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World Wide Web Resources on Antimicrobial Resistance

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Advances of modern technology, including the development of the Internet and the World Wide Web, have given clinicians and researches the opportunity to have immediate access to continuously updated information in various scientific fields. We compiled a list of World Wide Web resources of data from surveillance studies on antimicrobial resistance that may be useful to practitioners—especially infectious diseases specialists—as well as to scientists with a research interest in the field of antimicrobial resistance.

The growing problem of antimicrobial resistance has become a significant public health concern worldwide [1] and it involves practically all types of pathogens, including viruses, bacteria, mycobacteria, fungi, and parasites. Previous studies have shown the impact of antimicrobial resistance on various outcomes, including mortality, morbidity, and cost and length of hospitalization [2, 3]. The Infectious Diseases Society of America and the European Society of Clinical Microbiology and Infectious Diseases have recently published their concerns regarding the considerable proportion of clinical isolates that are resistant to most antimicrobial agents [4, 5]. Among the various clinically important bacteria, *Staphylococcus aureus, Streptococcus pneumoniae, Enterococcus* species, *Acinetobacter* species, *Pseudomonas* species, and *Klebsiella* species represent major pathogens associated with a high incidence of infection that are resistant to treatment with antibiotics of many antimicrobial classes [6–10].

When practicing medicine during this era of easy international travel, and because transfer of patients between hospitals in different countries is not rare, the clinician and especially the infectious diseases specialist should have easily available epidemiological data regarding antimicrobial resistance. In addition, investigators studying various aspects of the problem of antimicrobial resistance also benefit enormously from the availability of such data. Thus, both clinicians and investigators benefit by knowing the proportion of clinical isolates that are resistant to various antimicrobial agents in their community, hospital, area, country, and continent, as well as around the globe, because the cross-continental travel of both humans and goods causes the spread of antibiotic-resistant bacteria from one country to another.

Modern technology, including the development of the Internet and the World Wide Web, has made possible the collection and update of ongoing surveillance antimicrobial resistance data from various sources [11]. In this article, we listed a number of World Wide Web addresses of major international networks that present data regarding resistance to commonly used antimicrobial therapeutic agents. As a useful guidance tool to practitioners and researchers, we also sought to compile a list of major networks' Web pages/sites that provide valuable links to additional information that is relevant to the problem of antimicrobial resistance.

METHODS

We gathered information on the relevant World Wide Web resources by making use of Internet search engines (Google, AltaVista, and Yahoo). We used as key words the abbreviated names of major antimicrobial surveillance systems/projects (e.g., Meropenem Yearly Susceptibility Test Information Collection [MYSTIC], Global Synercid Microbiologic Assessment of Resistance Trends [GSMART], SENTRY, PROTEKT, National Nosocomial Infection Surveillance [NNIS], Victorian Nosocomial Infection Surveillance System [VICNISS], and International Network for the Study and Prevention of Emerging Antimicrobial Resistance [INSPEAR]). We also performed searches of the PubMed database, Current Contents, and the World Wide Web for information on additional relevant sources by using the following key words: "resistance," "antimicrobial resistance," "surveillance," "network," "program," and "pro-

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Table 1. Summary of the Web sites for major international networks and of sites that present data on antimicrobial resistance.

