

# Navigating the Web in Search of Resources on Antimicrobial Stewardship in Health Care Institutions

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**Bacterial resistance to antimicrobials has become a public health threat for which coordinated action at the international, national, and local level is needed. Current recommendations for the control of antimicrobial overuse and resistance in hospitals recommend various strategies, including antimicrobial stewardship programs. Several of these integrated and multidisciplinary antimicrobial management programs provide detailed information and recommendations on the Web. We performed a search of the most relevant and authoritative Web sites in English that were available without need for special registration or cost. The search excluded community-based programs, and we present only established programs or those providing expert information useful for building a hospital-based antimicrobial stewardship program. The overview of these Web sites may be useful either for institutions or individuals planning to implement such programs in their own health care institution or for educational purposes targeted at different professionals involved in improving antimicrobial practice.**

Antibiotics are among the most commonly prescribed drugs in hospitals. Inappropriate use of these agents may have deleterious consequences, because the emergence and dissemination of bacterial resistance is mainly driven by antibiotic selection pressure [1]. Despite many large-scale initiatives and campaigns at national and international level to promote more appropriate antibiotic use, no hospital or country in the world can claim to have resolved the problem of antibiotic misuse [2, 3].

Selection of the most appropriate antimicrobial treatment, optimization of drug dosing and duration of therapy needed to cure infection, improvement of patient safety through reducing the risk of toxicity and adverse effects, and control of resistant strains are the key principles of antimicrobial stewardship programs [4, 5]. Such institutional or nationwide comprehensive programs involve multiple strategies and cooperation among different professionals in health care, in a close alliance with infection control staff [6–8].

A Web search for the terms “antimicrobial/antibiotic stewardship” on a search engine such as Google easily retrieves >6000 hits. This review is not intended to summarize or evaluate the quality of all available Web-based resources related to antimicrobial stewardship programs. By identifying high-quality and readily accessible resources, we have tried rather to supply some practical help for national focus groups involved in antibiotic policy making, for institutions or individuals planning to implement such programs in their own health care institutions, or for educational and training purposes targeted at different professionals involved in improving antimicrobial practice. More specifically, we looked for practical information and Web sites covering the following areas and subjects:

1. Comprehensive Web sites, established by internationally recognized institutions, covering many different aspects of antimicrobial stewardship.
2. Institutional Web sites from health care organizations with established antimicrobial stewardship programs that may help health care professionals implement similar programs at their own institutions.
3. Web sites from other societies and organizations with an emphasis on optimizing antimicrobial use in health care institutions.

Received 17 October 2008; accepted 17 October 2008; electronically published 23 January 2009.

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**Clinical Infectious Diseases** 2009;48:626–32

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1058-4838/2009/4805-0018\$15.00

DOI: 10.1086/596762

## SEARCH METHODS

We retrieved English-language Web sites that can be accessed without a special registration procedure, gathered on the basis of the authors' personal files, along with an extensive Web search following cross-links from other Web pages. No attempt was made to perform a complete and systematic review of all available Web sites dealing with issues related to antimicrobial stewardship programs. Web sites were screened and selected according to the quality and ease of access to information on the basis of evaluations of the authors and the authoritativeness of or the degree of commercial relationship with the Web site sponsor(s).

The quality of the Web sites was determined by assessing the availability of comprehensive and up-to-date information, as was done elsewhere [9]. We did not include Web sites that redirected readers to recently published guidelines or to expert reviews that are easily retrievable through the PubMed database [7, 10–13]. Furthermore, we excluded Web sites that were not free of charge, were promotional in nature, did not offer information in English, exclusively described antibiotic control in the community, or dealt only indirectly with antimicrobial stewardship-related issues. Sites sponsored solely by the pharmaceutical industry were excluded, as were sites that, in the opinion of the authors, did not fulfill the criteria of independence, comprehensiveness, and exhaustiveness. Finally, the key words “antimicrobial resistance (AMR) control” were not considered a sufficient inclusion criterion, because Web sites dealing with control of antimicrobial resistance, in a broader sense, were recently reviewed in this journal [9, 14].

We particularly attempted to retrieve and highlight Web sites that had been generated by integrated antimicrobial stewardship networks of health care professionals, according to the recently published guidelines of the Society for Healthcare Epidemiology of America–Infectious Diseases Society of America [7]. These networks may include, for instance, infectious diseases specialists, hospital pharmacists with infectious diseases training, clinical microbiologists, clinical pharmacologists, information system specialists, and hospital epidemiologists. For those Web sites that were inadvertently omitted in this review, please contact us via e-mail and provide a URL address and a brief overview of the site.

