

# Antibiotic stewardship implementation in the EU: the way forward

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There is an urgent need for an agreement on the principles and key components of antibiotic stewardship to support the EU member states in developing their national or regional programs. A proposal for a conceptual framework was drafted during an international expert workshop on hospital antibiotic stewardship organized under the Czech presidency in Prague on 15 April 2009. This document aims at defining structural and organizational requirements to optimize antibiotic use for hospitalized patients. Optimization should aim at improving patient outcomes, ensuring cost-effective therapy, and reducing the adverse health and ecological effects of antimicrobial use, including drug resistance. Antibiotic stewardship is of relevance to hospital as well as community care. To progress on antibiotic stewardship implementation in the EU, we suggest that three issues need to be addressed: the need for further research on the comparative effectiveness and cost-effectiveness of antibiotic stewardship strategies and interventions in different healthcare settings, the development of expert consensus on key elements of evidence-based best practice in hospital and community antibiotic stewardship, and strengthening the legal basis and core funding of antibiotic stewardship programs as integral components of quality and efficiency of care promotion initiatives.

**KEYWORDS:** antibiotics • antibiotic stewardship • antimicrobial • Europe • resistance

The prevention and control of antimicrobial resistance relies on two complementary strategies: infection control measures to control spread of multidrug-resistant organisms, and the optimization of antibiotic usage for therapy and prophylaxis [1]. The latter endeavor is commonly summarized under the term ‘antibiotic stewardship’ (ABS). The implementation of organizational structures and marketing measures is essential to sustainably promote ABS as education alone, without incorporating intervention, has been only marginally effective in changing antimicrobial prescribing practices in the short term [2–5].

The problem of antimicrobial resistance also requires common strategies at the European level.

Resistant organisms are not constrained by national borders, so there is a need for cooperation at EU level. There is an urgent need for agreement on principles and key components of ABS to support the EU member states in developing their national or regional programs. Given that it will be impossible for any hospital to implement all the published recommendations at the same time, a weakness of guidelines

on antimicrobial stewardship (ABS) is that they do not provide advice on how to allocate priorities. The EU, through the European Centre for Disease Prevention and Control (ECDC), can provide added value in pooling expertise, provide scientific guidance towards identifying best practice and making surveillance data comparable between countries.

While the following will mainly concentrate on ABS implementation in the EU, it must be noted that there is also strong political commitment to support the development of new antimicrobial drugs [6,7]. As there is an enormous gap between the burden of infections due to multidrug-resistant bacteria and the development of new antimicrobials to tackle this problem, the Swedish presidency of the EU in the second half of 2009 has taken over to elaborate a European strategy on this topic.

## Background

The council recommendation of 15 November 2001 on the prudent use of antimicrobial agents in human medicine (2002/77/EC) asked EU member states to establish a national

intersectoral coordinating mechanism with the responsibility to establish a national strategy, strengthen surveillance systems on antimicrobial resistance and on the use of antimicrobial agents, to implement control and preventive measures to support the prudent use of antimicrobial agents, and limit the spread of communicable disease, to promote education and training of health professionals, and to inform the general public on the problem of antimicrobial resistance and the importance of prudent use of antimicrobial agents [1]. While in 2000 only six European countries had a national plan to contain antimicrobial resistance, by 2005, 16 countries had developed a national strategy and nine countries had implemented concrete action plans in this area [101,102]. The importance of coordinated action in the EU toward containing antimicrobial resistance was recently emphasized in 'Council conclusions on antimicrobial resistance' adopted in Luxembourg on 10 June 2008 [103] and with the adoption of the 'Council recommendation on patient safety, including the prevention and control of healthcare-associated infections' on 9 June 2009 [8].

#### European projects of importance for ABS

Several European projects are promoting ABS, including the European surveillance of Antimicrobial Consumption (ESAC), the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) Study Group for Antibiotic Policies (ESGAP) and the ABS International project.

