Drug and Therapeutics Committee
Training Course

Session 13.
The Role of the DTC in Containing Antimicrobial Resistance

Participants’ Guide
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<td>ACT</td>
<td>artemisinin-based combination therapy</td>
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<td>ADR</td>
<td>adverse drug reaction</td>
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<td>AIDS</td>
<td>acquired immunodeficiency syndrome</td>
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<td>AMR</td>
<td>antimicrobial resistance</td>
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<td>AOF</td>
<td>antibiotic order form</td>
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<td>ARI</td>
<td>acute respiratory infection</td>
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<td>DTC</td>
<td>Drug and Therapeutics Committee</td>
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<td>HIV</td>
<td>human immunodeficiency virus</td>
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<td>intensive care unit</td>
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<td>IV</td>
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<td>multidrug-resistant tuberculosis</td>
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<td>MRSA</td>
<td>methicillin-resistant <em>Staphylococcus aureus</em></td>
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<td>Pharmacy and Therapeutics Committee</td>
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<td>STG</td>
<td>standard treatment guideline</td>
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SESSION 13. ANTIMICROBIAL RESISTANCE

Purpose and Content

Session 13 provides information about the global threat of antimicrobial resistance (AMR) and the role of Drug and Therapeutics Committee (DTC) in containing AMR.

Objectives

After attending this session, participants will be able to—

- Understand the global situation of antimicrobial resistance
- Describe the role of the DTC in containing AMR
- Discuss multifaceted strategies to contain AMR

Preparation and Materials

- Read the Participants’ Guide the evening before the session.

Further Readings


**Introduction**

The use of antimicrobial medicines has greatly contributed to the decline in morbidity and mortality due to infectious diseases over the past half-century. This achievement is being undermined by the rapidly growing problem of AMR. Infectious diseases, such as tuberculosis (TB), sexually transmitted infections, acute respiratory infections, malaria, dysentery, and HIV/AIDS, are becoming increasingly difficult and expensive to treat, and the burden is greatest in developing countries where resources are limited and infection rates are high. The increased costs associated with resistant infections are seriously affecting infectious disease prevention, control, and treatment efforts worldwide and are undermining the gains achieved from health investments.

The factors contributing to AMR are multifaceted and are more evident in resource-constrained countries where problems with pharmaceutical access, quality, management, and use are generally the norm. The increased inflow of HIV/AIDS, TB, and malaria medicines from global...
health initiatives has greatly increased the potential for drug resistance in countries with deficient health systems and weak pharmaceutical management capacity, including scarce health professional expertise on AMR and rational antimicrobial use. Although proven tools and approaches exist to improve the management and use of antimicrobials, few AMR advocacy and containment programs are in place at the country level. Awareness about the dangers posed by AMR is generally nonexistent, and relevant pharmaceutical management and AMR interventions are not being implemented.

Global Situation of Antimicrobial Resistance

Drug resistance has emerged across the spectrum of microbes: viruses, fungi, parasites, and bacteria. Major pathogens that have become resistant to antimicrobials include—

- Bacteria causing diverse infections such as *Staphylococci*, *Enterococci*, and *E. coli*
- Agents causing respiratory infections such as *Streptococcus pneumoniae*, TB, and influenza
- Food-borne pathogens such as *Salmonella* and *Campylobacter*
- Sexually transmitted organisms such as *Neisseria gonorrhoeae*
- *Candida* and other fungal infections
- *Plasmodium falciparum*, the cause of malaria
- The human immunodeficiency virus (HIV), the cause of AIDS

Contributing to the accelerating surge of drug resistance are the ineffectiveness of chloroquine as a primary antimalarial agent, multidrug-resistant tuberculosis (MDR-TB) and extensively drug-resistant tuberculosis (XDR-TB), a diversity of antibiotic-resistant diarrheal diseases and acute respiratory infections, HIV/AIDS, and methicillin-resistant *Staphylococcus aureus* (MRSA). Many complex mechanisms of resistance to antifungal medicines have been observed.¹ Fluconazole was introduced in the early 1990s as therapy for candidiasis and was rapidly followed by the emergence of fluconazole-resistant oral candidiasis, which is seen in one-third of patients with advanced AIDS.² The first-line pharmaceutical treatment (chloroquine) for malaria is no longer effective in 81 of the 92 countries where malaria is a major health problem. Penicillin has substantially lost its effectiveness against pneumonia, meningitis, and gonorrhea in many countries. Eighty percent of *Staphylococcus aureus* isolates in the United States are penicillin-resistant and 32 percent are methicillin-resistant.

