Chapter 13

Multidisciplinary Antimicrobial Management Teams and the Role of the Pharmacist in Management of Infection

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1. INTRODUCTION

1.1. Background

Multidisciplinary or integrated care networks are used widely and successfully within healthcare systems for the delivery of patient care. Examples of such networks include, amongst others, pain control, diabetes, and cancer services. In the United Kingdom (UK), the model for healthcare reform proposes the expansion of multidisciplinary team working (Department of Health, 2000). The application of multidisciplinary team working to improve antimicrobial prescribing has been shown to be successful and is advocated by a number of bodies representing medical and allied professions. The inappropriate or suboptimal use of antimicrobials both in hospital and community settings remains a huge problem, despite the potential benefits of prudent, targeted prescribing practices. Antimicrobial costs account for at least 30% of the drug expenditure of most hospitals, with 30–50% of patients receiving antibiotics at any one time (Berman *et al*., 1992). Studies from the United States of America (USA) estimate that in excess of 50% of all antimicrobial

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prescriptions may be inappropriate, either in terms of drug choice, route of administration, dose, or length of treatment (Jarvis, 1996; Marr *et al*., 1988). In the Netherlands, surveys on antimicrobial use in the hospital setting specifically, suggest that this figure is at least 15% (Van der Meer and Gyssens, 2001). Prescribing practices should be targeted for improvement via a multidisciplinary team approach.

The reason for controlling antimicrobial use is to encourage responsible prescribing in order to (1) increase the quality of patient care, (2) contain costs, and (3) attempt to minimise the emergence of microbial resistance. There is currently a paucity of robust published data reporting the effects of antimicrobial prescribing control on such outcome measures and quality research using sound methodology is encouraged. Although cost containment has often been considered to be the overriding priority when instituting antimicrobial control measures, more emphasis must be placed upon measuring effects on aspects of patient outcome and upon the epidemiology of microbial pathogens (BSAC Working Party Report, 1994; Department of Health NHS Executive, 2000; Goldmann *et al*., 1996; House of Lords Select Committee Report, 1997; Shlaes *et al*., 1997).

Programmes to manage or control antimicrobial use are built upon antibiotic policies. These policies are based upon local epidemiology of prescribing practices and antimicrobial resistance patterns (BSAC Working Party Report, 1994; Shlaes *et al*., 1997) and include protocols and guidelines for the treatment and prevention of infection. Where available and appropriate, national guidelines and data should be taken into consideration. The preparation and implementation of such policies must involve prescribers who have ultimate responsibility for individual patient care (Knox and Holmes, 2002).

1.2. Understanding prescribing practices

The epidemiology of prescribing practices at a local level needs to be assessed before attempting to alter it. This will identify areas of inappropriate antimicrobial use where interventions could be targeted and have most impact. In addition, it is important to define key process or outcome indicators by which the impact of any intervention may be assessed (Nathwani *et al*., 2002). The factors that determine antimicrobial prescribing are multiple and complex and need to be fully realised and addressed (Avorn and Solomon, 2000). Changing prescribing practice equates to changing human behaviour, which can be extremely difficult to achieve. Studies addressing this are lacking. Factors such as clinician education, lack of local expertise, bed and staffing shortages, and consultation time constraints contribute to inappropriate antimicrobial prescribing. Furthermore, the rapid turnover of medical and nonmedical staff, particularly at junior level,

necessitates a sustained interventional effort to maintain improved prescribing habits. These issues can only be addressed if there is strong support from hospital management (Avorn and Solomon, 2000; Goldmann *et al*., 1996; Swindell *et al*., 1983). Other factors, such as changes in patient epidemiology over time are important to recognise as these may appreciably affect both antimicrobial prescribing and the epidemiology of pathogens within individual heathcare settings (Gould and Jappy, 2000).

1.3. Antimicrobial management programmes

Effective implementation of antibiotic management programmes is a complex task and as such, cannot be performed by an individual or individual discipline. Instead, a multidisciplinary team approach is required. Any control strategy that targets clinical practice requires the cooperation of senior members of clinical staff from the start if it is to be successfully implemented. Interventions aimed at improving antimicrobial prescribing are intended to contribute actively and positively to patient care. This needs to be emphasised in order to prevent interpretation of the exercise as being largely corrective or a curb on clinical freedom. To this end, the appointment of a key healthcare practitioner to lead or oversee such a programme will lend credibility to it and increase its chances of success (Ibrahim *et al*., 2001; Marr *et al*., 1988; Schentag *et al*., 1993). The support of hospital administration is also essential from the outset, to ensure that the appropriate administrative infrastructure, financial backing, and information technology (IT) is made available. Strategies to implement antimicrobial policies include passive and interactive prescriber education, standardised antimicrobial order forms, formulary restrictions, prior approval to start or continue antimicrobials, protocolised antimicrobial streamlining, prescribing feedback, computerised decision support, and online ordering. The use of passive education alone is not effective in altering prescribing habits. It is only when some form of antimicrobial restriction, combined with educational efforts is used, that success in altering prescribing practices is shown (Evans *et al*., 1998; Lipsky *et al*., 1999; Schiff and Rucker, 1998). The exception to this is one-on-one educational outreach (also called "academic detailing") which has been shown to be effective (Avorn and Soumerai, 1983). This strategy is used by the pharmaceutical industry, but is unlikely to be cost-effective or achievable in the majority of healthcare settings.