The ESAC was launched in 2001 with the support of the European Commission Public Health and Consumer policy funding programs, and since 2008 by the ECDC. There are 34 countries participating in ESAC, including all EU member states. Each country has its own national network of experts. They collect data on the use of antibiotics, antivirals and antimycotics, and send the data to the project coordinator at the University of Antwerp, Belgium for analysis and annual reporting of consumption trends. They elaborate methodology to ensure reliable comparison and evaluation of data on antibiotic prescribing in both primary and hospital care [6].

The ESGAP is a study group affiliated with ESCMID, and was founded in 1999. Using research, communication and advanced training projects, ESGAP is seeking to play a significant role in formulating and promulgating strategies to improve antimicrobial prescribing policies and practices in Europe [7,9]. The ESGAP homepage allows for the free download of the ESGAP Antibiotic Consumption Calculator (ABC Calc). ABC Calc is a simple computer tool to measure antibiotic consumption in hospitals and hospital wards as a number of defined daily doses (DDD) per 100 bed-days [104]. It was developed for ESGAP at the National Center for Antimicrobials and Infection Control, Statens Serum Institut (Copenhagen, Denmark). ESGAP leaders, namely Ian Gould and Jos van der Meer, are widely credited for introducing the term ABS into the European vocabulary [10,11].

The project 'ABS International: Implementing Antibiotic Strategies for Appropriate Use of Antibiotics in Hospitals in Member States of the EU' started in September 2006 in Austria, Belgium, Czech Republic, Germany, Hungary, Italy, Poland,

Slovenia and Slovakia. A training program for national ABS trainers, templates for ABS tools, such as an antibiotic list, guide for antibiotic treatment and surgical prophylaxis and recommendation for hospital ABS (H-ABS) organization, were elaborated and implemented. In pilot hospitals in all countries, training and consulting services for implementing organizational structures for ABS and for ABS marketing were delivered. Process measures as quality indicators for antibiotic use were developed and validated in pilot hospitals. ABS International, which ran until February 2009, was the first EU-funded initiative focusing on the implementation of structural measures in hospitals to promote the prudent use of antibiotics [12,13].

The presidency of the Council of the EU is rotated between member states on a 6-month basis. Within the frame of an EU conference entitled 'The microbial threat to patient safety under the Czech presidency in Prague on 15 April 2009', an expert workshop on H-ABS was organized in order to develop and discuss a first draft of conceptual framework of principles and key elements of ABS. The following basic principles for ABS in Europe originated from the abovementioned workshop. The resulting draft document should be seen as basis for further development of consensus by experts at EU level, with the support of the ECDC.

#### Conceptual framework & principles of H-ABS: the Prague Workshop proposal

##### *Introduction to the principles*

Systematic prevention and control of antimicrobial resistance is necessary to maintain long-lasting effectiveness of antimicrobial agents for treatment and prophylaxis of infections. Loss of their clinical effectiveness represents a significant threat for patients affected by serious, life-threatening infections in the hospital setting.

Effective prevention and control of antimicrobial resistance in hospitals is based on complementarily implemented activities focused on decrease in selective pressure of antimicrobials associated with their inappropriate use as well as reduction of spread and transmission of resistant microorganisms.

These principles are generally declared in the 'Council recommendation on prudent use of antimicrobial agents in human medicine', as well as in the recently proposed 'Council recommendation on patient safety' including 'Prevention and control of healthcare-associated infections'.

Whereas standards and measurable elements focusing on prevention and control of infections in healthcare institutions already exist (e.g., Joint Commission International accreditation standards, Improving Patient Safety in Europe standards and indicators), similar standards are not yet available for implementation of H-ABS. In 2009, one still finds a plethora of different approaches implemented in the 27 member states, with many states lacking national policies.

Recent EU projects (e.g., ABS International) have defined principles of H-ABS that can form the basis of discussions on appropriate standards and measurable elements to improve practices in healthcare institutions across Europe. These standards could be included as accountability criteria for hospital accreditation.