The following provides more examples and illustrate the increasing global problem of antimicrobial resistance.³

- Multidrug-resistant *S. enterica* serotype paratyphi (*S. paratyphi*) infections have been associated with an increase in the reported severity of disease and emerged as a major public health problem in Asia.

- Resistance of *Shigella* to ampicillin, tetracycline, co-trimoxazole, and chloramphenicol is widespread in Africa, even through these medicines are still used for first-line chemotherapy for dysentery in many parts of the continent. The introduction of nalidixic acid has been followed by emergence of *Shigella* resistance.

- The emergence and spread of *S. dysenteriae* type I resistant to co-trimoxazole, ampicillin, tetracycline, chloramphenicol, and increasingly nalidixic acid in the past two decades means that these inexpensive and widely available antimicrobials can no longer be used empirically.

- Penicillin and erythromycin resistance is an emerging problem in community-acquired *S. pneumoniae* in Asia, Mexico, Argentina, and Brazil as well as in parts of Kenya and Uganda.

- Widespread resistance of *N. gonorrhea* has necessitated the replacement of penicillin and tetracycline with more expensive first-line medicines, to which resistance quickly emerged. In the Caribbean and South America, azithromycin resistance was found in 16–72 percent of isolates in different locations, resulting in the recommendation that this medicine in turn be replaced by ceftriaxone, spectinomycin, or the quinolones. The high cost of other options, however, such as third-generation cephalosporins makes their use prohibitive in many developing countries.

- Antimicrobial resistance is becoming increasingly common in cholera infections in developing countries. Up to 90 percent of *Vibrio cholerae* isolates are resistant to at least one antimicrobial.

With antimicrobial options becoming limited, physicians in developing countries may have to use older antimicrobial medicines that have become increasingly ineffective, resulting in high rates of treatment failure.⁴ Furthermore, new antibiotics, including second-, third-, and fourth-line choices are much more expensive than the original first-line medicines. In resource-constrained settings, physicians often lack medicine susceptibility testing, or they do not have the option of changing therapies. With the increasing rates of AMR in developing countries, these limitations make their burden even greater.

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Hospital settings are an important source of drug-resistant infections. Nosocomial infections occur in up to 10 percent of hospitalized infections. Important bacteria causing nosocomial infections include MRSA, *Enterococcus faecium*, *E. faecalis*, *E. coli*, *K. pneumoniae*, *Enterobacter* spp., *Citrobacter* spp., *Pseudomonas aeruginosa*, and *Acinetobacter calcoaceticus*.

Nosocomial transmission of commonly encountered community acquired, multidrug-resistant organisms, such as pneumococcus, *M. tuberculosis*, *Salmonella* spp, *Shigella* spp, and *V. cholerae*, has been increasingly documented in developing countries. Horizontal transfer of resistant genes from one strain to another can also worsen the possibility of resistant nosocomial infections.

**Impact of AMR**

AMR increases morbidity and mortality in patients with a wide range of diseases. There is a prolonged period of infectiousness with increased risk of transmission of resistant organism. For example, a study of XDR-TB in South Africa in 2006 showed that 52 of 53 identified cases died from the disease. These patients with resistant (and untreated) TB certainly had opportunity to spread this disease to others.

The cost of AMR to the individual as well as society as a whole is enormous. The treatment of MDR TB, for example, is about 300 times more expensive to treat than drug-sensitive TB. The cost of treating MRSA is three times that of methicillin-sensitivity staphylococcus infections. Switching from chloroquine to artemisinin-based combination therapy (ACT) because of resistance comes with an 18-fold increase in cost. The use of second-line antimicrobials to treat resistant infections is not only more expensive, but also can lead to a higher incidence of adverse drug reactions (ADRs).

Antibiotics constitute about 20–40 percent of a hospital’s medicine budget and can lead to significant, unnecessary health care costs, if not carefully managed. Hospital-acquired infections drain precious resources that would otherwise be available for programs to improve access and quality of care.

**Causes of Antimicrobial Resistance**

Of the several key factors that contribute to the emergence and spread of AMR, inappropriate antimicrobial prescribing by health providers and inappropriate self-medication by patients, including poor compliance, are particularly important. Twenty to fifty percent of antimicrobials prescribed for human use may be unnecessary. About half of all antibiotics are used in the

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agricultural sector, not in humans; and forty to eighty percent of antimicrobials for animal use are highly questionable. Additionally, limited access to health care; unregulated availability of medicines; poor quality, substandard, or counterfeit antimicrobials; poor storage conditions; and inadequate infection control in health facilities are several system factors that contribute to the development and spread of AMR.

