

# MICROBIOLOGY



-- 3rd Party Material

## ANTIBIOTIC RESISTANCE: REVIEW OF THE SERIOUS THREATS

CONTACT HOURS: 2  
COURSE LEVEL: Intermediate  
CE BROKER #: 20-853716



-- COURSES ARE REVIEWED EVERY 2 YEARS --

### 4CEUINC By Continuing Education Unlimited

6231 PGA Blvd / Suite 104, #306 / Palm Beach Gardens, FL 33418  
888-423-8462 / General Fax: 561-775-4933 / Email: Lab@4ceuinc.com / www.4CEUINC.com

# COURSE OBJECTIVES

At the end of this course you will be able to:

- 1.) List the current serious antibiotic resistant threats.
- 2.) Recall important information you need to know about each organism, such as how it's spread, who may be at risk, etc.
- 3.) Recall the resistance profile over time for each organism.

**DISCLAIMER:** The reading material portion of this document is part of the Public Domain and remains free of charge and available at <https://www.cdc.gov/drugresistance/pdf/threats-report/2019-ar-threats-report-508.pdf>. If you purchase this course from 4CEUINC you are paying only for the Contact Hours & associated processing that's provided by 4CEUINC.

## RIGHTSHOLDER:

**Author:** CDC

**Copyright:** © 2019, Last Updates March 2, 2021

## PERMISSIONS

Permissions are not needed for **Public Domain** articles unless there is copyrighted artwork.

## ARTICLE REPRODUCTION

No permission is needed to reproduce or distribute this type of Public Domain content, as it is in the public domain. It is requested, however, that if this content is to be reproduced or distributed, the authoring institute or agency be given appropriate acknowledgement.

Occasionally, copyrighted material (such as a figure, table, or block of text), may appear in a U.S. government publication in Bookshelf. In these cases, a special copyright statement such as "Reprinted with permission from..." will accompany the material.

Access a copy of the original document at:  
<https://www.cdc.gov/drugresistance/pdf/threats-report/2019-ar-threats-report-508.pdf> .

## QUIZZES

- ✓ Unlimited quizzes may be photocopied for learning purposes when completing this course.

## CEUINC PROVIDER INFO:

LABORATORY & PHLEBOTOMY

CA Department of Health:	0001
Florida Board of Clinical Lab:	50-2256
ASCLS P.A.C.E.®	511

**LABORATORY:** Our courses are accepted by all States and Certification Agencies.

**PHLEBOTOMY:** Most licensing bodies accept P.A.C.E. credits. Please check with them directly for acceptance of our course credits.

## OTHER PROFESSIONS

CE Broker:	50-2256
------------	---------

We have multiple Florida providerships at [www.CEBroker.com](http://www.CEBroker.com).

Please search for #50-2256 under Providers for a full list of professions and course titles.

## IMPORTANT NOTE:

Do NOT Forward Certificates to the Florida Board Unless Requested  
CEU Certificates Must Be Retained for a Minimum of 4 Years in Florida



# Continuing Education Unlimited

6231 PGA Blvd, Suite 104 / #306 / Palm Beach Gardens, FL 33418  
Phone: 888-423-8462 / Fax: 561-775-4933 / Web: [www.4CEUINC.com](http://www.4CEUINC.com) / Email: [Lab@4ceuinc.com](mailto:Lab@4ceuinc.com)

Thanks for choosing 4CEUINC for your continuing education needs! We strive to offer you current course material at the most cost-effective price. If you have comments or suggestions, be sure to add them to your evaluation – we appreciate them. If you like our courses pass them on to a coworker or friend.

