

Navigating the World Wide Web in Search of Resources on Antimicrobial Resistance

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This overview gives information on navigating for English-language Web sites on antimicrobial resistance. Web sites were gathered on the basis of personal files, articles, and an exhaustive Web search of cross-links from other Web pages. The Web sites were categorized according to users' needs into 5 broad categories, as follows: comprehensive Web sites, with information on all aspects of antimicrobial resistance-related issues; Web sites with patient information about antimicrobial resistance and about methicillin-resistant *Staphylococcus aureus*, in particular; Web sites covering current multinational surveillance programs; Web sites on prevention of antimicrobial resistance in health care facilities; and Web sites on control of antimicrobial resistance in the community. We compiled a selection of Web sites that seemed to be useful as starting points for physicians, epidemiologists, researchers, or patients interested in this topic.

There is no region in the world that has been excluded from the inexorable spread of increasingly drug-resistant bacteria [1]. As the prevalence of antimicrobial resistance (AMR) continues to increase in most parts of the world, infectious disease physicians and hospital epidemiologists are under mounting pressure to rapidly access relevant and up-to-date sources of information about AMR-related issues. Although a great diversity of available Web-based data sources exists, the challenge is to find the sites of greatest relevance to their interests. A Web search for the term "antibiotic resistance" with use of a search engine, such as Google, retrieves >3.5 million Web sites. This brief overview gives some hints about search strategies and provides practical information on important Web sites that deal with AMR. We will focus on the following 5 situations and Internet user groups:

- (1) Those who wish to find comprehensive, scientifically oriented Web sites that cover a broad range of AMR-related topics and which will allow them to screen and download a maximum of information in a minimum of time
- (2) Those who want to give useful and reliable information to their patients so as to heighten awareness or to inform them about AMR either in the hospital or in the community
- (3) Those who need access to international surveillance data

on AMR

- (4) Those looking for Web sites that will assist in the prevention of nosocomial AMR transmission
- (5) Those wishing to obtain information about public campaigns and country-specific measures to control AMR in the community

SEARCH METHODS

This review focuses on Web sites in the English language that are accessible without a special registration procedure. Web sites were gathered on the basis of personal files of the authors, articles, and an exhaustive Web search of cross-links from other Web pages. However, no attempt was made to perform a complete and systematic review of all available Web sites dealing with AMR-related issues. Web sites were selected according to the quality of and ease of access to information, determined on the basis of the subjective impressions of the authors and the credibility of the sponsors of the Web site. The quality of the Web sites was determined by assessing the existence of comprehensive and up-to-date information [2]. We excluded Web sites that were not free of charge, were promotional in nature, were not in the English language, were related to scientific journals, or dealt only indirectly with AMR-related issues. Moreover, we did not target Web sites that dealt with new drug development, clinical trials, molecular epidemiology, or genotyping of AMR strains. For those Web sites that were inadvertently omitted in this mini-review, please contact us via email with the URL address and give a brief overview of the site.

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RESULTS

Of the many Web sites covering AMR-related issues, only those Web addresses included in tables 1–5 were categorized as high-interest sites for our target groups. In each table, we mention the source of information and the sponsor of the Web site, and we briefly summarize the content (except for Web sites listed in table 5, which are described below).

DISCUSSION

Comprehensive Web sites. We list key resources for AMR that we consider to be the most informative and up-to-date. Table 1 is by no means complete; however, it provides examples of useful Web sites. In particular, we recommend the following 3 Web sites as starting points for further Internet searches:

- (1) Bugs and Drugs on the Web (<http://www.antibioticresistance.org.uk>). This site provides the most complete list of cross-links to other Web resources for AMR.
- (2) Alliance for the Prudent Use of Antibiotics (<http://www.tufts.edu/med/apua/index.html>). This site provides information to consumers, clinicians, and researchers. Statistics, expert opinion, recommendations, and policy papers are given. A 68-page “Internet Guide on Antimicrobial Resistance” has recently been added.
- (3) Canadian Committee on Antibiotic Resistance (<http://www.ccar-ccra.com>). This site provides a rich selection of programs, news, and research reports.