Several factors contribute to the persistent problem of AMR in the community including cultural conceptions; patient demand for antimicrobials; economic incentives for prescribers and dispensers; influential advertising to consumers, prescribers, and providers by the pharmaceutical industry; and an insufficient level of training among health staff and pharmacists. Poverty and economic hardships that lead to early termination of treatments or sharing of medicines within the family also contribute to the emergence and spread of AMR.

Reasons for inappropriate prescribing include—

- Training deficiencies
- Diagnostic uncertainties
- Formularies and standard treatment guidelines (STGs) not available or not used
- Fear of poor patient outcome and need for self reassurance
- Fear of litigation
- Dispensing prescribers who are motivated by profit to sell more medicines
- Microbiological information not available or not used
- Patient demand
- Financial incentives such as gaining more money through sales of medicines
- Pharmaceutical manufacturers’ influence through inappropriate and biased advertising

**Key Approaches to Containing AMR**

To achieve progress in containing AMR, action is required at all levels of the health care system. Interventions to manage and contain AMR includes AMR advocacy, communications, training programs, research, surveillance, prevention of infectious diseases, improved pharmaceutical quality, improved medicine use, country-level interventions, pharmaceutical regulations, hospital and primary health clinic infection control programs, and improving pharmaceutical management capacity.

A key approach is preserving the effectiveness of existing antimicrobials, which can be achieved by implementing effective DTCs to monitor and control the use of antimicrobials at the hospital and primary health care level.

**Role of the DTC in Containing AMR**

DTCs are important to monitor and improve medicines use in institutional settings and help contain AMR. The World Health Organization (WHO) Global Strategy for Containment of Antimicrobial Resistance stated that DTCs are a key means of intervention to contain AMR in institutional settings. The Second International Conference on Improving Use of Medicines in

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9 Ibid.
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2004\textsuperscript{10} recommended that DTCs be established at all levels in institutional settings to assist efforts to improve use of medicines and contain costs.

In hospital settings, the DTC is a key body to help preserve effectiveness of existing antimicrobials. This goal can be accomplished by various methods—

- Updating and managing an antimicrobial formulary
- Developing policies on antimicrobial procurement and quality
- Developing and updating antibiotic guidelines and protocols
- Developing antimicrobial policies (e.g., reserve antimicrobials, levels of prescribing, automatic stop orders, and antimicrobial order forms) to improve compliance with antibiotic guidelines and protocols
- Evaluating antimicrobial use based on pre-established criteria of appropriateness and applying remedial measures
- Providing preservice and in-service education on rational use and AMR
- Contributing to collection and management of antimicrobial surveillance and resistance information for coordinated action with the Infection Control Committee
- Providing education to patients on the use and abuse of antimicrobials and encouraging adherence
- Supporting pharmacovigilance activities for antimicrobials

### Interventions to Contain Antimicrobial Resistance

#### Updating and Managing an Antimicrobial Formulary

The antimicrobial formulary must include agents considered most useful in the context of hospital’s patient population. Efficacy, safety, quality, pharmacokinetic disposition, and cost must all be considered in the decision to add an antimicrobial to the formulary. Duplications within a therapeutic class of antimicrobials should be avoided (e.g., quinolones or third-generation cephalosporins). The DTC or Antimicrobial Subcommittee may apply the techniques discussed in session 2, “Developing and Maintaining a Formulary.”

#### Developing Policies on Antimicrobial Procurement and Quality

The DTC or Antimicrobial Subcommittee can develop relevant policies for antimicrobial procurement and quality. For example, only those antimicrobials that have been approved for the formulary will be routinely procured for the hospital. Nonformulary antimicrobials can still be

\textsuperscript{10} http://www.icium.org.
purchased, but only with permission from the DTC through a nonformulary process. Policies may also be developed for procurement of generic antimicrobials from suppliers with a reliable track record.

**Developing and Updating Antimicrobial Guidelines and Protocols**

In addition to managing the antimicrobial formulary, the DTC or Antimicrobial Subcommittee provides guidelines for the use of both formulary and nonformulary antimicrobials. The hospital pharmacy dispenses the nonformulary antimicrobial only if the medicine is prescribed within these guidelines. For example, guidelines specific to antimicrobial dosage and duration may be developed by the subcommittee for formulary antimicrobials. They can be printed on dosing cards or in a concise, pocket-sized manual.