**Objectives**

- Ensuring effective, safe and cost-effective antibiotic treatment and prophylaxis of infections as an integral part of care for patients in the hospital setting;
- Prevention and control of antimicrobial resistance by means of prudent use of antibiotics in order to maintain their long-term effectiveness for treatment and prophylaxis;
- Reduction of occurrence of difficult-to-treat infections caused by multidrug-resistant microorganisms, which threaten quality of care and safety of hospitalized patients.

**Principles**

- Establishing an interdisciplinary H-ABS program focused on the optimization of quality of antibiotic usage and control of antimicrobial resistance at the hospital level;
- Creating an organizational structure to lead a H-ABS program, specification of its scope, functions, activities, competencies, leadership and accountability, including the indispensable support of hospital management;
- Ensuring sufficient capacity of the H-ABS program in terms of human, material and technical resources;
- Creating and implementing basic tools for H-ABS (e.g., an antibiotic list with specification of restricted drugs, control of antibiotic consumption, local surveillance of antimicrobial resistance, local guides for diagnostics of infections including clinical microbiology, local guides for initial and pathogen-specific therapy and for surgical prophylaxis, consulting and supervising of antibiotic usage);
- Performing epidemiological surveillance of antimicrobial resistance as required for optimization of antibiotic treatment and prophylaxis at the local level (e.g., local rates and trends of antimicrobial resistance, outputs of local surveillance of healthcare-associated infections, regional and national epidemiological patterns of community acquired infections, including levels of antimicrobial resistance of key pathogens);
- The systematic evaluation of quality of antibiotic usage in the hospital setting, based on relevant scientific knowledge, focused on identification of inappropriate practice. Continuous improvement of quality of antibiotic usage using relevant, validated, feasible and cost-effective quality indicators and quality management procedures;
- Effective coordination of the H-ABS program with the program on prevention and control of infections focused on the control of spreading of resistant pathogens;
- Continuous quality improvement of the H-ABS program, regarding capacity building, structure, organization, functions and effectiveness, based on implementation of action plans reflecting evaluation of adequate structure indicators and level of implementation of specific standards.

**Key elements of a H-ABS program****Establishment & objectives**

A healthcare institution establishes a specific interdisciplinary program, focused on high-quality antibiotic usage, aiming at the long-lasting sustainability of the effectiveness of antimicrobial agents for treatment and prophylaxis, a reduction of risk of antimicrobial resistance, as well as difficult-to-treat infections owing to multidrug-resistant pathogens threatening patient safety.

**Scope & priorities**

The scope of a H-ABS program takes into account the clinical spectrum and epidemiological characteristics of community-acquired and healthcare-associated infections, which occur in patients to whom the healthcare institution provides care. Priorities of the H-ABS program are appropriate in relation to the structure, scope and characteristics of provided healthcare (e.g., spectrum of clinical disciplines, characteristics of patient populations and proportion of intensive care unit beds).

**Conditions for effective operation**

- The management of the healthcare institution is responsible for ensuring sufficient resources (in particular human, financial and technical) and for support of the H-ABS program;
- The healthcare institution supports the personal development of professionals in the interdisciplinary ABS team;
- The healthcare institution disposes of sufficient capacity regarding diagnostics and clinical management of infections, appropriate to the scope and characteristics of provided healthcare;
- The healthcare institution has sufficient capacity of clinical microbiology services with a sufficient spectrum of examinations allowing pathogen-specific therapy and providing necessary and interpretable data for optimizing initial antimicrobial therapy, prophylaxis, and also effective prevention and control of antimicrobial resistance;
- The healthcare institution has access to the required data on antimicrobial resistance for optimization of antibiotic use and effective prevention and control of antimicrobial resistance;
- Inappropriate influence of marketing and promotion of pharmaceutical industry on operation and activities of the H-ABS program must be avoided. Relationships between the H-ABS program and the pharmaceutical industry must be regulated by national legislation, ethical rules of professional societies and bodies, and local rules established by the healthcare institution.