Three Web sites (for the Alliance for the Prudent Use of Antibiotics, Canadian Committee on Antibiotic Resistance, and the World Health Organization) offer material in languages other than English. The Antibiotic Resistance Links Web site, sponsored by Stanford University (Stanford, CA), presents an extensive directory of AMR-related resources on the Web, although without any additional material.

Web sites with information for patients and laypersons. Misconceptions about AMR-related issues are common among the general public. For instance, in the Programme for International Student Assessment study, which assessed knowledge and skills attained by 265,000 adolescents in 32 countries, a question asked whether the use of antibiotics may lead to antibiotic resistance; only 59% of students answered this question correctly [3].

The time-consuming process of explaining AMR-related issues to the patient may be shortened by the use of informative Web sites shown in table 2, which offer tools and material to increase patient comprehension and adherence to nonantibiotic treatment. Table 5 lists additional Web sites with educational material for patients and the general public. We found the Alliance for the Prudent Use of Antibiotics and Centers for Disease Control and Prevention Web sites to be the most user-friendly for lay persons, scientifically correct, and concise among the countless Web sites available. The Federal Drug

Administration Center for Veterinary Medicine Web site offers a downloadable 9-min video explaining how AMR emerges and proliferates (<http://www.fda.gov/cvm/antiresistvideo.htm>).

The second part of table 2 focuses on lay information about methicillin-resistant *Staphylococcus aureus* (MRSA). All of these Web sites are understandable by lay persons, but they vary in terms of the quality of the information provided. We recommend the MRSA Watch Web site and the Centers for Disease Control and Prevention Web site as “starters” for patients attempting to obtain objective information about health care-related or community-associated MRSA. Two Web sites offer chat rooms and links to patient “victim” groups (MRSA Resources; MRSA Support), but both sites lack objective information. For those interested in MRSA infections in pet animals, the site <http://pets-mrsa.com> provides some astonishing anecdotal accounts.

Web sites covering multinational AMR surveillance programs. Table 3 shows a compilation of Web sites covering multinational AMR surveillance programs. Three Web sites (the World Health Organization, Meropenem Yearly Susceptibility Test Information Collection, and Alexander network Web sites) offer interactive modules to generate customized resistance reports. These Web sites have also data on AMR in low- and middle-income countries, but updates are mostly lacking. All Centers for Disease Control and Prevention–sponsored Web sites offer reliable and objective AMR surveillance data, although the Intensive Care Antimicrobial Resistance Epidemiology Web site gives only limited access to primary data. Of interest, certain global surveillance studies do not offer Internet access (e.g., SENTRY Antimicrobial Surveillance Program) or are accessible only through registration (e.g., the PROTEKT Network). Several professional societies offer interesting AMR surveillance data for specific European regions (e.g., Paul-Ehrlich-Gesellschaft for Central Europe [<http://www.p-e-g.org/econtext/>], British Society for Antimicrobial Chemotherapy for the United Kingdom and Ireland [<http://www.bsacsurv.org>], and the French National Observatory for Epidemiology of Bacterial Resistance for France [<http://www.onerba.org>]).

Readers should bear in mind that several surveillance programs are sponsored entirely by the pharmaceutical industry and may be influenced by marketing agendas. An editorial pointed out that “some of these websites are a combination of fact, data, and opinion” [4, p. 125]. Although government-driven programs may be less biased, they may be more heterogeneous in their laboratory methods (e.g., breakpoints). All Web-based surveillance databases offer only aggregate data that may be prone to different biases [5]. Therefore, these surveillance databases are of little practical value for clinicians who are looking for decision support to optimize antibiotic treatment in individual patients.

Web sites with information on prevention of nosocomial AMR. Table 4 lists 2 types of Web sites that may help to control the spread of health care–associated AMR.

Table 1. Comprehensive Web sites with information on all aspects of antimicrobial resistance–related issues.