**Developing Antimicrobial Policies to Improve Compliance with Guidelines**

Multifaceted policies in combination with various approaches can be developed and implemented by the DTC to improve compliance with antimicrobial guidelines and protocols. Providing local evidence, rationale, and benefits of antimicrobial policies is important when seeking consensus from hospital-wide stakeholders so that prescribers do not feel that they are being “policed” by the DTC while implementing antimicrobial policies.

**Levels of Antimicrobial Prescribing Policies**

Prescribing policies should establish three levels of antimicrobials: first-choice, restricted-choice, and reserve.

- **First-choice antimicrobials**—to be prescribed by all doctors

- **Restricted-choice antimicrobials**—for multiple-resistant pathogens, polymicrobial infections, or certain patient conditions that need special attention or more expensive antimicrobials to be prescribed after discussion with head of department

- Certain antimicrobials can be restricted to particular physician specialties or service areas (e.g., an intensive care unit [ICU]). Restriction may also be applied to certain antimicrobials with broad spectrum of activity.

- **Reserve antimicrobials**—useful for a wide range of infections, but whose use can be restricted because of the need to reduce the risk of developing resistance or because of their relatively high cost

For example, carbapenems (imipenem/meropenem) are broad-spectrum antimicrobials for a majority of gram-positive and gram-negative pathogens. Hospitals try to reserve these antibiotics for use only for special conditions such as resistant nosocomial infections, and they are usually dispensed only after discussion with infectious disease physicians or department heads.
Automatic Stop Orders

The purpose of an automatic stop order is to appropriately limit the duration of antimicrobial usage. This strategy has been used successfully to limit duration of surgical prophylaxis in United Kingdom hospitals. Additionally, stop dates can be used for the use of empiric or therapeutic antimicrobials. The Antimicrobial Subcommittee makes a recommendation to the DTC to authorize stop orders for a list of priority antimicrobials based on dosing and duration of therapy. These steps can be best implemented using antimicrobial order forms (AOFs).

Antimicrobial Order Forms

Rather than the regular prescription form, the AOF is a special preprinted form usually in a different color. Prescribers categorize antimicrobials as prophylaxis, empirical, or therapeutic. For surgical prophylaxis, automatic discontinuation of the antimicrobial takes place usually in the range of 24–48 hours as decided by the institution; for empiric treatment, the suspected cause of infection must be stated; for therapeutic treatment, isolated pathogens and relevant susceptibility is stated. An example of an AOF is provided in figure 1.\textsuperscript{11}

\textsuperscript{11} Sital Shah, Chief Pharmacist, Aga Khan University Hospital, Nairobi, Kenya. Former participant of International DTC Training of Trainers course, Malaysia, 2005.
Figure 1. Sample antibiotic order form.
Within the AOF, an automatic stop order policy and list of restricted antimicrobials specific to the individual hospital are provided. Instructions on use of local culture and sensitivity testing are also provided (figure 2).

**Figure 2. Sample instructions in an AOF.**
Intravenous-to-Oral Conversion

Another method to achieve a more rational use of antimicrobials is through an intravenous (IV) - to-oral conversion policy, a widely used method of lowering medicine costs for an institution and its patients. Several advantages have been associated with this method such as less preparation time, lower risks of complications or adverse effects, and potential shortening of the length of hospital stay. The IV-to-oral conversion program involves establishing criteria for conversion, choosing an appropriate antimicrobial, consulting with the relevant physician, and monitoring the patient after conversion. For this policy to be successful, clear guidelines need to be established determining which patients can be converted and which patients should not.

Evaluating Antimicrobial Use Based on Pre-established Criteria of Appropriateness and Applying Remedial Measures

Select high-cost antimicrobials or those that may have the greatest potential for abuse and then conduct a drug use evaluation (DUE) using the techniques described in session 11, “Drug Use Evaluation.” This review is especially useful if the Antimicrobial Subcommittee established guidelines for specific antimicrobials and wants to determine compliance with the guidelines (pre-established criteria). The evaluation may be conducted by reviewing a random sample of prescriptions or case notes over a long period (e.g., 6 to 12 months) or a short study period (e.g., 1 to 3 months) where patients have received the specific antimicrobial.