In the UK, under the supervision of the Effective Practice and Organisation of Care group of the Cochrane Collaboration, a review of international published studies of antimicrobial control programmes in the hospital setting has been conducted by a working party of the British Society of Antimicrobial Chemotherapy (BSAC) and the Hospital Infection Society (Davey *et al*., 2002). Preliminary results to date show that published studies concentrate primarily

on reporting economic outcomes, with the effect on patient outcomes generally being measured by length of inpatient stay and mortality. Studies assessing effects on antimicrobial resistance patterns are few. The major inadequacy of many published studies is the use of flawed methodology such as the use of uncontrolled before and after intervention data. In these instances, confounding factors such as patient case-mix, elements of healthcare provision, and purchasing agreements are not easy to control for, thus making interpretation of conclusions difficult. This review confirms that there is a paucity of and need for further well-designed and conducted studies to assess the impact of different models of antimicrobial control programmes.

2. MULTIDISCIPLINARY ANTIMICROBIAL MANAGEMENT TEAMS

The idea of a multidisciplinary approach for the improvement of antimicrobial prescribing practice is not new. In 1988, the Infectious Diseases Society of America (IDSA) published guidelines that advocated such an approach for the improvement of use of antimicrobials in hospitals (Marr *et al*., 1988). Likewise in Europe, as an outcome of the European Union Conference on "the Microbial Threat," it was recommended that every hospital introduce a multidisciplinary Antimicrobial Management (or Review) Team (AMT), and that this team be given both the authority to modify antimicrobial prescribing practices as well as the responsibility for ensuring compliance with guidelines (The Copenhagen Recommendations, 1998). Authority implies the support of hospital administration, which is essential for the implementation of control programmes. This is succinctly put by Goldmann *et al*. (1996) who advocate a "multidisciplinary, systems-oriented approach, catalysed by hospital leadership." In addition, fundamental to the design of antimicrobial management programmes and the function of a multidisciplinary AMT is the careful consideration and design of an IT strategy to facilitate their implementation. Inadequate resources and a lack of manpower are limiting factors in many healthcare settings, and well-conducted studies are needed to confirm the most cost-effective methods of implementing a team approach.

2.1. Structure of Antimicrobial Management Teams

Members of an AMT should include professionals with expertise and interest in dealing with the management and prevention of infection. As a minimum this will include an Infectious Diseases (ID) Physician or Clinical Microbiologist and a clinical pharmacist with experience in infection management (Infectious

Diseases Pharmacist) (Fraser *et al*., 1997; Gross *et al*., 2001; Hirschman *et al*., 1988; Jenney *et al*., 1999; Lee *et al*., 1995; Schentag *et al*., 1993), but may also include any or all of an Infection Control professional or hospital epidemiologist, a drug-utilisation review pharmacist, members from the microbiology laboratory staff, and colleagues representing medical and surgical specialties, and an IT expert (Berman *et al*., 1992; Cook and Sanchez, 1992; Gentry *et al*., 2000; Gums *et al*., 1999; Hayman and Crane, 1993; Minooee and Rickman, 2000; Prado *et al*., 2002).

A team approach requires strong leadership, good management and organisation, and strict role definitions for each member. This is to avoid potential role conflict between members of the team, which may be encountered when professionals from multiple disciplines work together (Barriere *et al*., 1989; Burke *et al*., 1996; Marr *et al*., 1988). Crucially, as with any multidisciplinary team working approach, clear lines of accountability for each member of the team need to be defined from the start. This is not always emphasised in examples in the published literature. It is recommended that there should be a nominated individual to take the lead in overseeing antimicrobial management programmes (Department of Health, 1999). Although results of a recent postal survey of North American ID pharmacists' perspectives on antibiotic control programmes highlighted ID physician leadership as one of the most important factors in predicting the success of a programme (Garey *et al*., 2000), the authors believe that a successful lead may be either clinical (ID physician or Clinical Microbiologist) or non-clinical (Pharmacist). However, recognised support from a key clinician for the team leader will serve to enhance the profile and is necessary to increase the chance of success of any scheme aimed at influencing clinical practice (Ibrahim *et al*., 2001; Marr *et al*., 1988; Schentag *et al*., 1993). Other factors identified in the survey by Garey *et al*. (2000) which increased intervention success included a multidisciplinary approach and adequate allotment of time and resources.