**Structure, organization, personnel & management**

- The H-ABS program is coordinated by an interdisciplinary ABS team, whose composition, roles, responsibilities and leadership are defined, recognized and supported by the hospital management;
- The ABS team is composed of experienced specialists with relevant education, training and authority, representing appropriate disciplines related to the scope of H-ABS and prevention

and control of antimicrobial resistance (e.g., clinical microbiology, infectious diseases, intensive care, surgery, hospital pharmacy, infection control, other clinical disciplines as appropriate);

- The ABS team is responsible for ensuring, coordinating and managing all functions and activities of the H-ABS program (see the section entitled 'Functions & activities');
- Sufficient numbers of clinical consultants with appropriate education and training are available to provide their services for clinical wards regarding support of prudent use of antimicrobial agents for individual patients (see the section entitled 'Functions & activities: Development & regular updating of local guides for diagnostics, treatment & prophylaxis of infections');
- H-ABS-linked physicians effectively cooperating with the ABS team are implemented on clinical wards, to ensure all appropriate functions and activities of the H-ABS program at this level;
- Supporting staff are available for optimal operation and ensuring functions of the H-ABS program as appropriate and necessary (e.g. data documentation assistants, information technology specialists, epidemiologists and biostatisticians, preferably also project managers, communication and public-relations specialists).

#### **Functions & activities**

Local surveillance of antimicrobial resistance

Competent professionals regularly process, evaluate, compare and interpret local data regarding clinically and epidemiologically important patterns of antimicrobial resistance, to be adequately useful for updating local guides for initial antimicrobial therapy, for effective control of spread of resistant microorganisms, as well as restriction of particular groups of antimicrobials with potential risk of resistance. Intelligible and easy-to-implement outputs of this activity are routinely distributed to all concerned personnel as appropriate.

Local surveillance of antibiotic consumption

Competent professionals regularly process, evaluate, compare and interpret local data regarding consumption of antimicrobials to detect important quantitative and qualitative changes as soon as possible, when a detailed analysis of reasons of observed trends is needed for early implementation of appropriate control measures. Intelligible and easy-to-implement outputs of this activity are routinely distributed to all concerned personnel as appropriate.

Categorization of antimicrobial agents & creating antibiotic lists  
The healthcare institution, through its ABS team, defines and regularly updates a generic list of essential antimicrobial agents according to the scope and characteristics of provided care, as well as the spectrum and epidemiological characteristics of incurred infections. Categorization of restricted drugs, including a description of specific rules for its use and prescribing is integrated. Appropriate additional information can be included, such as pricing and dosage, among others. This list (antibiotic list) is widely available for all prescribing physicians, the hospital pharmacy and other relevant healthcare workers.

Development & regular updating of local guides for diagnostics, treatment & prophylaxis of infections

The interdisciplinary ABS team develops and regularly updates local guides for diagnostics, treatment and prophylaxis of infections in co-operation with clinical and diagnostic hospital departments. These guides have to correspond to the scientific knowledge, relevant international and national guidelines, have to take into account adequate national, regional and local epidemiological characteristics and have to be easy to understand and widely available.

Clinical consulting & services focusing on support of prudent use of antimicrobial agents

Services on clinical consulting of individual patients for differential diagnosis, treatment and prophylaxis of infections are an integral part of the H-ABS program. These activities also cover supervision of usage of restricted drugs and interpretation and active reporting of critical results of microbiology examinations aimed at early conversion from empiric to pathogen-specific therapy, where possible. Consultations must be widely available and routinely documented in patient records to ensure continuity of care.

Systematic measuring, evaluating & improving quality of antibiotic usage

The H-ABS program implements activities focused on systematic improvement of quality of antibiotic usage in the interest of optimization of treatment and prophylaxis of infections. Adequate procedures and measures are used, which are of scientific relevance, validated, feasible, cost effective and ideally resulting from measurement of relevant quality indicators.