## GENERAL COURSE INFORMATION

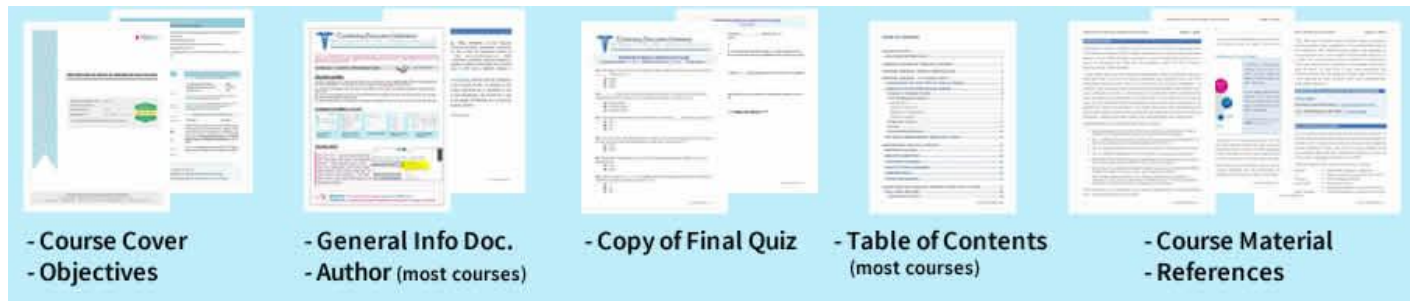


Last Revised 12/08/20

### ONLINE COURSE:

- 1.) When completing your course, you can read the course material online, OR you can download the PDF file to read offline. Per copyright law, you're entitled to print one copy of each PDF file.
- 2.) Quizzes can be printed out if you'd like to work offline while you're reading. Once you're done, simply transfer your answers to the online quiz for grading.
- 3.) Once you have passed your online quiz, you will be asked to take a course evaluation immediately afterward OR by visiting your "Course History" link at any time. You must complete the evaluation before you can print your certificate.
- 4.) After the evaluation, the link changes to "print" so you can print your Certificate of Completion now or at a later date.

### COURSE DOCUMENT LAYOUT:



### ONLINE LINKS:

**IMPORTANT:** Some links inside the PDF files may not open in a separate window. The easiest way to view links is to right click on the link, then select either "open link in new tab" or "open link in new window". This will allow you to view the information in a separate window.



**WEBSITE:** You can find us online at [www.4CEUINC.com](http://www.4CEUINC.com)

**COMPANY:** Continuing Education Unlimited is the parent company of 4CEUINC



# Continuing Education Unlimited

6231 PGA Blvd, Suite 104 / #306 / Palm Beach Gardens, FL 33418  
Phone: 888-423-8462 / Fax: 561-775-4933 / Web: [www.4CEUINC.com](http://www.4CEUINC.com) / Email: [Lab@4ceuinc.com](mailto:Lab@4ceuinc.com)

## FREQUENTLY ASKED QUESTIONS



Last Revised 06/01/21

### Q. Your phones are often busy, how can I reach you?

**A.** Because we have a small staff, the most efficient way would be to fill out a "Contact Us" form. On the main menu at [www.4CEUINC.com](http://www.4CEUINC.com), go to 'Support', 'Contact Us', then fill out the form. Be sure to enter your full information.

### Q. I ordered a Printed Answer Sheet, may I complete the quiz online?

**A. YES**, quizzes from all course formats can be completed online, just log into your profile and go to "My Courses".  
**PLEASE NOTE:** As of April 2019, all quizzes must be completed online, even if you ordered a printed book.

### Q. I need my certificate dated on a certain day how can I be sure that this will happen?

**A.** 1.) If submitting Answer Sheets via fax, allow adequate processing time, taking into consideration weekends and holidays when we are not in the office. 2.) Complete the quiz online, which gets graded and recorded immediately.

### Q. What score is considered passing?

**A.** A score of 70% or higher is considered a passing grade. In the event that you do not pass on your first attempt, you are allowed to take the quiz again.

### Q. Does your company allow me to fax my Answer Sheet to your office?

**A. YES**, you may fax your answer sheet to **561-775-4948**. You **must** include a cover sheet with your full name, license number & telephone number. Keep a record of the time & date you send the fax in the event that there is a problem!

### Q. May I share my Combo Course or Textbook with others?

**A. YES**, Combo Courses and Textbooks can be shared. One person will buy the "complete course" package & each additional person will purchase an "online quiz only". Remember to share **BOTH** the reading material **and** the quiz.

### Q. Do you mail my certificate of completion after I fax my Answer Sheets?

**A. No**, due to ongoing mail delivery issues, we no longer mail certificates. You can print your certificate at any time by visiting your online "Course History" list.

### Q. May I print out an online course?

**A. YES**, you may print **1 copy** of an online course. Copyright laws do not allow more than one copy to be printed!

### Q. Where can I find additional information out about a course?

**A.** Basic course information is located on the course cover. Additional information is located on the 2<sup>nd</sup> page of each course.