2.2. Functions and responsibilities of AMTs

The AMT can be viewed as the driving force behind the formulation and implementation of antimicrobial policies with the aim to ensure prudent, appropriate antimicrobial prescribing within healthcare settings. IT systems must be specifically adapted to the needs of the AMT in order to ensure efficient functioning, and members of the team should be involved with development of these where possible. Responsibilities of the team include selection of antimicrobial agents for empirical and individual uses, development of protocols and guidelines for antimicrobial use, and establishment and regular review of an antimicrobial formulary (including consideration of new drugs to

be included). This is done in collaboration with clinical colleagues who are encouraged to take ownership of such policies relevant to their speciality. In addition, the team has educational responsibilities and is active in developing and updating continuing educational programmes for other professional staff. The maintenance of self-education is of paramount importance, and research must be high on the agenda. Surveillance activities as well as audit and feedback functions are equally important. Examples of these functions include the monitoring and reporting of compliance with published protocols and guidelines for antimicrobial use. Reasons for breaches in protocols should be identified and addressed, and protocols may need to be adapted accordingly.

2.3. AMTs—models of delivery

As noted above, there is a paucity of adequate published literature on the effects of AMTs on antimicrobial prescribing. The majority of published studies primarily report on economic outcomes (Hayman and Crane, 1993; Hirschman *et al*., 1988; Lee *et al*., 1995; Schentag *et al*., 1993) with some in addition revealing modest positive patient outcome, measured as trends towards decreasing inpatient stay and mortality (Fraser *et al*., 1997; Gentry *et al*., 2000; Gross *et al*., 2001; Gums *et al*., 1999). Occasional studies report solely on effects on prescriber compliance with local recommendations for antimicrobial use (Berman *et al*., 1992; Cook and Sanchez, 1992; Feucht and Rice, 2003; Jenney *et al*., 1999; Prado *et al*., 2002). None of the above-mentioned studies assess the effect on the epidemiology of antimicrobial resistance. Examples that illustrate how individual institutions implement AMTs may not be directly applicable universally as they have been developed with local frameworks of staffing organisation and clinical approach. For example, historically, hospital pharmacists in North America, UK, and Australasia have had primarily a clinical, ward-based role, which is in contrast with many other countries in Europe, where hospital pharmacists have less of a ward-based, clinical presence. This will obviously influence how AMTs and the role of the pharmacist can be developed in these different countries. However, published illustrations are useful in providing a framework to guide the development and application of AMTs worldwide.

2.4. Operational aspects of AMTs

The specific way in which the AMT operates from a day-to-day basis can be tailored to individual circumstances. The team as a whole is responsible for identifying key areas for intervention through surveillance activities, as well as overseeing the formulation of appropriate protocols and guidelines for treatment

and prophylaxis. Ways in which the team communicates appropriate interventions to antimicrobial prescribing will differ depending upon the available workforce, expertise, and IT. Consults may be conveyed telephonically, in written format, by direct bedside consultation on individual patients or by formal directorate-based consultations (e.g., specialist unit ward rounds). Where suitable IT is in place, advice can be given at the point of prescribing (e.g., electronic prescribing) (Table 1).

The following are examples of primarily telephonic and/or ward-based consults, given as a team approach either by a pharmacist with variable degrees of expertise in infection management and/or members of an ID team or a microbiologist.

In one of the first published randomised trials to evaluate whether antibiotic choices could be influenced favourably by a multidisciplinary AMT, patients were reviewed by both an ID fellow and a clinical pharmacist and suggested changes to therapy were placed in the medical progress note section of the medical records (Fraser *et al*., 1997). In a study by Gums *et al*. (1999), antibiotic consults were undertaken by an ID physician and/or clinical pharmacy fellow. The consult was in the form of a simple one-page format and was either left on the patient's chart or communicated directly to the attending physician depending upon urgency. In both models, pertinent information regarding rationale for changing antimicrobial therapy was included. The multidisciplinary nature of the interventions was considered to be important in encouraging physician acceptance, which occurred in over 85% of cases. Gross *et al*. (2001) reported successful interventions by an AMT comprising an ID physician and a clinical pharmacist with post-graduate training in anti-infective therapy. Consults in this study, which largely comprised approval of restricted antimicrobials, were conveyed telephonically. Similarly, in a report by Jenney *et al*. (1999), a combination of telephonic and ward-based consultation by ID registrars and/or pharmacy staff was successfully used to implement an antibiotic control programme.