Site (sponsor or organization)	URL	Ease of navigation	Practical information for clinicians	Epidemiological data	News section	Material to download	Material in multiple languages	Links to other Web sites
Alliance for the Prudent Use of Antibiotics (Tufts University)	http://www.tufts.edu/med/apua/home.html	Excellent	Yes	Yes	Yes	Yes	Yes	Yes
Bugs and Drugs on the Web (National Electronic Library of Infection)	http://www.antibioticresistance.org.uk	Excellent	Yes	No	Yes	Yes	No	Yes
Action on Antibiotic Resistance (React)	http://www.react-group.org	Excellent	No	Yes	Yes	Yes	No	Yes
CCAR (Canadian Committee on Antibiotic Resistance)	http://www.ccar-ccra.com	Average	Yes	Yes	Yes	Yes	Yes	Yes
Drug Resistance (World Health Organization)	http://www.who.int/drugresistance/en/	Average	No	Yes	No	Yes	Yes	No
Antibiotic Resistance (US Food and Drug Administration)	http://www.fda.gov/oc/opacom/hottopics/anti_resist.html	Average	No	No	Yes	Yes	No	Yes
Antibiotic Resistance Links (Stanford University)	http://www.stanford.edu/~dgurney/research/AntibioticResistanceLinks.html	Average	No	No	No	No	No	Yes

Table 2. Patient and consumer information about antimicrobial resistance in general and methicillin-resistant *Staphylococcus aureus* (MRSA).

Site (sponsor or organization)	URL	Design and ease of navigation	Amount and scope of information	Question and answer section	Teaching material	Materials in multiple languages	Links to other Web sites	Quality
General information								
Alliance for the Prudent Use of Antibiotics (Tufts University)	http://www.tufts.edu/med/apua/Patients/patient.html	Excellent	Large	Yes	Yes	Yes	Yes	Excellent
The Bug Investigators (National Health Service)	http://www.buginvestigators.co.uk	Excellent	Large	No	Yes	No	No	Excellent
Antibiotic Resistance (American Academy of Family Physicians)	http://familydoctor.org/659.xml	Excellent	Limited	Yes	No	Yes	Yes	Good
Why Files on Antimicrobial Resistance (University of Wisconsin)	http://whyfiles.org/038badbugs/index.html	Excellent	Large	Yes	No	No	Yes	Good
Campaign to End Antibiotic Overuse (Keep Antibiotics Working group)	http://www.keepantibioticsworking.org	Excellent	Limited (focused on agriculture)	Yes	No	No	Yes	Good
Consumer Education: Antibiotic Resistance (US Food and Drug Administration)	http://www.fda.gov/cder/consumerinfo/antibiotics_text.htm	Average	Large	Yes	Yes	Yes	Yes	Good
MRSA-specific information								
MRSA Watch (Dave Roberts)	http://tahilla.typepad.com/mrsawatch/	Excellent	Large	No	No	No	Yes	Excellent
MRSA Information for the Public (Centers for Disease Control and Prevention)	http://www.cdc.gov/ncidod/dhqp/ar_mrsa_ca_public.html	Excellent	Limited (focused on community MRSA)	Yes	No	No	Yes	Excellent
MRSA Resources (WebRing)	http://www.mrsaresources.com/	Excellent	Large	Yes	Yes	No	Yes	Variable
MRSA infection (unknown sponsor)	http://www.mrsainfection.org/	Excellent	Large	Yes	Yes	No	Yes	Variable
MRSASUPPORT (MRSA support group)	http://www.mrsasupport.co.uk/	Average	Limited	No	No	No	Yes	Variable

Table 3. Current antimicrobial resistance surveillance programs.