### Q. What are your most popular courses?

**A.** Currently our most popular courses remain the Laboratory Subscription and our Combo Courses.

### Q. Does 4CEUINC offer group discounts or group packages?

**A. YES.** We require at least 5 participants and a person to act as the educational coordinator for the group. Discounted pricing depends on the number of participants and the package chosen. Please call 561-775-4944 Ext. 4 for details.

### Q. Does 4CEUINC report to CE Broker for Florida licensees?

**A. YES.** Once you complete the online quiz, your course completions are sent to CE Broker immediately, provided that you have your correct Florida license number listed in your profile at the time of course completion.



**ALERT:** When faxing your Answer Sheets, add a cover sheet with your Full Name, License # (if applicable), and phone #. Make a note of the date and time you faxed them! This will safeguard you in the event that your answer sheet does not reach its destination.



## FINAL QUIZ: ANTIBIOTIC RESISTANCE - REVIEW OF THE SERIOUS THREATS

CE Broker Provider #: 50-2256 | CE Broker Course ID: 20-853716 | Contact Hours: 2

- 1.) Campylobacter spreads to people through raw or undercooked chicken, unpasteurized milk, contaminated food and water, and through direct contact with animals. ([Review Pg. 3](#))
  - A. True
  - B. False
  
- 2.) Many clinical laboratories do not have the capacity to test Candida for drug resistance, limiting the ability to guide treatment and track resistance. ([Review Pg. 6](#))
  - A. True
  - B. False
  
- 3.) About \_\_\_\_\_ of patients with ESBL-producing Enterobacteriaceae infections had no known underlying health conditions. ([Review Pg. 7](#))
  - A. two-thirds
  - B. one-half
  - C. one-quarter
  
- 4.) Patients at high risk for VRE infections include those who are undergoing complex or prolonged healthcare stays, or patients with weakened immune systems. ([Review Pg. 10](#))
  - A. True
  - B. False
  
- 5.) Multi-drug resistant (MDR) Pseudomonas is particularly dangerous for patients with chronic lung diseases. ([Review Pg. 11](#))
  - A. True
  - B. False
  
- 6.) Looking at the resistance snapshot, \_\_\_\_ of all non-typhoidal Salmonella are resistant to at least one essential antibiotic. ([Review Pg. 14](#))
  - A. 5%
  - B. 16%
  - C. 25%

## FINAL QUIZ: ANTIBIOTIC RESISTANCE - REVIEW OF THE SERIOUS THREATS

- Quiz Page 2 -

- 7.) Most people in the United States become infected with drug-resistant *Salmonella* Serotype Typhi while traveling to countries where the disease is common. ([Review Pg. 15](#))
- A. True
  - B. False
- 8.) Ciprofloxacin resistant *Shigella* is estimated to affect \_\_\_ per 100,000 U.S. population. ([Review Pg. 18](#))
- A. 2
  - B. 10
  - C. 30
- 9.) People who inject drugs are \_\_\_ times more likely to develop a serious MRSA infection than those who do not. ([Review Pg. 19](#))
- A. 5
  - B. 12
  - C. 16
- 10.) Pneumococcal conjugate vaccine (PCV) has reduced pneumococcal infections caused by vaccine strains by more than \_\_\_ in children. ([Review Pg. 22](#))
- A. 20%
  - B. 65%
  - C. 90%
- 11.) MDR TB is resistant to three first-line antibiotics. ([Review Pg. 23](#))
- A. True
  - B. False

**\*\*\*\*END OF QUIZ\*\*\*\***



# List of All Threats

## Urgent Threats

- Carbapenem-resistant *Acinetobacter*
- *Candida auris*
- *Clostridioides difficile*
- Carbapenem-resistant Enterobacteriaceae
- Drug-resistant *Neisseria gonorrhoeae*

## Serious Threats

- Drug-resistant *Campylobacter*
- Drug-resistant *Candida*
- ESBL-producing Enterobacteriaceae
- Vancomycin-resistant *Enterococci*
- Multidrug-resistant *Pseudomonas aeruginosa*
- Drug-resistant nontyphoidal *Salmonella*
- Drug-resistant *Salmonella* serotype Typhi
- Drug-resistant *Shigella*
- Methicillin-resistant *Staphylococcus aureus*
- Drug-resistant *Streptococcus pneumoniae*
- Drug-resistant Tuberculosis