Further examples highlight the role of the clinical pharmacist in operational aspects of the AMT. Lee *et al*. (1995) describe a system where patients

Table 1. AMT activities—effecting interventions

- Telephoned consults
- Written consults
  - Clinical notes
  - Attached to prescription chart
  - Attachment of stickers/notes to prescription chart
- Automated computer-assisted decision support at the point of prescribing
- Attendance at clinical unit- or specialty-based ward rounds
- Formal ward-based review of individual patients
- Participation in educational events

suitable for intervention were identified by ward-based pharmacists, according to protocol. These patients were presented to the AMT for a decision upon changes to therapy. Subsequent evaluation of patient's clinical progress was made by the pharmacists and reported to the ID physician only when a new development or complication arose. In a prospective evaluation by Barenfanger *et al*. (2001), interventions involving antimicrobial agents by pharmacists were either written or telephonic. In this instance, microbiology expertise was available to the pharmacists as necessary. Uniquely, pharmacists intervening in patient care for the study group in this report were given prior specific in-service training sessions on microbiological topics to enable more informed interventions to be made. Such topics included guidelines for determination of contamination vs colonisation; interpretations of Gram-staining; and guidelines for interpretation of results from sterile and non-sterile sites. In addition, pharmacists in the intervention group had the use of a computer software program (TheraTrac 2) to allow for more timely access to patient data. This software program served as an electronic link between data generated in the microbiology laboratory and data available in the pharmacy department, such as current antimicrobial therapy and patient allergies.

A similar computer software program was used in an example by Schentag *et al*. (1993). In this illustration, optimisation of antimicrobial therapy was undertaken by clinical pharmacy antimicrobial specialists. These pharmacists worked in conjunction with members of the Clinical Infectious Diseases Division. The latter advised primarily on empirical antimicrobial therapy and consulted on complex cases. This was done either telephonically or directly by ward-based review. The roles of the two specialist teams were seen to be complementary rather than conflicting, which was vital in ensuring success in implementing the programme.

Feucht and Rice (2003) describe the use of monthly educational conferences, directed at medical residents, to reinforce previously disseminated local hospital prescribing guidelines. Information on aspects of antimicrobial resistance was also highlighted as part of this interventional programme.

There are many further examples of specialist pharmacist-led antimicrobial control programmes (Cradle *et al*., 1995; McMullin *et al*., 1999). Gentry *et al*. (2000) describe the role of a clinical pharmacist specialist in infectious diseases who was appointed to lead an antimicrobial control programme. In this example, consultations for change were conveyed directly at ward level by both the pharmacist and an ID physician depending upon complexity of the case.

2.5. Methods of identifying targets for intervention

A variety of methods can be used to identify patients who are suitable for intervention by an AMT (Table 2). A commonly used point of contact to identify

Table 2. AMT activities—methods of identifying targets for intervention

- Attendance of clinical unit- or speciality-based ward rounds
- Response to formal request for review
- Review of antimicrobial requests
  - Ward-based chart review
  - Computer-generated order review
  - Antibiotic order forms
  - Analysis of consumption/expenditure data
  - Use of restricted antimicrobials
- Review of significant microbiological data
- Therapeutic drug monitoring
- Renal function
- Reports of adverse drug reactions
- Review of compliance to standard protocols

patients who may benefit from tailoring of antimicrobial therapy is that of formal ward rounds either of specialist units or on review of newly admitted patients. Attendance on these rounds by a member of an AMT is invaluable. Patients are also regularly identified in most healthcare settings by formal requests for review from the clinician ultimately responsible for individual patient care. In published examples by Cradle *et al*. (1995), Fraser *et al*. (1997), Gentry *et al*. (2000), Gross *et al*. (2001), Feucht and Rice (2003), and Wyllie *et al*. (2003), use of prescription chart review, pharmacy records, and/or computer-generated antimicrobial orders identify specific antimicrobial use likely to benefit from consult by an AMT. Other reports describe a variety of integrated methods to identify patients. These include pertinent microbiological data (culture and sensitivity results), chart reviews, antibiotic levels, renal dysfunction, use of restricted antimicrobials, and reviews of compliance to standard protocols (Gums *et al*., 1999; Lee *et al*., 1995).

Suitable computerised systems as described by Lee *et al*. (1995) and Barenfanger *et al*. (2001) can facilitate identification processes by linking up microbiological and pharmacy data.

2.6. Intervention activities

One of the key factors that allow for successful intervention is that certain alterations in antimicrobial use can be protocolised. This is important, as it will enable each member of the AMT to give consistent advice in those specific situations. Examples include dose alterations, intravenous to oral switching of antibiotics (sequential therapy), streamlining or narrowing of empirical therapy based on culture results and clinical diagnosis, advice on therapeutic drug monitoring and interpretation of levels, limiting antimicrobial prophylaxis,

Table 3. AMT activities—interventions

- Antimicrobial dose or regimen alteration
- Streamlining and sequential therapy
- Discontinuation of antimicrobials
- Advice on and as a result of therapeutic drug monitoring
- Automatic stop orders for:
  - antimicrobial prophylaxis
  - restricted antimicrobials
  - empirical antimicrobials
- Approval of restricted antimicrobials
- Assistance in interpretation of laboratory results
- Indications for specific antimicrobial use
- Suggestions for additional laboratory test ordering
- Formal educational events

indications for use of specific antimicrobials, approval of restricted antimicrobials, and additional laboratory test ordering (Table 3). In situations where protocols cannot be applied or where more complex clinical advice is required, appropriate expertise in the form of an ID physician or clinical microbiologist should be sought.