Education & training

The healthcare institution ensures through its ABS team regular training of prescribing physicians and other relevant healthcare workers in diagnostics, treatment and prophylaxis of infections, focusing on appropriate use of antimicrobial agents as well as prevention and control of antimicrobial resistance. Training activities cover information on recent problems of antimicrobial resistance, inappropriate use of antimicrobials and adequate control measures for improvement. ABS team members and clinical consultants participate in systematic continuing education and training in all areas needed for their professional skills.

#### **Tools**

Specific tools are developed and available at all appropriate levels to ensure optimal operation of the H-ABS program. These tools are complementary to its functions (see Functions & activities) and cover in particular:

- Antibiotic lists
- Local guides for diagnostics of infections including microbiology laboratory
- Local guides for initial antimicrobial therapy
- Local guides for pathogen-specific antimicrobial therapy

- Local guides for surgical prophylaxis
- Tools for controlling antibiotic consumption
- Tools for controlling antimicrobial resistance

### **Integration of the H-ABS program with the hospital program on quality & safety: links & relationships**

The progress of continuous quality improvement of the H-ABS program is regularly evaluated using appropriate methods (measuring structure indicators and auditing implementation of H-ABS standards). Outputs of this evaluation are used for further development through realization of H-ABS action plans with appropriate timing.

The H-ABS program is linked to the program on prevention and control of infections of the healthcare institution. Representatives of both programs are reciprocally involved in their organizational structures.

Hospital ABS program activities are linked with and integrated into the hospital drug policy, especially in terms of rational and cost-effective use of medicines, reduction of medication errors, undesirable adverse reactions and drug interactions. A representative of the H-ABS program is a member of the organizational structure responsible for agenda of hospital drug policy (e.g., a hospital drug and therapeutic committee).

Relationships of H-ABS programs with cooperating healthcare facilities and subjects (e.g., general practitioners, ambulatory specialists and hospitals) are formulated.

The H-ABS program of a healthcare institution is linked with the 'national intersectoral coordination mechanism' (see Council recommendation of 15 November 2001 [11]) as appropriate.

### **National programs & professional initiatives in ABS**

National initiatives on ABS are operated in a number of EU member states. The following are illustrative examples of successful initiatives.

In The Netherlands, a working party of professional experts on antibiotic policies (Stichting Werkgroep Antibioticabellied [SWAB]) was founded in 1996, and has been supported by the government since 1999 [14]. The major goal of the Dutch working party on antibiotic policy is to contribute to the containment of developing antimicrobial resistance and of expanding costs of the use of antibiotics. This is achieved by optimizing the use of antibiotics by means of guideline development, education and antibiotic resistance surveillance. Recommendations based on a systemic review of the literature and graded conclusions have been published within a hospital guideline program. These national guidelines cover pneumonia (1999, updated 2005), bronchitis (1999), septicemia (1999, update 2009), surgical prophylaxis (2000), urinary tract infections (2005), acute diarrhea (2006), methicillin-resistant *Staphylococcus aureus* carriage (2007), fungal infections (2008) and include a draft on meningitis (2009) [105].

In Sweden, the Swedish strategic program for the rational use of antimicrobial agents and surveillance of resistance (Strategigruppen för Rationell Antibiotikaeftersyn och Minskad Antibiotikaresistens [STRAMA]) has been supported

by the government since 2000 [15,106]. Since its formation in 1995, STRAMA's primary goal has been to preserve the availability of effective antibiotics for human beings and animals. STRAMA has enabled a joint strategy to be established between all Swedish authorities and organizations involved with antibiotic use and infection control. STRAMA is organized at two levels: a network of independent local multidisciplinary groups in each county that provides prescribers with feedback on antibiotic use and resistance and implements guidelines; and a national executive working group funded by the government. STRAMA's multidisciplinary and multisectorial program has developed into a coordinated national effort that has contributed to a decrease in antibiotic use without measurable negative consequences. However, the decentralized system with 21 counties and regions has resulted in divergence of action plans and rules.

