

*The National Antimicrobial
Resistance Monitoring
System (NARMS)*



*Strategic Plan
2012-2016*

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Background

Foodborne diseases are an important cause of morbidity and mortality worldwide. Distribution of contaminated food, travel, and migration contribute to the problem of foodborne diseases. Non-typhoidal *Salmonella* and *Campylobacter* are the leading bacterial causes of foodborne illness in the United States and many other countries. Each year these two pathogens alone cause over 2.5 million cases of illness in the U.S., resulting in tens of thousands of hospitalizations and hundreds of deaths. Certain populations, such as young children (<5 years), the elderly, and the immunocompromised, are at higher risk for infection. Most *Salmonella* and *Campylobacter* infections are self-limited, but antimicrobial agents are essential to treat severe illness. Data also show that resistant pathogens can cause more severe or prolonged illness. Resistance has also emerged in foodborne commensal bacteria, such as *Enterococcus* and *Escherichia coli*, which may serve as reservoirs of resistance genes for pathogens of public health importance. Antimicrobial resistance among bacterial foodborne pathogens is a global public health hazard.

The National Antimicrobial Resistance Monitoring System (NARMS), established in 1996, is a collaboration among the U.S. Food and Drug Administration (FDA), the U.S. Centers for Disease Control and Prevention (CDC), the U.S. Department of Agriculture (USDA), and state and local health departments. NARMS monitors antimicrobial susceptibility in enteric bacteria from humans, retail meats and food-producing animals. The human isolate component of NARMS started in 1996, testing non-Typhi *Salmonella* and *Escherichia coli* O157 isolates. In 1997, testing of *Campylobacter* began, followed by *Salmonella* serotype Typhi and *Shigella* in 1999. The animal component of NARMS started in 1997 with monitoring of *Salmonella* isolated from chicken, turkey, cattle, and swine carcasses, and later expanded to include *Campylobacter* (1998), *E. coli* (2000), and *Enterococcus* (2003) isolated from chicken carcasses. The retail meat component of NARMS started in 2002 with testing of *Salmonella*, *Campylobacter*, *E. coli*, and *Enterococcus* isolates from chicken, ground turkey, pork, and ground beef sold in retail stores.

In addition to monitoring, NARMS conducts epidemiologic and microbiologic research studies. Some studies examine risk factors and clinical outcomes of infections with specific bacterial serotypes or subsets of bacteria that exhibit particular resistance patterns. Microbiological research studies focus on understanding the genetic mechanisms of antimicrobial resistance in enteric bacteria and the mechanisms that permit the transfer of resistance between bacteria, on improving methods for isolation and typing, and on developing new methods for antimicrobial susceptibility testing. Additionally, NARMS examines enteric bacteria for genetic interrelatedness using methods such as pulsed-field gel electrophoresis (PFGE) and multilocus sequence typing (MLST). NARMS scientists enter PFGE results into CDC's PulseNet database or USDA's VetNet database.

In March 2007, an External Subcommittee of the Science Board to the FDA conducted a review of the NARMS program. This subcommittee made recommendations related to

four areas of work performed by NARMS: 1) sampling, 2) research, 3) international activities, and 4) data management and reporting. Included in the report was a recommendation to develop long-range strategic plans. In September 2008, NARMS held an interagency planning meeting in Athens, Georgia to prioritize the Science Board subcommittee recommendations and implement measures to address them. In August 2009, a second meeting was held in Rockville, Maryland to report on progress, and to begin formulating a Strategic Plan. Subsequent public meetings in Atlanta (2010) and St. Louis (2011) were held to seek stakeholder input on program priorities.

Mission

Food-producing animals and their products are known sources of antimicrobial-resistant infections in humans.

NARMS is a national public health surveillance program that monitors the susceptibility of enteric bacteria to antimicrobial agents of medical importance in order to help assess the impact of veterinary antimicrobial use on human health.