In the example by Lee *et al*. (1995) and Gentry *et al*. (2000), treatment and surgical prophylaxis guidelines were developed in order to maintain consistency in the team's recommendations. In the former, specific interventional activities included rationalising of intravenous cephalosporin use, rapid identification of patients eligible for home therapy, switch from intravenous to oral agents, and discontinuing extended use of intravenous antibiotics. Appropriate patients were identified at a ward level via these protocols, and decision for changing therapy was approved at team level. The focus of the model described by Gentry *et al*. (2000) was upon modifying the approval process of non-formulary and restricted antibiotics. The clinical pharmacy specialist was given authority and primary responsibility to approve restricted and non-formulary drugs within these guidelines. In addition, the pharmacist assisted the clinical team with clinical follow-up. In both examples, an ID physician consult was advised for complex cases or those falling outside of approved protocols.

The focus of the education-based example given by Feucht and Rice (2003) was to improve the use of intravenous vancomycin and fluoroquinolone prescribing practices in line with locally produced guidelines for appropriate use of these agents. A clinical pharmacist prospectively reviewed new orders for these drugs and intervened where appropriate, with the aim of reducing unnecessary duplication of anti-Gram-negative agent use and reducing the duration of inappropriate empirical antibiotic cover.

A team approach to improve antibiotic turnaround times has been used successfully on a medical intensive care unit (Watling *et al*., 1996), although effect on patient outcomes was not measured. In this example, the use of a pre-printed antibiotic order form was instrumental in eliminating errors in prescription interpretation, and improved communication between all members of the healthcare staff facilitated improvement in timeliness of therapy.

Extended intervention activities were employed in the studies by Schentag *et al*. (1993) and Barenfanger *et al*. (2001). Defined interventions included antimicrobial dose adjustments, early discontinuation of intravenous antibiotics, sequential therapy, and protocol-driven early conversion from empiric to targeted therapy. In both examples, the clinically specialised pharmacists were given primary responsibility for implementing the programme but worked closely with ID physicians and microbiologists in a complementary fashion.

A number of common conclusions can be drawn from the published literature on AMTs. First, where an approach to addressing the issue of antimicrobial prescribing is multidisciplinary, it is more likely to gain acceptance from clinical colleagues. Second, leadership of such a team (or recognised support of a non-clinical lead) by a respected clinician lends credibility to it. Third, roles within the team should be well defined in order to avoid potential conflict. Fourth, a sustained effort is required to improve antimicrobial prescribing. Fifth, educational benefits are seen where clinical AMT intervention is employed, which in turn serve to sustain improved prescribing practices.

3. THE ROLE OF THE PHARMACIST IN INFECTION MANAGEMENT

There is a global precedence to promote the role of pharmacists in the prevention and treatment of infection in order to enhance prudent antimicrobial prescribing (ASHP, 1998; Audit Commissions Report NHS England and Wales, 2001; Bosch, 2000; BSAC Working Party Report, 1994; IDSA, 1997; Shlaes *et al*., 1997). It is important to establish a role for pharmacists complementary to those of other specialists in infection management. An excellent review published by Dickerson *et al*. (2000) discusses the active contribution made by pharmacists towards promoting optimal antimicrobial use in both the hospital and community settings by providing education; developing and implementing clinical practice guidelines; and audit and feedback activities (see also Table 4). Pharmacists with specific training in infection management may be referred to as Infectious Diseases (ID), Microbiology or Antibiotic Use Review (AUR) Pharmacists. It is notable, however, that pharmacists working in other specialised clinical areas, for example, Critical Care Units, Oncology,

Table 4. The role of the pharmacist in infection management

- Clinical role in conjunction with colleagues on AMT
  - Member of antimicrobial review committee—policy making, clinical practice guideline development, new drugs review
  - Identification of patients for intervention activities
  - Initiation of streamlining or sequential therapy
  - Dose adjustments
  - Therapeutic drug monitoring
  - Approval of restricted antimicrobials
- Provision of expert advice on antimicrobial use
- Surveillance of antimicrobial use
  - Collection and analysis of local consumption and expenditure
  - Compliance with policies
  - Prescribing errors
- Audit and feedback
  - Includes evaluation of impact of clinical guidelines on process of care, patient outcomes, financial outcomes, and antimicrobial resistance patterns
- Educational role directed at
  - Clinicians at the point of prescribing and generally
  - Nursing and technical staff
  - Patients—UK NHS medicines information patients' helpline
  - Pharmacists
- Infection Control activities—integrating antibiotic control with infection control
  - Member of hospital/community infection control committees
- Provision of outpatient or community parenteral therapy programmes
- Coordination and implementation of immunisation programmes
  - Community and hospital

Haematology and Transplant Units, Renal Units, and Human Immunodeficiency Virus (HIV) medicine will have a good working knowledge of likely infections and antimicrobial use in these settings.