In Belgium, the Belgian Antibiotic Policy Coordination Committee (BAPCOC) was officially established in 1999 by royal decree. The overall objective of BAPCOC is to promote judicious use of antibiotics in humans and animals and to promote infection control and hospital hygiene, with the overall aim of reducing antibiotic resistance and optimizing care. BAPCOC fostered strong and interdisciplinary public health, scientific and political leadership, which led to many evidence-based interventions, such as multimedia campaigns to promote the prudent use of antibiotics in the community, national campaigns to promote hand hygiene in hospitals, publication of clinical practice guidelines and guides for primary and hospital care, enacting of legislation for mandatory implementation, funding of dedicated staff and technical support to ABS teams in all Belgian hospitals, training of over 500 healthcare professionals in ABS, integration of surveillance programs on antibiotic use and resistance in humans and animals and the promotion of research [16,107].

In the Czech Republic, the centrally regulated healthcare system existing in former communist Czechoslovakia, with limited financial resources, resulted in low level antibiotic consumption and rare occurrence of antimicrobial resistance. Despite the obvious defects of the ancient regime, some remarkable activities established during this period have proved beneficial from the long-term perspective [17,108]. One of these was the establishment of 'antibiotic centers' in the 1970s, which contributed to promoting the prudent use of antibiotics. These organizational units were incorporated into the clinical microbiology departments and were made responsible for local surveillance of antimicrobial resistance and supervision of the use of 'restricted' antimicrobials. The network of antibiotic centers has remained active until the present time and currently represents a local structure ready for use in organizing further ABS interventions.

In Austria, the Federal Ministry of Health commissioned a project entitled 'Antibiotic Strategies' in 1997 [18]. This ABS endeavor was succeeded by three further projects, all focusing on hospitals, and finally succeeded to implement organizational ABS structures and ABS teams in 67 out of the 269 Austrian hospitals [19]. More than 400 physicians and pharmacists thus far underwent basic and advanced training in ABS performed by the Austrian ABS Group.

The aforementioned examples are just a few to underline the plethora of different approaches in organizing ABS programs in Europe. While these national programs represent examples of 'successful' national initiatives on ABS, it is important to note that none of them have been linked with improved patient outcomes, particularly reducing adverse health and ecological effects of antibiotics. In addition, the cost-effectiveness of these programs has not been evaluated at this time. The extensive literature published on programs in other EU member states further underlines the need for consensus development on best practice in Europe [20–25].

### Expert commentary

#### **ABS versus ABS program**

There is also a need to clarify the meaning of ABS and the related terminology. Terms such as 'antibiotic (AB) policy', 'AB strategy', 'AB stewardship' and 'AB management' are often used synonymously. ABS, as a function and responsibility of national health authorities, of hospitals and community-care practitioners has to be distinguished from ABS programs. ABS programs are composed of organizational structures and action plans for implementing ABS. Whenever an ABS program is implemented, a multitude of interventions are required. Single interventions, such as hiring an antibiotic officer or performing ABS-related training, are never sufficient alone. A program is per definition a combination of several related interventions.

The starting point for any successful ABS project or program is the development of a formal business case, qualitatively and quantitatively describing the costs and benefits of its components. To analyze a business case, output-related ABS quality indicators should be defined and measured before and after the interventions. Planning and running an ABS program is a complex endeavor. In order to succeed, implementation of an ABS program requires a clear process for initiating, sustaining and evaluating its performance [5,26].

To deliver an ABS project or program successfully, social competence is required in addition to technical (antibiotic specific) competence. The implementation of ABS in a hospital or care network should be conceived as a process of cultural and system change for this organization. If the antibiotic team does not possess the change management competence, it may be necessary to involve external experts with this competence.