## RESULTS

The search for and subsequent evaluation of important Web sites dealing with antimicrobial stewardship programs retrieved a large number of sites; therefore, an effort has been made to highlight only those of outstanding interest in the authors' opinion. They are shown in tables 1 and 2, categorized into different areas and types of sponsors, as described in the introduction. In table 3, other interesting Web sites that do not

exclusively cover antimicrobial stewardship in healthcare are shown. Most of these sites cross-link to information containing interesting documents and presentations, points of view or other perspectives on antimicrobial stewardship program-related issues. Many of them refer to the recently published IDSA-SHEA guidelines [7]; others include valuable independent contents. In all tables, we mention the source of information and the sponsor of the Web site, and we briefly summarize the content.

## DISCUSSION

**Web sites of outstanding interest.** The following sites represent in the authors' opinion the best starting points for designing and implementing antimicrobial stewardship programs in health care institutions, regardless whether they are of local or national dimension. These sites provide, to different extents, guidelines, hospital or national antibiotic guides, clinical and diagnostic pathways, and pharmacy-related material, such as dosing, formulary restriction systems, or surveillance data on drug consumption.

- The Centers for Disease Control and Prevention (<http://www.cdc.gov/drugresistance/healthcare/default.htm>). This well-known site offers teaching material to download and many valuable tools, in languages in addition to English, including the “12 Steps to Prevent Antimicrobial Resistance among Hospitalized Adults” campaign. It should be considered the cornerstone of antimicrobial stewardship programs in North America.
- The Healthcare Infection Control Special Interest Group ([http://www.asid.net.au/hicsigwiki/index.php?title=Antibiotic\\_stewardship\\_programs#Guides](http://www.asid.net.au/hicsigwiki/index.php?title=Antibiotic_stewardship_programs#Guides)). This site from Australia and New Zealand is rich with helpful information and teaching materials, provides a large number of related links, and represents a good example of multidisciplinary antimicrobial stewardship.
- The Nebraska Medical Center (<http://www.nebraskamed.com/careers/education/asp/index.aspx>). This is one of the best Web sites to provide information about the different aspects of an institutional antimicrobial stewardship program.
- The Washington University in St. Louis and Barnes-Jewish Hospital (<http://id2.wustl.edu/~casabar/antibiotics.html>). This site provides data on patterns of antimicrobial resistance, algorithms, and flow charts; is very rich in information about the antimicrobial stewardship program implemented; and may be very helpful to professionals who are willing to undertake such a program in their own institution. However, navigation of the institutional site is far from easy.
- The “Antimicrobial Management Program” (<http://www.uphs.upenn.edu/bugdrug/>) of The University of Pennsylvania Health System (<http://pennhealth.com>). This very interesting and complete site covers many aspects of antimi-

**Table 1. Comprehensive Web sites from national or international organizations with information on many aspects of antimicrobial stewardship.**