The data are tabulated, and compliance with various indicators is determined. If noncompliance is observed from the data, a remedial measure may be taken to improve the use of the antimicrobial. The remedial measure may be conducted through variety of methods as described in session 9, “Strategies to Improve Medicine Use—Overview.” After the intervention, a second evaluation is performed to determine the impact of the intervention on the use of the antimicrobial.

Providing Preservice and In-service Education on Rational Use and AMR

Training in the appropriate use of antimicrobials is essential for all health professionals within the hospital or primary health care facility. Regular in-service education programs can improve the use of antimicrobials and decrease the incidence of ADRs as well as decrease overall health care cost. Such education should also be provided at the undergraduate and post-graduate levels and local academic institutions should be encouraged to adopt rational antimicrobial use and AMR concepts in their curriculums.

Liaising with the Infection Control Committee with Regard to the Assessment and Use of Data Obtained from Monitoring AMR

Surveillance of bacterial resistance to antimicrobials is an essential component of any program to contain the spread of resistance. Only by knowing the extent of the problem can appropriate choices be made and staff persuaded to change their medicine use behavior. Resistance data not only helps in choosing the correct antimicrobial in individual patient care; if collated, it also allows a DTC to be informed about sensitivity patterns when choosing antimicrobials for the formulary. Many hospital laboratories do not actually collate resistance data to inform the
formulary process, but the DTC has a role to ensure that such information is provided if possible. The microbiology department and the infection control team will collect this data.

Resistance is often reported in terms of the number of isolates. Such data, however, usually include multiple specimens from a few very sick patients and does not give an accurate picture of overall resistance in all patients. To inform the formulary process, resistance data should be representative of all likely patients, and therefore the data should be collated by case (or patient), not by isolate. If specimens for culture are taken from patients on arrival at a hospital, before they receive any antibiotics, the resulting data may be used to gain an impression of resistance patterns in the community.

Detailed discussion about resistance surveillance is beyond the scope of this manual. If surveillance is done, however, quality control within the laboratory is extremely important. Having inaccurate reports is worse than having none at all. Any good and reliable microbiology laboratory should be able to demonstrate to the DTC documented internal and external quality assurance.

- **Internal quality assurance** consists of regularly conducting and recording various internal checks to ensure that all laboratory equipment is functional and that all specimen collection and processing are done in a reliable manner.

- **External quality assurance** is accomplished when the laboratory participates in an external scheme run by a reference laboratory. In this situation, the reference laboratory sends out test clinical specimens, and asks the participating laboratory to identify the organism and its sensitivity pattern. In this way, the competence of the participating laboratory can be checked against that of the reference laboratory.

**Providing Education to Patients on the Use and Abuse of Antimicrobials and Encouraging Adherence**

Dispensing pharmacists in the hospital outpatient ward must educate patients on the appropriate use of antimicrobials and encourage adherence. Besides one-to-one education to the patient, the Antimicrobial Subcommittee can create simple poster boards to be placed in the patient waiting area and near the dispensing window. Depending on the institutional context, patient education may also help reduce patients’ unnecessary demands to the provider for an antimicrobial.

**Supporting Pharmacovigilance Activities for Antimicrobials**

Antimicrobial safety and toxicity must be monitored in a coordinated, systematic method. The Antimicrobial Subcommittee may adopt various strategies, as discussed in session 4, “Assessing and Managing Medicine Safety.” Pharmacovigilance for specific antimicrobials with known safety concerns must be designed and implemented. Additionally, antimicrobial use in vulnerable groups such as pediatric and elderly patients may also be monitored. Interventions include dose adjustment in cases of hepatic or renal failure for certain antimicrobials (e.g., aminoglycosides, vancomycin), alertness for allergies (penicillins), and identification of relevant interactions with other medicines (macrolides, azoles). These pharmacovigilance activities will
decrease the incidence of ADRs, decrease the unnecessary use of alternate antimicrobials, and improve the overall use of antimicrobials.

**Establishing An Antimicrobial Subcommittee within a DTC**

Establishing an Antimicrobial Subcommittee within a DTC can help create a task force to design educational and intervention programs to contain the threat of AMR. The Antimicrobial Subcommittee can take leadership in developing policies concerning use of antimicrobials for approval by the DTC and medical staff. The Antimicrobial Subcommittee also has a role in evaluating and selecting antimicrobials for the formulary.

