS are participating in such a programme, but for pragmatic reasons it is being largely funded by the pharmaceutical industry and so will always have the potential for distortion of the objectives by conflicting interests. Comparisons should be made between data obtained from routine passive surveillance systems and sentinel surveys for the purpose of mutual validation. These data may indicate apparent clustering of antimicrobial resistance, warranting further studies to examine the reasons. However, such studies would fall outside the scope of routine surveillance.

The surveillance methods described thus far apply only to organisms isolated from routine laboratory specimens. Such methods seem likely to overestimate the level of resistance in organisms causing infection in the community, because of bias in sampling by primary care physicians. If there is a desire to examine the effect of sampling bias at a local level, laboratory staff need to establish sentinel primary care practices, using similar selection criteria to those for laboratories given above. The general practitioners would agree to send, for a defined time period, samples from all patients presenting with a particular clinical condition that fitted a case definition. In order to gain a picture of the degree of sampling bias at a national level, an appropriate sample of laboratories and their constituent primary care practices would be selected to supply the data.

One of the suggestions made at the meeting at the Royal
Society of Medicine was that there should be surveillance of resistance amongst organisms generally regarded as commensal flora. No assumptions can be made about how prevalence of resistance in commensal flora relates to that in pathogens, but this is currently an area of research with regard to community infections. Commensal flora are important in molecular research to provide us with early knowledge of novel resistance mechanisms, which may impact on resistance in pathogens and hence the need for the development of new treatments. Similar molecular studies may be applied to organisms generated from the sentinel laboratories. Whilst being valuable, these studies are not integral to the routine surveillance programme.

In order to gain information about resistance amongst certain genera or species, e.g. *Acinetobacter* or *Pseudomonas*, causing infections in hospitalized patients, there should be agreement between the central testing laboratory and the sentinel laboratories (or all laboratories if more relevant) to collect and test isolates from appropriate specimens. This should be more reliable than attempting to acquire the information from routinely generated passive surveillance data.

In summary, it is easy to collect data, but it is difficult to make best use of them. To do so without bias is also difficult. The objectives of surveillance should be clearly defined and the methods designed to fit these objectives. Systems should be no more complex or expensive than they need to be to fulfil the defined purpose. Priority should be given to those programmes that require the least investment for the greatest return, but it has to be appreciated that no single method will provide reliable answers to all questions. It is important that any system adopted should be formally evaluated.

Finally, in the current political climate of being seen to be doing something about resistance to antimicrobials, it is important to appreciate the limited extent to which surveillance can contribute to this. Surveillance can merely indicate the need to alter prescribing habits or improve infection control practice, or indicate where more research is required. It may enable these efforts to be targeted to areas where resistance rates are higher and thus save on resources, but it should never be seen as an end in itself.

References