Title/subject	Web address	Contents/objective	Source or sponsor
Antimicrobial Resistance Information Bank	http://rhone.b3e.jussieu.fr/arinfobank/	Central Web page for the Antimicrobial Resistance Information Bank	WHO
Antimicrobial resistance data	http://rhone.b3e.jussieu.fr/arinfobank/ResistanceDataSearch.php	Only resistance data from published documents included; the Web site focuses on a limited number of bacterial species and antimicrobial agents	WHO
Drug resistance	http://www.who.int/drugresistance/en/	Information on malaria, tuberculosis, and HIV/AIDS	WHO
The European Antimicrobial Resistance Surveillance System	http://www.rivm.nl/earss/	Information on *Escherichia coli, Enterococcus faecalis, Enterococcus faecium, Klebsiella pneumoniae, Pseudomonas aeruginosa, Staphylococcus aureus,* and *Streptococcus pneumoniae*	EARSS
Meropenem Yearly Susceptibility Test Information Collection database[a]	http://www.mystic-data.org/	Interactive database providing resistance data and statistics on several bacteria regarding several antimicrobial agents since 1997	AIM
Infectious Disease Surveillance: Surveillance Resources Links	http://www.cdc.gov/ncidod/osr/site/surv_resources/data_reports.htm	Available infectious disease surveillance data and reports provided by the name of surveillance system, by the common disease name, and by the disease topic	CDC
Infectious Disease Surveillance: Emerging Infections Programs	http://www.cdc.gov/ncidod/osr/site/eip/sites.htm	Emerging infections programs in the United States	CDC
Antimicrobial Resistance in Health Care Settings	http://www.cdc.gov/ncidod/dhqp/ar.html	Data on drug-resistant organisms, prevention and control, campaigns, and laboratory practices	CDC
NARMS (National Antimicrobial Resistance Monitoring System): Enteric Bacteria	http://www.cdc.gov/narms/	NARMS highlights and annual reports	CDC for NARMS
NARMS	http://www.fda.gov/cvm/narms_pg.html	NARMS data, presentations, and publications	FDA for NARMS
Project ICARE (Intensive Care Antimicrobial Resistance Epidemiology) publications	http://www.sph.emory.edu/ICARE/publications.php	Published data on antimicrobial resistance in the healthcare system generated from Project ICARE	RSPH
European Network for Antimicrobial Resistance and Epidemiology	http://www.enare.org/publications.html	Peer-reviewed publications about resistance by ENARE members since 2003	Eijkman-Winkler Institute for Medical Microbiology, University Hospital Utrecht
The Alexander Network	http://www.alexandernetwork.com/DesktopDefault.aspx	Local and regional data from surveillance studies conducted on >150 different pathogens in 54 countries.	The Alexander Network
Network on Antibiotic Resistance in *Staphylococcus aureus*	http://www.narsa.net/content/default.jsp	Web site on *S. aureus*	NIH and NIAID
Reservoirs Of Antibiotic Resistance	http://www.roarproject.org/	ROAR publications available; registration required for database access	APUA
Antimicrobial Resistance Surveillance and Control in the Mediterranean Region	http://www.slh.gov.mt/armed/default1.asp	*E. coli, E. faecalis, E. faecium, K. pneumoniae, P. aeruginosa, S. aureus,* and *S. pneumoniae*	ARMed Project; St. Luke's Hospital, Malta
European Surveillance of Antibiotic Consumption	http://www.esac.ua.ac.be/main.aspx?c=*ESAC2&n=21600	Interesting interactive database on antibiotic use in European countries, among other things	DG/SANCO
European Surveillance of Antimicrobial Resistance	http://www.esbic.de/esbic/ind_esar.htm	Overall results of resistance tests; has not been updated since 1999	ESCMID
Pneumococcal Disease in Europe	http://www.ktl.fi/pnceuro/	Study of *S. pneumoniae* in 4 European countries	The Finnish National Public Health Institute
Hospital in Europe, Link for Infection Control through Surveillance	http://helics.univ-lyon1.fr/helicshome.htm	Online final reports on resistance in intensive care unit settings and for surgical site infections	IPSE
Annual Report of the Monitoring/Surveillance Network for Resistance to Antibiotics 2003	http://www.paho.org/english/ad/dpc/cd/amr-lima-2004.htm	Annual report for 2003, as well as links to Web sites on prevention and control of communicable diseases	PAHO, WHO
Resistance Surveillance Website	http://www.bsacsurv.org/	Data on antimicrobial resistance for respiratory tract infections and bacteremia	BSAC[b]
ProMED-mail	http://www.promedmail.org/pls/promed/f?p=2400:1000	The global electronic reporting system for outbreaks of emerging infectious diseases and toxins; open to all sources	ISID

NOTE. AIM, Academy for Infection Management; APUA, Alliance for the Prudent use of Antibiotics; ARMed, Antimicrobial Resistance Surveillance and Control in the Mediterranean Region; BSAC, British Society for Antimicrobial Chemotherapy; CDC, Centers for Disease Control and Prevention; DG/SANCO, Directorate-General, Health and Consumer Protection, European Commission; EARSS, European Antimicrobial Resistance Surveillance System; ESCMID, European Society of Clinical Microbiology and Infectious Diseases; FDA, US Food and Drug Administration; IPSE, Improving Patient Safety in Europe (supported by the European Union DG/SANCO); ISID, International Society for Infectious Diseases; NARMS, National Antimicrobial Resistance Monitoring System; NIAID, National Institute of Allergy and Infectious Diseases; NIH, National Institute of Health; PAHO, Pan American Health Association; ROAR, Reservoirs Of Antibiotic Resistance; RSPH, Rollins School of Public Health of Emory University; WHO, World Health Organization

[a] Data are from 100 centers worldwide.

[b] Data are from the United Kingdom and Ireland.

Table 2. Summary of the Web pages for major networks and of sites that provide valuable Web links on antimicrobial resistance.