To accomplish its mission, NARMS conducts the following activities:

1. Monitors trends in antimicrobial resistance among enteric bacteria from humans, retail meats, and animals
2. Disseminates timely information on antimicrobial resistance in pathogenic and commensal organisms to stakeholders in the U.S. and abroad to promote interventions that reduce resistance among foodborne bacteria
3. Conducts research to better understand the emergence, persistence, and spread of antimicrobial resistance
4. Provides data that assist the FDA in making decisions related to the approval of safe and effective antimicrobial drugs for animals

Overview of Accomplishments, 1996-2011

From 1996-2011, major accomplishments of NARMS include:

1. Documented and communicated antimicrobial resistance prevalence data on more than 56,000 clinical isolates from humans, 110,000 isolates from food-producing animals, and enteric bacteria isolated from over 40,000 retail meat samples.
2. Published annual reports on surveillance findings for each NARMS component.
3. Published annual NARMS Executive Reports since 2003 to communicate findings to stakeholders and the public. These summarize NARMS data for human, retail meat, and food-producing animal isolates.
4. Improved testing methods to better ensure quality control of results and to facilitate testing. For example, NARMS scientists developed the first standardized *in vitro* antimicrobial susceptibility testing method for *Campylobacter*, and incorporated it into the NARMS protocol.
5. Collected and communicated data on risk factors, clinical outcomes, and genetic mechanisms of antimicrobial resistance to the scientific community through publication of peer-reviewed research manuscripts in scientific journals and presentations at scientific meetings.
6. Provided data for FDA policy and regulatory actions related to the use of fluoroquinolones in poultry and the extra-label use of cephalosporins in food-producing animals
7. Facilitated international research collaborations on foodborne disease and assisted Mexico (ResistVet), Canada (CIPARS), China, Colombia (COIPARS), and other countries in building surveillance programs for antimicrobial-resistant foodborne pathogens.
8. In partnership with the World Health Organization (WHO), participated in the development of guidance documents and engaged in capacity-building exercises to enhance laboratory-based surveillance of foodborne diseases, antimicrobial resistance, and outbreak detection and response in many countries.
9. Used PFGE and other genetic tests to assist in national outbreak investigations and source attribution studies
10. Presented NARMS data to the Clinical and Laboratory Standards Institute (CLSI) to help revise interpretive criteria for fluoroquinolones and macrolides
11. Since 2004, tested over 1,000 isolates from ill humans and contaminated foods associated with outbreaks of enteric disease in the United States to understand better the sources of antimicrobial-resistant infections in humans and to aid in outbreak investigations

Strategic Goals and Objectives

NARMS has established four strategic goals listed in order of importance. These goals build on progress made since NARMS began, with special emphasis on the recommendations made by the FDA Science Board subcommittee review in 2007.

Goal 1: Develop a sampling strategy that is more representative of food animal production and consumption and more applicable to trend analysis

Sound sampling strategies are vital to the success of any monitoring program. In NARMS, each sampling point along the farm-to-fork continuum presents its own set of advantages and disadvantages. Current NARMS sampling leverages pre-existing public health and food safety surveillance programs at one or more of these sampling points, however, these programs do not meet all of NARMS needs. Improving and expanding sampling schemes so that the data will best reflect U.S. food-producing animal production, distribution and consumption is a top priority for NARMS.

Objective 1.1: Improve the geographic representativeness of retail meat testing and increase the total number of retail meat isolates recovered in order to better assess trends

Objective 1.2: Modify animal slaughter sampling to establish a statistically designed scheme that allows an unbiased national estimate of resistance prevalence in target organisms

Objective 1.3: Conduct pilot studies to collect animal drug use and resistance data on-farm to assess the feasibility of a pre-harvest sampling approach for NARMS in dairy and feedlot cattle, poultry, and swine

Goal 2: Optimize data acquisition, analysis, and reporting

Optimizing data acquisition, analysis, and reporting requires the development of advanced information technology tools that will: 1) merge specified data from different sample sources; 2) ensure data integrity; 3) enhance and automate reporting functions; 4) provide controlled export of specified data for use with other software programs; 5) provide advanced data mining and analysis capabilities; and 6) provide for continuous improvements and future capacity, including increased accessibility of data in various forms to stakeholders and the public.

Objective 2.1: Develop and launch an integrated database that will allow data sharing among NARMS partners and stakeholders in a secure environment, and provide tools for efficient exploration and analysis of data across sample sources

Objective 2.2: Develop a web-based program that facilitates data collection from public health sites

Objective 2.3: Publish annual surveillance reports within the calendar year following isolate collection

Objective 2.4: Link NARMS data across existing foodborne disease surveillance and drug use databases in order to facilitate the understanding of trends in foodborne disease and antimicrobial resistance

Goal 3: Strengthen collaborative research projects

Research is a vital component of the NARMS program. Microbiological studies can answer specific questions about the relatedness of isolates and their genes from humans and foods. Laboratory research is needed to evaluate and develop new testing and analytical methods, to catalogue and characterize the genes causing resistance and the genetic elements that carry them, and to investigate bacterial features associated with the spread of resistant organisms in the food supply. Epidemiologic research is needed to help estimate the burden of illness due to resistant foodborne pathogens, to identify risk factors for acquiring resistant infections, to assess the clinical outcomes of resistant infections, and to help measure the impact of interventions designed to limit the spread of resistance.