For the Antimicrobial Subcommittee to be successful, clear terms of reference (box 1) and composition of subcommittee must be established. For example, in a private hospital in Kenya, the composition of the Antimicrobial Subcommittee is multidisciplinary, consisting of the following—

- Clinical pharmacist
- Microbiologist
- Nurse representative
- Physician representative
- Chief pharmacist

**Box 1. Terms of Reference for Antimicrobial Subcommittee:**

Example from Kenya

1. Ensure hospital antibiotics policy is adhered to in the ICU.
2. Promote rational use of antibiotics.
3. Educate the doctors, nurses, and pharmacy staff on appropriate antibiotic usage.
4. Conduct medicine usage review and regular audits.
5. Ensure sensitivity and resistance patterns are determined.

At this hospital, DUE was conducted and showed an overuse of carbapenem antimicrobials. This finding was brought to the attention of the DTC and resulted in guidelines being implemented for the use of these medicines. A substantial decrease in the use of these medicines occurred along with significant cost savings. The DTC also addressed the use of injections in the

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12 Sital Shah, Chief Pharmacist, Aga Khan University Hospital, Nairobi, Kenya. Former participant of International DTC Training of Trainers course, Malaysia, 2005.
outpatient department. Simple indicators studies were employed and resulted in reduced use of injections in the outpatient department along with cost savings on these medicines and the cost to administer.

Other examples of DTC related activities that have led to improved antimicrobial use include the following—

- **AOF**—This form required staff to record the indication for the antimicrobial and an indication if it was treatment or prophylaxis. The implementation of this form has reduced the use of expensive broad-spectrum antimicrobials at a hospital in Nairobi.

- **AOF in Thailand**—This form guided physicians to give explicit information about anatomic and etiologic diagnosis and suspected antimicrobial sensitivity. This action resulted in decreased use of unnecessary antimicrobials and a 30 percent reduction in cost for these medicines.¹³

- **IV to oral switching of antimicrobials**—This activity, led by the DTC, instituted a program of switching from IV to oral antimicrobials at the earliest possible time to conserve the use IV antimicrobials and to decrease cost. Guideline adherence was encouraged and monitored. This activity resulted in improved use of antimicrobials including a decrease in expensive intravenous medicines.¹⁴

### DTC Collaboration with Hospital Departments and Committees

DTCs can collaborate with other hospital units and departments (figure 3) resulting in synergistic action to contain the threat of AMR with the following—

- Different departments—for education of students, physicians, pharmacists, nurses, and patients

- The Infection Control Committee—to reduce spread of resistant pathogens

- The microbiology department—for collection and management of information on pathogens and resistant patterns

- Hospital management—to develop and implement policies on antibiotic use

- Pharmacy—to improve antimicrobial procurement and quality


Activity

Each group should discuss and identify a common antimicrobial use problem or issue concerning AMR in its hospitals. The group should then come up with one or more strategies to address these problems. Be prepared to discuss the following questions—

- What strategies will you use to solve the antibiotic use problem? How will you utilize the DTC (if it exists) to lead or support the process?

- How will you monitor your strategy?

- What may be the potential barriers in implementing your strategy?

Summary

Certainly, antimicrobial medicines have greatly contributed to the decline in morbidity and mortality due to infectious diseases over the past half-century. Without effective antimicrobials, infectious diseases would have been devastating to the world’s population.
This achievement is being undermined by the rapidly growing problem of AMR. WHO has identified the DTC as an important intervention mechanism to manage and contain AMR in hospitals. A DTC can do much to contain AMR, such as setting up programs and interventions to identify antimicrobial use problems and implementing specific interventions to improve prescribing, using, and managing antimicrobials.

To be effective, the DTC needs to obtain institutional management and leadership support. Documentation of clinical and economic benefits of the DTC will provide evidence to senior hospital administrators of the vital role the DTC plays in helping to preserve the effectiveness of existing antimicrobials. This effect can be accomplished by multifaceted methods led by the DTC including the following—

- Updating and managing an antimicrobial formulary
- Developing policies on antimicrobial procurement and quality
- Developing and updating antibiotic guidelines and protocols
- Developing policies (e.g., reserve antimicrobials, levels of prescribing, automatic stop orders, and AOFs) to improve compliance with guidelines and protocols
- Evaluating antimicrobial use based on pre-established criteria of appropriateness and applying remedial measures (DUE)
- Providing preservice and in-service education on rational use and AMR
- Liaising with the Infection Control Committee with regard to assessment and use of data obtained from monitoring antimicrobial resistance
- Providing education to patients on the use and abuse of antimicrobials and encouraging adherence
- Supporting pharmacovigilance activities for antimicrobials