## Concerning Threats

- Erythromycin-resistant group A *Streptococcus*
- Clindamycin-resistant group B *Streptococcus*

## Watch List

- Azole-resistant *Aspergillus fumigatus*
- Drug-resistant *Mycoplasma genitalium*
- Drug-resistant *Bordetella pertussis*



# Serious Threats

These organisms are public health threats that require prompt and sustained action:



DRUG-RESISTANT  
**CAMPYLOBACTER**



DRUG-RESISTANT  
**CANDIDA**



ESBL-PRODUCING  
**ENTEROBACTERIACEAE**



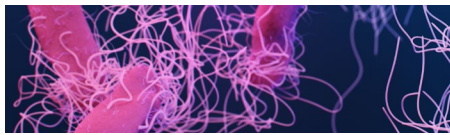
VANCOMYCIN-RESISTANT  
**ENTEROCOCCI**



MULTIDRUG-RESISTANT  
**PSEUDOMONAS AERUGINOSA**



DRUG-RESISTANT  
**NONTYPHOIDAL SALMONELLA**



DRUG-RESISTANT  
**SALMONELLA SEROTYPE TYPHI**



DRUG-RESISTANT  
**SHIGELLA**



METHICILLIN-RESISTANT  
**STAPHYLOCOCCUS AUREUS**



DRUG-RESISTANT  
**STREPTOCOCCUS PNEUMONIAE**



DRUG-RESISTANT  
**TUBERCULOSIS**



# DRUG-RESISTANT **CAMPYLOBACTER**

THREAT LEVEL **SERIOUS**



**448,400**  
Estimated  
infections  
each year



**70**  
Estimated  
deaths  
each year

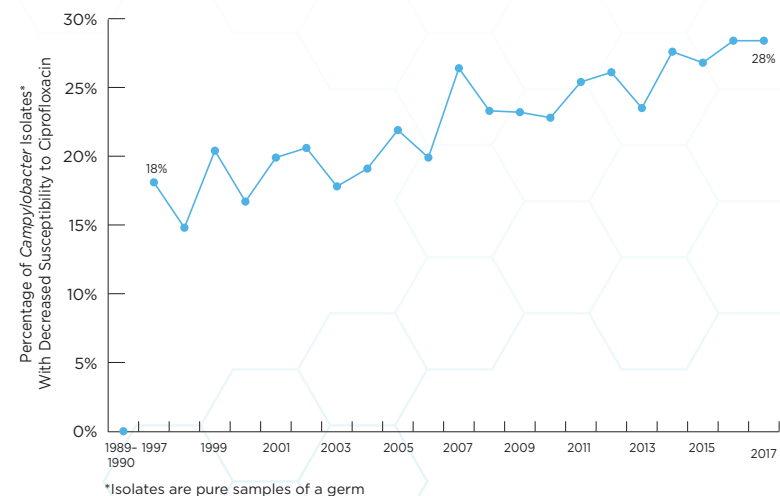
*Campylobacter* are bacteria that usually cause diarrhea (often bloody), fever, abdominal cramps, and sometimes complications such as irritable bowel syndrome, temporary paralysis, and arthritis.

## WHAT YOU NEED TO KNOW

- *Campylobacter* causes an estimated 1.5 million infections and \$270 million in direct medical costs every year. Of those infections, 29% have decreased susceptibility to fluoroquinolones (e.g., ciprofloxacin) or macrolides (e.g., azithromycin), the antibiotics used to treat severe *Campylobacter* infections.
- *Campylobacter* spreads to people through raw or undercooked chicken, unpasteurized milk, contaminated food and water, and through direct contact with animals.
- *Campylobacter* infections with decreased susceptibility are more common in low- and middle-income countries, putting travelers at risk for infections that may be harder to treat.

## RESISTANCE OVER TIME

The percentage of *Campylobacter* with decreased susceptibility to ciprofloxacin has almost doubled in 20 years, limiting treatment options for patients.



Annual national testing began in 1997. Data for 1989-1990 from a sentinel county survey.



U.S. Department of  
Health and Human Services  
Centers for Disease  
Control and Prevention

## PUPPIES MADE PEOPLE SICK

How could an adorable puppy cause her owner to have a month-long hospital stay, including multiple stays in the intensive care unit? That is what happened to Mike, a 67-year-old retired professor with an existing chronic disease. Within a week of bringing home puppy Mabel from a pet store, Mike experienced diarrhea, fatigue, and lower back pain. The pain became excruciating and he was hospitalized with failing kidneys.