3.1. Lead role in AMTs

Where available, a dedicated ID pharmacist should play a lead role in and be viewed as co-therapist with other members of the AMT (Barriere *et al*., 1989; Lee *et al*., 1995). The above examples by Schentag *et al*. (1993), Cradle *et al*. (1995), Lee *et al*. (1995), McMullin *et al*. (1999), Gentry *et al*. (2000), and Barenfanger *et al*. (2001) illustrate the possible role expansion of an appropriately trained pharmacist working within a multidisciplinary AMT in a variety of hospital settings. These illustrations and the other examples given above, demonstrate how, as members of a team dedicated to improving antimicrobial use in the hospital setting or with access to such a resource, clinical pharmacists

with differing levels of expertise in infection management can make specific contributions towards optimising antimicrobial prescribing.

3.2. Specialist advice and education

The educational role of the pharmacist is extremely valuable, with opportunities to inform prescribing clinicians at the point of care and in general about prudent antimicrobial prescribing (Fraser *et al*., 1997; Gentry *et al*., 2000). Pharmacists involved in education use a variety of methods to improve prescribing knowledge. In the examples of antimicrobial control programmes described above, communicating the rationale for changing antimicrobials to clinicians at the point of prescribing increased the likelihood that the suggested changes were made. This also contributed to the maintenance of positive alterations in prescribing practice.

A major specific role of clinical pharmacists in infection management is to provide specialist advice on aspects of antimicrobial use such as appropriate initial dose of antimicrobial and dose alterations according to renal or hepatic function, therapeutic drug monitoring, and information on drug interactions and side effects. This information can be supplied directly at the point of prescribing, on review of drug charts or antimicrobial order forms, within a formulary, via computer-assisted support programmes, or as a telephonic service. Formal pharmacokinetic consultation services are commonly established in teaching hospitals and tertiary referral facilities and could be further expanded in smaller community hospitals (Bedard and McLean, 1994).

Therapeutic drug monitoring programmes are successfully led by appropriately trained pharmacists and result in improved, consistent prescribing of antimicrobials such as aminoglycosides and glycopeptides, with fewer associated adverse drug reactions (Lynch *et al*., 1992) as well as having financial benefits (Ariano *et al*., 1995).

Other opportunities for disseminating information to other medical and allied professionals include formal lectures and teaching sessions within undergraduate and postgraduate training schemes, interactive educational meetings, participation in Grand Rounds, clinical ward rounds, interactive computerised educational activities (e.g., available on hospital intranet), and where resources are available, academic detailing. The reasons for the need for responsible antimicrobial use should be emphasised at clinical staff induction programmes.

In addition to providing education to medical and nursing professionals, pharmacists also provide a valuable resource for patients. A variety of pharmacist-run, telephonic-based medicines information services to provide advice to patients on aspects of their medication are available worldwide (Raynor *et al*., 2000). In addition, appropriate patient counselling given at the point of discharge or at

outpatient dispensing is designed to empower patients and is likely to improve compliance.

Pharmacists are involved in teaching other members of their professional group and, in addition, as part of continuing professional development, must maintain their knowledge- and skill-base. Adequate resources and time should be allocated for this within healthcare settings.

3.3. Surveillance and audit activities

Surveillance activities include monitoring of antimicrobial use, generating meaningful expenditure and consumption data, and monitoring the occurrence of adverse drug reactions. Pharmacy-based monitoring services are a valuable tool for reviewing hospital prescribing and have been shown to have a positive impact (Berman *et al*., 1992; Burke, 2001; Dean *et al*., 2002a; Fletcher *et al*., 1990). Pharmacists should play an increasing role in monitoring compliance to clinical guidelines as well as evaluating their impact on the process of care and patient outcomes (Dickerson *et al*., 2000). Regular application of relatively simple collection methods such as point prevalence studies can provide a wealth of information on local prescribing practices as well as providing a means by which to monitor and feedback the effects of interventional activities (Dean *et al*., 2002a). Formal pharmacy-oriented drug surveillance networks have been shown to be successful in collecting drug experience data generated during the routine clinical care of patients (Grasela *et al*., 1987). As an integral part of these processes, suitable information technology and substantial effort are needed so that data may be standardised and pooled across healthcare institutions to aid in addressing important public health issues (Grasela *et al*., 1993).

Prescribing errors are an important target for improvement, and initiatives to reduce such errors have been proposed and implemented both in the UK and in the USA (Dean *et al*., 2002b). Errors include drug overdosing or underdosing, inappropriate dosing interval, incorrect route of delivery, prescription of agents to patients known to be allergic, and delay or omission to give a prescribed drug. Prescribing errors may result in serious adverse patient outcomes. In a review by Lesar *et al*. (1997), antimicrobials were associated with almost 40% of all medication-prescribing errors. Ward-based pharmacists who routinely examine drug charts on a daily basis are ideally situated to identify errors, as well as to gather information on possible reasons for them. Antimicrobial review systems have the potential to reduce prescribing errors and hence their associated adverse events in hospitalised patients (Guglielmo *et al*., 1999).