Site (sponsor or organization)	URL	Yearly update of resistance data	Region	Surveillance scheme	Indicator bacteria under surveillance	Access to surveillance data	Online access to publications	Comments
Academia/government-driven programs								
European Antimicrobial Resistance Surveillance System (European Commission)	http://www.rivm.nl/earss	Yes	Europe	Community and nosocomial	7	Yes	Yes	Most comprehensive Web site on AMR surveillance in Europe
Active Bacterial Core surveillance (CDC)	http://www.cdc.gov/ncidod/dbmd/abcs/	Yes	United States	Community	5	Yes	Yes	Most helpful database on AMR surveillance of respiratory pathogens in the United States
National Antimicrobial Resistance Monitoring System (CDC and FDA)	http://www.cdc.gov/narms	Yes	United States	Community	5	Yes	Yes	Most helpful database on AMR surveillance of enteric bacteria in the United States
Intensive Care Antimicrobial Resistance Epidemiology (under the auspices of CDC)	http://www.sph.emory.edu/ICARE/index.php	No	United States	Nosocomial	Variable	No	Yes	Yearly summary report published in <i>American Journal of Infection Control</i>
Asian Network for Surveillance of Resistant Pathogens (ARFID)	http://www.ansorp.org	Yes	Asia	Community	Variable	No	Yes	Most helpful, independent AMR surveillance system of respiratory and enteric pathogens in Asia
Antimicrobial Resistance Info Bank (WHO)	http://rhone.b3e.jussieu.fr/arinfobank/	No	Worldwide	Community and nosocomial	Variable	Yes	No	Helpful for finding AMR data in low- and middle-income countries
Industry-supported programs and sites								
Meropenem Yearly Susceptibility Test Information Collection (AstraZeneca)	http://www.mystic-data.org/	Yes	Worldwide	Community and nosocomial	34	Yes	No	Extensive amount of AMR data. Navigation time-consuming
Alexander Network (GlaxoSmithKline)	http://www.alexandernetwork.com	No	Worldwide	Community and nosocomial	Mainly respiratory pathogens	Yes	Yes	Permits longitudinal analyses of AMR trends in 54 countries
LIBRA (Bayer)	http://www.librainitiative.com	No	Worldwide	Community and nosocomial	Variable	Yes	Yes	Susceptibility testing methods not standardized; limited usefulness

NOTE. AMR, antimicrobial resistance; CDC, Centers for Disease Control and Prevention; FDA, US Food and Drug Administration; WHO, World Health Organization.

Table 4. Prevention of antimicrobial resistance in the health care facilities.

Site (sponsor or organization)	URL	Educational material	Slides	Guidelines	Software	Multilanguage	Comments
Comprehensive sites							
Drug Resistance (CDC)	http://www.cdc.gov/drugresistance/healthcare/default.htm	Yes	Yes	Yes	No	No	Very informative
Division of Healthcare Quality Promotion (CDC)	http://www.cdc.gov/ncidod/dhqp/index.html	Yes	Yes	Yes	No	No	Very informative
Association for Professionals in Infection Control and Epidemiology (APIC)	http://www.apic.org	Yes	Yes	Yes	No	No	Very useful, offering many educational tools
National Resource for Infection Control (United Kingdom)	http://www.nric.org.uk	Yes	No	Yes	No	No	Recently launched, single-access point for resources on infection control
Global Safety Challenge (WHO)	http://www.who.int/patientsafety/challenge/en/	Yes	No	Yes	No	Yes	Contains new WHO guidelines on hand hygiene
Hospital Infection Society (United Kingdom)	http://www.his.org.uk	Yes	No	No	No	No	Rich resource library with many guidelines
Other sites							
Infection Control Service (Kingston General Hospital, Canada)	http://www.path.queensu.ca/ic/	Yes	Yes	Yes	No	No	Userfriendly and comprehensive
Center for Interdisciplinary Research on AMR (Columbia University)	http://cumc.columbia.edu/dept/nursing/CIRAR/index.html	Yes	Yes	No	No	No	Recently opened site, focused on interdisciplinary research
Antimicrobial Resistance Prevention Initiative (ASM/SHEA)	http://www.icaac.org/arpi.htm	No	Yes	No	No	No	Up-to-date CME course with excellent slide presentations
Antibiotic resistance control and prevention (European Commission)	http://www.abdn.ac.uk/arpac/index	No	Yes	Yes	No	Yes	Contains useful slide shows
BALTICCARE (International Federation of Infection Control and Baltic Network for Infection Control)	http://www.balticcare.org/Links.htm	Yes	Yes	Yes	Yes	No	Useful links to many Internet-based tools
Hospital in Europe Link for Infection Control through Surveillance (European Commission)	http://helics.univ-lyon1.fr/helicshome.htm	No	No	Yes	Yes	No	HELICS surveillance software available after free registration