Name of site or sponsor	URL	Ease of navigation	Practical information for professionals	Amount and scope of information	Teaching material to download	Material in multiple languages	Links to other Web sites
Centers for Disease Control and Prevention	<a href="http://www.cdc.gov/drugresistance/healthcare/default.htm">http://www.cdc.gov/drugresistance/healthcare/default.htm</a>	Excellent	Yes	Large	Yes	Yes	Yes
The Public Health Agency of Canada	<a href="http://www.phac-aspc.gc.ca/cipars-picra/links-liens_e.html">http://www.phac-aspc.gc.ca/cipars-picra/links-liens_e.html</a>	Excellent	No	Average	Yes	Yes	Yes
Healthcare Infection Control Special Interest Group	<a href="http://www.asid.net.au/hicsgwiki/index.php?title=Antibiotic_stewardship_programs">http://www.asid.net.au/hicsgwiki/index.php?title=Antibiotic_stewardship_programs</a>	Excellent	Yes	Large	Yes	No	Yes
DeBug Infection Prevention Program	<a href="http://www.debug.net.au/index.html">http://www.debug.net.au/index.html</a>	Excellent	Yes	Average	Yes	No	Yes
Antibiotic Resistance Alliance Education Wisconsin	<a href="http://www.areasinitiatives.org">http://www.areasinitiatives.org</a>	Good	No	Average	Yes	No	Yes
European Project Group "ABS International"	<a href="http://www.abs-international.eu/">http://www.abs-international.eu/</a>	Excellent	No	Average	No	No	Yes
Antibiotic Resistance Prevention and Control	<a href="http://www.abdn.ac.uk/arpac/">http://www.abdn.ac.uk/arpac/</a>	Good	No	Small	Yes	Yes	Yes
The Scottish Government– Health and Community Care	<a href="http://www.scotland.gov.uk/Publications/2005/09/02132609/Z6099">http://www.scotland.gov.uk/Publications/2005/09/02132609/Z6099</a>	Excellent	Yes	Large	Yes	No	Yes
Appropriate Antibiotic Prescribing	<a href="http://www.dundee.ac.uk/facmedden/APT/index.htm">http://www.dundee.ac.uk/facmedden/APT/index.htm</a>	Excellent	Yes	Large	Yes	No	Yes
National Resource for Infection Control	<a href="http://www.nric.org.uk/integratedCRD.nsf/NRIC_Policy_AntimicrobialPrescribing?OpenForm">http://www.nric.org.uk/integratedCRD.nsf/NRIC_Policy_AntimicrobialPrescribing?OpenForm</a>	Excellent	Yes	Large	No	No	Yes
The Dutch Working Party on Antibiotic Policy	<a href="http://www.swab.nl/swab/swabcms.nsf/showrfs/foreign">http://www.swab.nl/swab/swabcms.nsf/showrfs/foreign</a>	Good	Yes	Average	Yes	Yes	No

**Table 2. Institutional Web sites with established antimicrobial stewardship programs.**

Institution or organization	URL	Design and ease of navigation	Amount and scope of information	Teaching material to download	Material in multiple languages	Links to other Web sites	Quality
Nebraska Medical Center	<a href="http://www.nebraskamed.com/careers/education/asp/index.aspx">http://www.nebraskamed.com/careers/education/asp/index.aspx</a>	Excellent	Large	Yes	No	Yes	Excellent
Wake Forest University Baptist Medical Center	<a href="http://www1.wfubmc.edu/d/hosp/Antimicrobial+Stewardship/">http://www1.wfubmc.edu/d/hosp/Antimicrobial+Stewardship/</a>	Excellent	Large	Yes	No	Yes	Excellent
The Washington University in St. Louis and Barnes-Jewish Hospital	<a href="http://fd2.wustl.edu/casabar/antibiotics.html">http://fd2.wustl.edu/casabar/antibiotics.html</a>	Average	Large	Yes	No	Yes	Good
The University of Pennsylvania Health System	<a href="http://www.uphs.upenn.edu/bugdrug/">http://www.uphs.upenn.edu/bugdrug/</a>	Excellent	Large	Yes	No	Yes	Excellent
Johns Hopkins Medical Institutions	<a href="http://www.hopkins-abxguide.org/cme_center.html">http://www.hopkins-abxguide.org/cme_center.html</a> <a href="http://www.hopkinsmedicine.org/AMF">http://www.hopkinsmedicine.org/AMF</a>	Excellent	Large	Yes	No	Yes	Excellent
University of Kentucky Chandler Medical Center	<a href="http://www.hosp.uky.edu/pharmacy/amt/default.html">http://www.hosp.uky.edu/pharmacy/amt/default.html</a>	Excellent	Large	Yes	No	Yes	Excellent

**Table 3. Other Web sites of interest for persons committed to antimicrobial stewardship.**

Name of site or sponsor	URL	Country	Guidelines	News	Educational and teaching material	Material available in multiple languages
Prudent Antibiotic User Website	<a href="http://www.pause-online.org.uk/">http://www.pause-online.org.uk/</a>	United Kingdom	Yes	No	Yes	No
Cumbria National Health System, Acute Trust Antibiotic Guidelines	<a href="http://www.cumbriapct.nhs.uk/medicinesmanagement/antibioticprescribingguidelines/2007/hospitalfrontpage.aspx">http://www.cumbriapct.nhs.uk/medicinesmanagement/antibioticprescribingguidelines/2007/hospitalfrontpage.aspx</a>	United Kingdom	Yes	No	Yes	No
Agency for Healthcare Research and Quality	<a href="http://www.ahrq.gov/downloads/pub/evidence/pdf/medigap/medigap.pdf">http://www.ahrq.gov/downloads/pub/evidence/pdf/medigap/medigap.pdf</a>	United States	No	No	Yes	No
Academy for Infection Management	<a href="http://www.infectionacademy.org/">http://www.infectionacademy.org/</a>	United States	Yes	Yes	Yes	No
Premier Inc.	<a href="http://www.premierinc.com/quality-safety/tools-services/safety/topics/guidelines/other.jsp">http://www.premierinc.com/quality-safety/tools-services/safety/topics/guidelines/other.jsp</a>	United States	Yes	No	Yes	No
Bugs and Drugs—Antimicrobial Reference Book	<a href="http://www.bugsanddrugs.ca">http://www.bugsanddrugs.ca</a>	Canada	Yes	No	No	No
American Society of Health-System Pharmacists	<a href="http://www.ashp.org/s_ashp/index.asp">http://www.ashp.org/s_ashp/index.asp</a>	United States	Yes	Yes	Yes	No