Audit functions are an integral part of any process of care. Results of surveillance activities should be actively reported back to relevant parties. Examples include evaluation of compliance to clinical guidelines as well as of their impact on patient outcomes, impact of antimicrobial management and educational programmes on defined key indicators. As seen in the examples cited above,

feedback to clinicians on prescribing practices serves to effect positive prescribing changes.

3.4. Implementation of streamlining and sequential therapy

Antimicrobial streamlining is the conversion of broad-spectrum empirical therapy to a narrower spectrum agent, intravenous to oral switch (sequential therapy), as well as controlling the use of "redundant" combinations of antimicrobials. Such interventions have been shown to be safe and efficacious, and contribute to substantial cost savings (Ramirez, 1996). Specifically, the use of sequential therapy as a single measure of modifying antimicrobial use is an accepted method by which to improve the quality of patient care, achieve cost savings, and reduce drug administration time (Hamilton-Miller, 1996; Lelekis and Gould, 2001). Pharmacists, in many instances, may take the lead in initiating streamlining and sequential therapy (Allen *et al*., 1992; Cairns, 1998; Chawla and Slayter, 1996; Frighetto *et al*., 1992; Kuti *et al*., 2002; Pastel *et al*., 1992).

3.5. Provision of outpatient or home parenteral therapy services

Outpatient or home parenteral anti-infective therapy (OHPAT) for a variety of specific infectious conditions can lead to improved patient care and has become an accepted and growing practice worldwide (Nathwani and Zambrowski, 2000; Williams *et al*., 1997). The key element for successful delivery of such a service is a team approach (the patient, nurse, pharmacist, and clinician). In the USA and Canada (where this is usually referred to as community-based parenteral anti-infective therapy or CoPAT), a well-developed infrastructure for delivery of this service exists and practice guidelines have been published. Outside of these counties, the service is generally less well developed, although in the UK, national guidelines are also available (Nathwani and Conlan, 1998) and several centres have successful working programmes. Aside from the responsibility of preparing and supplying the anti-infective agent, specific roles for the specialist pharmacist in ensuring the successful running of such programmes include the evaluation of the patient for suitability for OHPAT, development of a treatment plan, provision of education (to patients and healthcare workers), and collection of outcome data.

3.6. Infection control activities

Infection control and antibiotic control should be more formally integrated in the hospital setting. An ID pharmacist should be encouraged to be a member

of the Infection Control Team and attend infection control committee meetings on a regular basis. In the USA, both the American Society of Consultant Pharmacists (ASCP) and the American Society of Health-System Pharmacists (ASHP) have published statements regarding the contribution by pharmacists towards promoting infection control activities (ASCP, 1997; ASHP, 1998). Participation in policy-making, education, surveillance, and quality assurance activities are some of the areas where a pharmacist with a background in infection management can be a valuable resource.

3.7. Adult immunisation programmes

Vaccination campaigns against infectious diseases are a key part of community health initiatives. In the community setting, pharmacist-led adult immunisation programmes for pneumococcal and influenza vaccination have long been advocated by ASHP (1993). Within both community and hospital settings, pharmacists can facilitate identification of patients and staff to be targeted for vaccination, provide relevant education, and supply the vaccine. In addition, in select instances, pharmacists may be in the best position to administer the vaccine (Grabenstein and Bonasso, 1999; Sanchez *et al*., 2003).

3.8. Formulary development

Antibiotic formulary development, collation, and distribution, as well as regular review and update, require a collaborative effort in which the pharmacist can take the lead. The duties of an infectious diseases pharmacist in this regard, are guided by an antimicrobial review committee. Cook and Sanchez (1992) describe a model of multidisciplinary approach to development and implementation of an effective antibiotic formulary. During this process, pharmacist/physician working relationships were strengthened and the result was unanimous formulary acceptance.

4. TRAINING AND SUPPORT IN INFECTION MANAGEMENT FOR PHARMACISTS

4.1. Promoting the role of the pharmacist in infection management

In Europe, North America, and Australia, aside from government initiatives, the case for promoting the role of pharmacists in infection management is advocated by such authorities as the United Kingdom Clinical Pharmacy Association (UKCPA), the European Society of Clinical Pharmacy (ESCP), the ASHP, the

Society of Infectious Diseases Pharmacists (SIDP), the American College of Clinical Pharmacy (ACCP), and the Canadian Society of Hospital Pharmacists (CSHP). In addition, other professional bodies worldwide support an extended role for pharmacists (e.g., BSAC, IDSA, the Society for Healthcare Epidemiology of America, the Canadian Infectious Disease Society, Australian Society for Antimicrobials [ASA]).