NOTE. AMR, antimicrobial resistance; ASM, American Society of Microbiology; CDC, Centers for Disease Control and Prevention; CME, continuing medical education; SHEA, Society of Healthcare Epidemiology of America; WHO, World Health Organization.

Table 5. Web sites with information on control of antimicrobial resistance in the community.

Site (sponsor or organization)	URL	Country/state
Get Smart (Centers for Disease Control and Prevention)	http://www.cdc.gov/drugresistance/community	United States
Do Bugs need Drugs? (Health Canada)	http://www.dobugsneeddrugs.org/	Canada
Antibiotiques (Belgian Campaign for More Appropriate Use of Antibiotics)	http://www.antibiotiques.org/	Belgium
WARN (Wisconsin Antibiotic Resistance Network)	http://www.warnwisconsin.org/	Wisconsin
Antimicrobial Resistance Information (Arizona Department of Health Services)	http://www.azdhs.gov/phs/oids/abx/public_info.htm	Arizona
Alliance Working for Antibiotic Resistance Education (California Medical Association)	http://www.aware.md	California
AWARE (Oregon Alliance Working for Antibiotic Resistance Education)	http://oregon.gov/DHS/ph/antibiotics/index.shtml	Oregon
Reducing Antibiotics for Children in Massachusetts (Agency for Healthcare Research and Quality)	http://www.reachmass.org	Massachusetts

- (1) Comprehensive Web sites, which cover a wide range of information and guidelines to help in the prevention of AMR in health care facilities. Most informative are the 2 Centers for Disease Control and Prevention Web sites and the Association for Practitioners in Infection Control Web site.
- (2) Web sites providing practical tools to implement a prevention program, such as posters, door stickers, pocket cards, and recommendations. Two Web sites also provide access to software for hospital epidemiology, with computer-assisted data collection tools (e.g., the Hospital in Europe Link for Infection Control through Surveillance [European Commission] network and the International Federation of Infection Control and Baltic Network for Infection Control network).

The Web sites of the National Resource for Infection Control (United Kingdom) and the Infection Control Service of Kingston General Hospital (Canada) are particularly helpful starting points for Web searches on infection control resources. Regarding up-to-date information on hand hygiene issues, we recommend the Global Safety Challenge site of the World Health Organization. Finally, for comprehensive information about control of nosocomial outbreaks, the Outbreak Worldwide Database site (<http://www.outbreak-database.com>) provides a systematic review and worldwide database of published reports.

Web sites with information on control of AMR in the community. Several countries have recently taken the bold step of launching campaigns to educate physicians and patients about antibiotic misuse and the threat of drug resistance. These campaigns show promise in changing attitudes and behavior, both among the public and among health care professionals [6].

Table 5 lists user-friendly Web sites that may be of interest to those who try to obtain information about these campaigns and counter measures to control AMR in the community. All

of the listed organizations have created well-organized Web sites with downloadable material for educational campaigns and high-quality material for parents, teachers, and clinicians in several languages (including tutorials, fact sheets, slide presentations, guidelines, and games). Probably the most diverse and comprehensive materials are offered by the Get Smart (Centers for Disease Control and Prevention) and Do Bugs need Drugs (Health Canada) sites.

CONCLUSIONS

Two decades after the World Wide Web concept was designed by scientists at the European Organization for Nuclear Research (CERN; Geneva, Switzerland), the Internet has become a rich source of information on AMR. We compiled a selection of Web sites that seem to be most useful as starting points for interested physicians, epidemiologists, or patients.

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