#### **ABS in hospitals & community care**

While many experts understand ABS merely as hospital-based activities, ABS must be seen within a broader area of application. Community care, the veterinary sector and also the interfaces between hospital and community care within regions need to be involved. In some countries, experts from hospitals informally lead the general practitioners in a region (e.g., telephone consultations), but formal cooperation structures are required to ensure optimal patient treatment. ABS programs must be adapted to reflect the tremendous differences between healthcare systems across Europe as well within any country between large tertiary-care facilities versus small community hospitals. The

interfaces between a university hospital in a metropolitan area and its surrounding physicians are quite different from the mode of cooperation between physicians in a small rural hospital and its referring doctors.

#### **Need for further research**

The current evidence base supporting the general effectiveness, broad applicability and efficiency of specific ABS interventions remains limited in strength and volume [27]. Systematic reviews in the field have identified a number of significant limitations of the majority of published studies in terms of poor generalizability of findings due to the paucity of multicenter studies, low quality of study design, especially short-term evaluation and uncontrolled before-after series, and paucity of studies evaluating noneconomic outcomes. In particular, there is a need to compare the effectiveness of single or combined interventions on clinical and ecological outcomes across healthcare systems. The link between performance according to process of care quality indicators and clinical and resistance outcomes also needs further study. While the lack of quality research linking ABS programs with outcomes is acknowledged, it is still important to realize obvious opportunities for impacting patient outcomes, including cost-effectiveness, reduction in toxicity, and reduction in superinfection/infection due to multidrug-resistant bacteria [28].

#### **Partnerships & funding for ABS initiatives**

Selling, marketing and lobbying toward all stakeholders (hospital owners, learned societies, public-health authorities, health insurance organizations and patients' representatives) must be an integral part of all endeavors to promote ABS. This broad awareness is crucial for establishing ABS especially, but also for maintaining it. Cooperation of all stakeholders must be achieved to implement ABS in a sustainable form in hospital and community care. In addition, representatives of the pharmaceutical industry have to be involved within a defined code of ethics and in a spirit of dialogue towards efficiency of care.

#### **Overcoming the barriers of different healthcare systems in Europe**

Barriers to implementing ABS programs described for the USA [27–31] are very similar to those experienced in European ABS programs: acquiring funding for ABS is of paramount importance. In the EU, healthcare is the responsibility of the individual member state, and there are various organizational arrangements for the delivery of care and their supporting financing and insurance systems. These differences dictate national or regional implementation of ABS programs, which will probably fail to provide a comprehensive solution. Multiresistant organisms do not stop at national boundaries; therefore, agreement on common principles of action and international cooperation on these issues is important. The problem of antimicrobial resistance requires a common strategy at the community level [32].

The differences in human resources available at hospital and community levels across Europe in terms of staffing levels and education level of medical specialists (infectious disease

specialists, infection control physicians or clinically trained pharmacists) also hamper the European-wide implementation of ABS [33–35]. In Europe, hospital or clinical pharmacists trained in infectious diseases are extremely rare in a majority of countries while they are more widely deployed in others. The lack of experts should not be used as an excuse for failing to implement ABS. As the project ABS International has shown, such deficits can be overcome in part by first introducing short course training programs [12,13]. Within the ABS International project, shortage of adequately trained infectious disease physicians and pharmacists led to the creation of the ‘antibiotic officer’, a physician trained in a 2-week ABS program to support ABS-related activities [36–38].

### Legal framework for ABS programs

In many member states of the EU, it is still not standard practice to formally define ABS programs at national, regional and hospital levels. A formal definition and legal framework of ABS programs would facilitate their appropriate endorsement by healthcare executives and adequate budget appropriation.

### Conclusion

We conclude from our review that successful implementation of ABS in the EU will require addressing three major gaps: need for further research on the comparative effectiveness and cost–effectiveness of ABS strategies and interventions in different healthcare settings, development of expert consensus on key elements of evidence-based best practice in hospital and community ABS, and strengthening the legal basis and core funding of ABS programs as integral components of quality and efficiency of care promotion initiatives.