4.2. Information networking and specialised practice interest groups

Networking groups for pharmacists with the aim of disseminating information and expertise in management of infections are facilitated and supported by some of the above-mentioned organisations (Table 5). As an example, as a result of a survey of NHS Trusts, the UK (Lawson *et al*., 2000), a national network for pharmacists involved in antimicrobial prescribing has been established. The Infection Management Practice Interest Group (now called the Infection Management Group) under the auspices of the UKCPA, aims to provide and exchange information regarding clinical experience, evidence, and best practice. Its remit also includes encouraging and supporting practice research, in addition to providing education events. This information can be further networked amongst other existing UKCPA practice interest groups for pharmacists representing other hospital specialties who have a role in antimicrobial prescribing. Other organisations that have special interest groups in infectious diseases specifically for pharmacists, with active e-mail discussion

Table 5. Resources and support networks for pharmacists in infectious disease and antimicrobial management

- Europe
  - United Kingdom Clinical Pharmacy Association (UKCPA)—Practice Interest Group in Infection Management: www.ukcpa.org
  - European Society of Clinical Pharmacy (ESCP)—Special Interest Group in Infectious Diseases: www.escpweb.org
- USA
  - Society of Infectious Diseases Pharmacists (SIDP): www.sidp.org
  - American College of Clinical Pharmacists (ACCP)—Practice and Research Network in Infectious Diseases: www.accp.com
  - American Society of Health-System Pharmacists (ASHP): www.ashp.org
  - American Society of Consultant Pharmacists (ASCP): www.ascp.org
- Canada
  - Canadian Society of Hospital Pharmacists (CSHP)—Pharmacy Specialty Network in Infectious Diseases: www.cshp.ca
- Australia
  - Australian Society for Antimicrobials (ASA): www.asainc.net.au

facilities include the ESCP, SIDP, ACCP, and CSHP. Active discussion and sharing of expertise by all professionals with an interest in infectious disease management is encouraged and facilitated by other organisations such as the IDSA, Hospital Infection Society, and the ASA.

4.3. Post-graduate training opportunities in infection management

Although many post-graduate courses for pharmacists contain modules relating to infectious diseases and antimicrobial management, current opportunities for dedicated training in these specific areas are limited. In the USA, there are structured full-time residency programmes in Infectious Diseases pharmacy practice which are defined as organised, directed, post-graduate programmes that centre on developing the competencies necessary to provide pharmaceutical care to patients with infectious diseases (minimum 12 months). Baseline standards and learning objectives to be met by these programmes have been prepared jointly by the ASHP and the SIDP. These can be found on the ASHP website (www.ashp.org). Fellowships in research or practice are also available. More recently, in the UK, a part-time MSc in Infection Management for pharmacists is now available. This is a collaborative venture between the Health Protection Agency (HPA), Imperial College Faculty of Medicine (London), and the Academic Pharmacy Unit (Hammersmith Hospitals NHS Trust, London). In Belgium, there is a recently introduced training course in Hospital Management of Anti-Infectives open to healthcare professionals including pharmacists (Professor M. Struelens, personal communication), however, to the authors' best knowledge, there are no other post-graduate training programmes in infection management designed specifically for pharmacists in any other countries.

5. THE FUTURE

A multidisciplinary effort is required to ensure prudent, responsible, antimicrobial prescribing practice in healthcare settings. The way forward is via the formation of antimicrobial management teams which facilitate the formulation, implementation, and auditing of antimicrobial management programmes. More research is urgently needed to produce a solid evidence-base to direct the way in which antimicrobial use can be positively influenced. This includes monitoring financial, clinical, and antimicrobial resistance outcomes of such interventions. Substantial ongoing administrative, financial, and IT support is crucial to pave the way and to ensure the success of these initiatives.

In the UK and elsewhere, it is apparent that the contribution of the pharmacist in promoting prudent antimicrobial prescribing and infection management is under-recognised and under-utilised. The misguided view of the pharmacist as "prescribing policemen" in implementing prescribing restrictions and enforcing drug approval needs to be actively discouraged. Instead, their profile and status as professionals who can contribute actively and effectively to the prevention and treatment of infectious disease, within a multidisciplinary team framework, should be promoted. In countries where there has been under-investment in this role, improved opportunities for training for pharmacists, and the creation of new posts must be high on the agenda. Over the past 3 years, the UK has seen the creation of at least 14 new hospital posts for infectious diseases/antimicrobial pharmacists, as well as the development of a post-graduate training course in infection management specifically for pharmacists who wish to practice in this area. In addition, specific funding from the Department of Health has been provided to support initiatives led by hospital-based pharmacists to promote prudent antimicrobial prescribing.

Inappropriate antibiotic prescribing must remain prominent on the research agenda. In this era of accountability and antibiotic resistant "superbugs," as members of the healthcare profession, we all have a duty of care to ensure responsible antimicrobial prescribing. Success of initiatives to achieve this remains a strategic priority, which is dependent upon hospital leadership and administrative support. The formation and deployment of multidisciplinary AMTs can successfully bring together the necessary expertise to effect relevant antimicrobial control programmes to positively influence use of antimicrobial agents.

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