Objective 3.1: Conduct *ad hoc* studies to estimate the prevalence of resistant microbial hazards in various food products relevant to public health in order to better assess risks to consumers

Objective 3.2: Evaluate and apply existing research tools, and develop new ones, to enhance surveillance of antimicrobial-resistant bacteria

Objective 3.3: Conduct crosscutting epidemiologic studies focused on the attribution of antimicrobial-resistant enteric infections to foods, food animal and other sources, including the analysis of bacterial isolates from outbreaks.

Objective 3.4: Seek out new partnerships within and outside of government to leverage resources dedicated to microbial food safety and help prevent the development, persistence, and transmission of antimicrobial resistance

Goal 4: Collaborate with international institutions that promote food safety, especially those focused on mitigating the spread of antimicrobial-resistant bacteria

Foodborne disease and antimicrobial resistance are international health issues that require global solutions. The worldwide trade in food-producing animals and food products has greatly increased over the last decade and will continue to grow. Likewise, antimicrobial resistance in pathogens found in food-producing animals and food products is an international problem. U.S. consumers become infected with antimicrobial-resistant pathogens both when they travel abroad and when they consume contaminated imported food.

Since its inception, NARMS has collaborated with other countries to help build laboratory capacity for foodborne disease surveillance, including surveillance in developing countries. Strengthening global surveillance for antimicrobial-resistant pathogens in the food chain is an important step in preventing and mitigating the emergence and international spread of antimicrobial resistant bacteria.

Objective 4.1: Support the WHO Advisory Group for Integrated Surveillance of Antimicrobial Resistance (WHO-AGISAR), the WHO Global Foodborne Infections Network (GFN), the World Organization for Animal Health (OIE), and the Trans-Atlantic Task Force on Antimicrobial Resistance to help build international capacity and cooperation for the surveillance of foodborne disease and antimicrobial resistance

Objective 4.2: Work more closely with international partners to harmonize antimicrobial resistance testing and reporting, and to facilitate data sharing

Objective 4.3: Foster international research collaborations, special regional studies, and national pilot projects to characterize unique and common elements in the epidemiology of antimicrobial-resistant foodborne pathogens in different countries.

Challenges and Opportunities

Institutional challenges include financial resource limitations, competing food safety priorities, human resources limitations, information technology and security constraints, and limitations on laboratory resources needed to investigate evolving scientific issues in a timely manner.

Food safety is a priority for public health. This provides an incentive for interagency collaborations that can address important aspects of food and feed safety issues pertinent to antimicrobial resistance, and may make possible the expansion of NARMS monitoring and the fulfillment of NARMS strategic goals.

Similar trends can be seen in the global arena; there is a growing consensus that food safety is best addressed through global partnerships such as WHO-GFN, WHO-AGISAR, and others. NARMS will continue to work closely with WHO, with other antimicrobial resistance surveillance programs, and with food safety and public health authorities abroad, to harmonize testing and reporting methods to facilitate data sharing and communication with international partners and stakeholders.

Conclusion

The *NARMS Strategic Plan* is a dynamic roadmap that outlines the program's commitment to sustained food safety through antimicrobial resistance monitoring, research, and international collaborations. The NARMS program is critical to accomplishing the public health mission of the U.S. Department of Health and Human Services and ultimately in protecting the health of Americans through safer food. NARMS will continue to provide reliable information that is vital to protecting and promoting public health.

Links to Additional Information

Additional information about NARMS, including comprehensive annual reports for each NARMS component, can be found on the FDA, CDC, and USDA websites listed below. The FDA website also includes NARMS Executive Reports.

FDA: <http://www.fda.gov/AnimalVeterinary/SafetyHealth/AntimicrobialResistance/NationalAntimicrobialResistanceMonitoringSystem/default.htm>

CDC: <http://www.cdc.gov/narms>

USDA: <http://ars.usda.gov/Main/docs.htm?docid=6750>