crobial stewardship on the Web. It provides updated guidelines for antimicrobial therapy, discusses issues related to formulary restrictions, provides current susceptibility and clinical microbiology data, and discusses pharmacologic considerations for dose adjustments, and lists infection control procedures.

- The DeBug Infection Prevention Program (<http://www.debug.net.au/index.html>). Although this Web site is mostly committed to infection control and prevention, it supports many aspects of antimicrobial stewardship programs, with downloadable examples of informative campaigns. Moreover, a computer-assisted antibiotic formulary and pharmacy order form is available.

**Web sites with special information about antimicrobial stewardship programs.** In this section, we describe some interesting Web sites that we found. These Web sites contain often practical information that may be also helpful for implementation of antimicrobial stewardship programs.

- The Public Health Agency of Canada ([http://www.phac-aspc.gc.ca/cipars-picra/links-liens\\_e.html](http://www.phac-aspc.gc.ca/cipars-picra/links-liens_e.html)). Although it mainly focuses on antimicrobial resistance and veterinary medicine, rather than on antimicrobial stewardship, this site provides several links to national or international institutions and agencies involved in pursuing multidisciplinary antibiotic policies.
- European Project “ABS International” (<http://www.abs-international.eu/>). This is the Web site of an international, multicenter project subsidized by the European Community that is run by a for-profit organization, which involves several European countries. Its aim is to share attitudes and knowledge about implementation of guidelines on antibiotic practices. The Web site is still under construction and does not yet provide a huge amount of useful information.
- Bugs and Drugs (<http://www.bugsanddrugs.ca>). This Canadian Web site is co-sponsored by Capital Health from the Alberta Health Services (<http://www.capitalhealth.ca/default.htm>) and the Canadian Committee on Antibiotic Resistance (<http://www.ccar-ccra.com>). Although it is not really committed to antimicrobial stewardship programs, this interesting site provides the booklet “Bugs and Drugs,” which contains a huge amount of information about antibiotic characteristics, indications, and restrictions, as well as information on microbiological issues. The last edition of the booklet was published in 2006, but corrections and updates are also available.
- The Cumbria National Health System Acute Trust Antibiotic Guidelines (<http://www.cumbriapct.nhs.uk/medicinesmanagement/antibioticprescribingguidelines/2007/hospitalfrontpage.aspx>). This Web site from United Kingdom not only offers detailed guidelines for antimicrobial prophylaxis and empirical treatment of adults, but it also links to some pharmacy-

related items. Although microbiology and infection control aspects are not thoroughly tackled, this represents a very interesting and useful Web site.

- Prudent Antibiotic User Website (PAUSE) (<http://www.pause-online.org.uk>). This Web site from United Kingdom provides shared standardized teaching materials that aim to effect more prudent antimicrobial prescribing practices. It is particularly suited to the needs of undergraduate medical curriculum but can be adopted for postgraduate training. It is now also supported by the European Society of Clinical Microbiology and Infectious Diseases as a valued educational web site. It is a good Web site from an educational standpoint, although it lacks a comprehensive approach to all key aspects of stewardship.
- The Dutch Working Party on Antibiotic Policy (SWAB) (<http://swab.nl>). This site contains updated antibiotic guidelines formulated by experts in The Netherlands and encompasses the so-called NethMap project, an ongoing national surveillance system on the use of antimicrobial agents related to the prevalence of resistance to antimicrobials among the most important human pathogens. English-language contents are of average completeness, and teaching material is scanty.