Title/subject	Web address	Contents/objective	Source or sponsor
Antibiotic/antimicrobial resistance–related links	http://www.cdc.gov/drugresistance/links.htm	Extensive list of links on antimicrobial resistance from US and international sources	CDC
Infectious disease surveillance and surveillance resource quick links	http://www.cdc.gov/ncidod/osr/site/surv_resources/quick-links.htm	Links to available published data on surveillance/resistance in alphabetical order	CDC
Links provided by the Antimicrobial Resistance Information Bank	http://rhone.b3e.jussieu.fr/arinfobank/links.php	Links to the Web sites of international surveillance associations	WHO
National/international networks on antimicrobial resistance	http://www.rivm.nl/earss/links/	Provides links to national and international networks Web pages on antibiotic resistance.	RIVM
Antibiotic resistance archives	http://www.antibioresistance.be/Links.html	Provides links to Web pages on antibiotic resistance; at the time of our search, some were inaccessible	Belgian Service of Biosafety and Biotechnology
Antimicrobial resistance	http://www.hpa.org.uk/infections/topics_az/antimicrobial_resistance/menu.htm	Data on related topics and links	HPA
SSAC links	http://www.srga.org/SSAC/links/links.html	Links to Scandinavian organizations and other international organizations that study the antimicrobial resistance.	SSAC
Communicable diseases surveillance–related links	http://www.health.gov.au/internet/wcms/publishing.nsf/Content/cda-cdilinks.htm-copy2	Links to the Web sites of Australian and international organizations and associations studying antimicrobial resistance	Australian government, Department of Health and Aging
Antibiotic resistance resources	http://www.antibiotic.ru/en/ar/links.shtml	Links to Web pages on antibiotic resistance; at the time of our search, some of these were inaccessible	Institute of Antimicrobial Chemotherapy and Department of Clinical Pharmacology, Smolensk State Medical Academy
Antimicrobial resistance	http://www.idlinks.com/antimicrobial_resistance.htm	Links to Web pages on antibiotic resistance; at the time of our search, some of these were inaccessible	IDLINKS
Antimicrobial resistance	http://www.geis.fhp.osd.mil/GEIS/SurveillanceActivities/AntimicrobialResistance/antimicrobialRes.asp	Mostly links on published documents on antimicrobial resistance	DoD-GEIS

NOTE. CDC, Centers for Disease Control and Prevention; DoD-GEIS, US Department of Defence-Global Emerging Infections System; HPA, Health Protection Agency (United Kingdom); IDLINKS, Infectious Diseases Links; RIVM, The Dutch Institute for Public Health and the Environment; SSAC, Scandinavian Society for Antimicrobial Chemotherapy; WHO, World Health Organization.

ject." In addition, we reviewed the information provided in the initially identified sources to find additional World Wide Web links that contained data relevant to antimicrobial resistance.

We chose to include in our lists dependable English-language Web pages, which we categorized into 2 groups: those that presented antimicrobial resistance data from major international networks, and those that provided links to other international surveillance organizations/associations that study antimicrobial resistance. Regarding the first group of Web pages, those that were finally presented in our assessment were selected from a very extensive catalogue on the basis of the following criteria: they provided international surveillance data (i.e., >2 countries were involved), they provided comprehensive and evidence-based information, and it was easy to access that information. In the second group, we included link-providing Web pages from the Web sites that, to our knowledge, are frequently visited by experts on infection.

Although we managed, through our gathering strategy, to review most of the major international networks' Web sites/pages, it is inevitable that some were overlooked. For some others, we decided that they did not fulfill the criteria to be included.

RESULTS

In table 1, we list 23 Web pages/sites for 18 major international networks that present data on antimicrobial resistance, either as interactive databases or in reports from international antimicrobial resistance surveillance systems. We accessed each of the Web addresses and verified that they contain data from surveillance studies of antimicrobial resistance.

In table 2, we list 11 major networks' Web pages/sites that provided numerous valuable links to the Web sites for international organizations/associations that conduct research on antimicrobial resistance and/or suggest guidelines for infection control and for prudent use of antibiotics. We accessed each of the links included in this table and verified that they contain information relevant to the field of antimicrobial resistance.

DISCUSSION

The goal of our effort was to provide to clinicians and investigators immediate access to a collection of World Wide Web resources that include updated information regarding the antimicrobial resistance patterns of clinical isolates from patients of various parts of the world. We acknowledge that the lists we present are far from exhaustive. Rather, they should be regarded as a subset of relevant World Wide Web resources that include readily available information on antimicrobial resistance.

We need to highlight the significance of the numerous national antimicrobial resistance surveillance projects that are monitoring the resistance patterns of clinical isolates recovered from patients within the borders of each country. The investigators involved in some of these projects report their national data in scientific publications. In addition, a minority of data related to these efforts are included in regional Web sites. Although inclusion of the Web sites for the various national antimicrobial surveillance networks for each country would be valuable, it was considered to be out of the scope of this project.

We believe that efforts directed toward continuous updates of information in databases that report the findings of surveillance studies of antimicrobial resistance should be encouraged and financially supported. The toll of infections due to multidrug-resistant pathogens is too high for us to ignore the significance of various types of studies of antimicrobial resistance.

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