### Five-year view

While activities on ABS are presently based on the political aim to fight antimicrobial resistance, in the near future patient quality management will become the basic legitimation for ABS activities. Increased acceptance of quality management in hospitals and the move toward certification or accreditation will foster increased institutionalization of ABS and its wide acceptance.

While presently the complementarities between infection control and stewardship is widely acknowledged, in real life these two topics are often addressed by different projects and not yet adequately integrated [39]. In order to succeed, these two different topics will have to be more formally integrated.

New tools to measure antibiotic consumption, different from the WHO’s DDD approach, will be developed and complementary tools will be developed to evaluate the quality of antibiotic use in hospital and community care.

Antibiotic stewardship will become an established topic in academic education of healthcare professionals. The critical need for studies clearly demonstrating the value of ABS programs will be addressed by funding agencies. Such studies must take place in the next few years to either validate cost–effectiveness or demonstrate lack of cost–effectiveness of ABS.

The topic ‘sustainability’ (economical, ecological and social consequences of ABS) will be considered in detail in the business case analyses and will become measurable.

The successive EU presidencies of the Czech Republic, Sweden and Belgium decided to make antimicrobial resistance a health priority [109]. The Czech EU conference proposed a comprehensive conceptual framework for ABS in European hospitals.

### Key issues

- The problem of antimicrobial resistance cannot be contained by national initiatives alone, but requires a common strategy at community level. In the EU, there is a clear political commitment to achieve this.
- Strategies to prevent the emergence of antibiotic-resistant organisms through appropriate antibiotic use are essential if we are to guide resources optimally and improve patient outcome.
- Antibiotic stewardship (ABS) programs provide a formalized, practical and manageable approach to improving the use of antibiotics in healthcare systems.
- Mere publication of evidence-based practice guidelines regarding antibiotic use is insufficient to significantly impact antibiotic prescribing patterns.
- In the USA, prospective auditing with feedback and preauthorization are the two primary strategies of hospital ABS programs.
- In the EU, the major focus is laid on the implementation of basic structures to support antimicrobial stewardship sustainably. The basis for any ABS project or program has to be a quantitative and qualitative business case.
- ABS is of relevance in hospitals as well as in community care.
- To evaluate interventions, output-related ABS quality indicators have to be defined and measured before and after the interventions. These quality indicators will need to include tangible patient outcomes, such as reduction in toxicity, decreased superinfection/antibacterial resistance, and improved cost–effectiveness. Linking these clear patient outcomes with ABS programs would seem to be critical to the advancement of antimicrobial stewardship in the EU and showing ‘the way forward’.
- A document drafted during a workshop on hospital ABS organized under the Czech presidency in Prague on 15 April 2009 provides a concept framework to develop consensus guidance on how to optimize antibiotic use for hospitalized patients.
- Need for further research and validation includes health technology assessment in terms of effectiveness, development of new tools for hospital benchmarking of antibiotic consumption and quality indicators for antibiotic use.
- The lack of legal basis for ABS programs is limiting their support in many member states.
- The guidance and support for effective and efficient ABS has to be provided at different levels, including hospital-level and community-care networks by professional teams, at a national level by health authorities and programs, and at the EU level by international ABS networks, learned societies and the European Centre for Disease Prevention and Control.

During the second part of 2009, the Swedish Presidency of the EU organized a follow-up conference focusing on the gap between increasing multidrug resistance and the need for new antibiotics through incentives for research and development of such antibiotics. In the second part of 2010, it is foreseen that the Belgium Presidency will focus on partnership with the ECDC and learned societies on the appropriate use of quality indicators, including process and outcome indicators for ABS in hospitals. These partnership approaches between professionals, member state authorities and EU institutions will no doubt bring measurable progress in the implementation of ABS at the EU level.

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