**Other Web sites of interest.** In table 3, we describe other Web sites that do not present implemented or institutional antimicrobial stewardship programs but, rather, documents that, in our opinion, could be worth a look. Some of them provide useful tools or take into account interesting aspects of antimicrobial stewardship programs. The website of the Academy for Infection Management (<http://www.infectionacademy.org>), which is partly sponsored by the pharmaceutical industry, offers a rich resource library with case studies, guidelines, and other educational material. Finally, Johns Hopkins Medical Institutions now provide their high-quality antibiotic guidelines on the Internet (<http://www.hopkinsmedicine.org/AMP>).

**Limitations.** There are some limitations to our approach. Our exclusion of non-English language Web sites may have excluded high-quality resources from some non-English-speaking countries and probably introduces a bias toward programs from North America, Australia, and the United Kingdom. For instance, useful Web sites in French (e.g., the Web site for Antibiolor [<http://www.antibiolor.org/site/index.php>]) or German (e.g., the Web site for AntiBiotika Strategien [<http://www.antibiotika-strategien.at>]) exist and may provide help for interested colleagues in Europe and elsewhere. We did not use other search engines, and this may have limited the number of hits we received. Finally, some antimicrobial stewardship programs may be immersed in infection control or prevention programs and, therefore, may not have appeared under our search terms.

## CONCLUSIONS

Internet resources have become important tools for getting information and advice on improving antimicrobial programs in everyday practice. In the era of high-level resistance of many hospital-acquired pathogens, a multidisciplinary approach is necessary: microbiologists, infectious diseases specialists, clinical pharmacists, and infection control experts should cooperate in antimicrobial stewardship programs. This brief review of easily accessible available resources on the Web may be helpful for anyone who is willing either to implement or to improve hospital-based antimicrobial stewardship programs or to educate hospital professionals about better antimicrobial practices.

## Acknowledgments

We thank Catherine Dumartin, Dominique Monnet, Sara Cosgrove, Ronald Polk, Richard Drew, and Victor Yu for their critical comments and help in finding additional Web sites relevant to this article.

**Financial support.** A small, unrestricted grant was provided by the European Society of Clinical Microbiology and Infectious Diseases Study Group for Antibiotic Policies.

**Potential conflicts of interest.** All authors: no conflicts.

## References

1. Harbarth S, Samore MH. Antimicrobial resistance determinants and future control. *Emerg Infect Dis* **2005**; *11*:794–801.
2. Goossens H, Guillemot D, Ferech M, et al. National campaigns to improve antibiotic use. *Eur J Clin Pharmacol* **2006**; *62*:373–9.
3. Harbarth S. Should the development of new antibiotics be a public health priority? *Curr Opin Crit Care* **2007**; *13*:554–6.
4. MacDougall C, Polk RE. Antimicrobial stewardship programs in health care systems. *Clin Microbiol Rev* **2005**; *18*:638–56.
5. Fishman N. Antimicrobial stewardship. *Am J Med* **2006**; *119*:S53–61; discussion S62–70.
6. van Kasteren ME, Mannien J, Kullberg BJ, et al. Quality improvement of surgical prophylaxis in Dutch hospitals: evaluation of a multi-site intervention by time series analysis. *J Antimicrob Chemother* **2005**; *56*:1094–102.
7. Dellit TH, Owens RC, McGowan JE Jr, et al. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. *Clin Infect Dis* **2007**; *44*:159–77.
8. Agwu AL, Lee CK, Jain SK, et al. A World Wide Web–based antimicrobial stewardship program improves efficiency, communication, and user satisfaction and reduces cost in a tertiary care pediatric medical center. *Clin Infect Dis* **2008**; *47*:747–53.
9. Harbarth S, Emonet S. Navigating the World Wide Web in search of resources on antimicrobial resistance. *Clin Infect Dis* **2006**; *43*:72–8.
10. Lesprit P, Brun-Buisson C. Hospital antibiotic stewardship. *Curr Opin Infect Dis* **2008**; *21*:344–9.
11. Owens RC Jr. Antimicrobial stewardship: concepts and strategies in the 21st century. *Diagn Microbiol Infect Dis* **2008**; *61*:110–28.
12. Gould IM. Antibiotic policies to control hospital-acquired infection. *J Antimicrob Chemother* **2008**; *61*:763–5.
13. Patel D, Lawson W, Guglielmo BJ. Antimicrobial stewardship programs: interventions and associated outcomes. *Expert Rev Anti Infect Ther* **2008**; *6*:209–22.
14. Falagas ME, Karveli EA. World Wide Web resources on antimicrobial resistance. *Clin Infect Dis* **2006**; *43*:630–3.