Mike was one of 113 people across 17 states identified as part of an outbreak of multidrug-resistant *Campylobacter* infections linked to pet store puppies. Only one type of antibiotic was able to treat his resistant infection. Due to complications from this infection and his chronic disease, he needed surgery to remove a dead section of stomach. Three months later, Mike finally felt well enough to return to post-retirement work at a bookstore. He still enjoys his pup, but is careful to wash his hands when cleaning up after her.

## RESISTANCE SNAPSHOT

As decreased susceptibility in *Campylobacter* increases, the antibiotic options for those who need treatment could disappear.



PERCENTAGE OF *CAMPYLOBACTER*\*



ESTIMATED NUMBER OF INFECTIONS PER YEAR

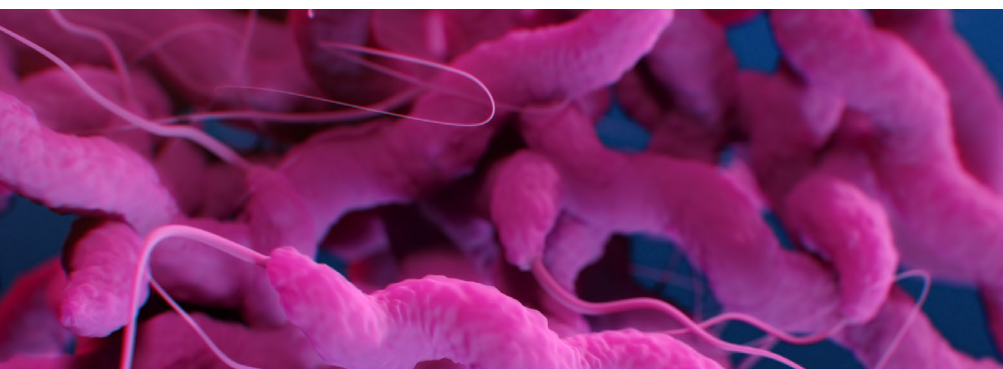


ESTIMATED INFECTIONS PER 100,000 U.S. POPULATION

	PERCENTAGE OF <i>CAMPYLOBACTER</i> *	ESTIMATED NUMBER OF INFECTIONS PER YEAR	ESTIMATED INFECTIONS PER 100,000 U.S. POPULATION
DECREASED SUSCEPTIBILITY TO CIPROFLOXACIN	28%	429,600	130
DECREASED SUSCEPTIBILITY TO AZITHROMYCIN	4%	55,600	20
DECREASED SUSCEPTIBILITY TO CIPROFLOXACIN <b>OR</b> AZITHROMYCIN	29%	448,400	140
DECREASED SUSCEPTIBILITY TO CIPROFLOXACIN <b>AND</b> AZITHROMYCIN	2%	36,800	10

Antibiotic susceptibility helps describe how sensitive germs are to particular antibiotics. An antibiotic can stop the growth of or kill a susceptible germ.

\*Average (2015–2017), includes *Campylobacter jejuni* and *Campylobacter coli*.



## ONLINE RESOURCES

### About *Campylobacter*

[www.cdc.gov/campylobacter](http://www.cdc.gov/campylobacter)

### NARMSNow: Human Data, *Campylobacter* Resistance

[wwwn.cdc.gov/NARMSNow](http://wwwn.cdc.gov/NARMSNow)

# DRUG-RESISTANT **CANDIDA SPECIES**

THREAT LEVEL **SERIOUS**



**34,800**

Estimated cases  
in hospitalized  
patients in 2017



**1,700**

Estimated  
deaths in  
2017

Dozens of *Candida* species—a group of fungi—cause infections, ranging from mild oral and vaginal yeast infections to severe invasive infections. Many are resistant to the antifungals used to treat them.

## WHAT YOU NEED TO KNOW

- Only three classes of antifungal drugs are available to treat severe *Candida* infections: azoles, echinocandins, and amphotericin B.
- *Candida* species commonly cause bloodstream infections in hospitalized patients. About one in four of these patients die.
- *Candida* species also cause common yeast infections, which can affect the mouth, skin, and vagina, resulting in more than 3.6 million U.S. healthcare visits each year, and \$3 billion estimated direct medical costs.
- Antibiotics used to treat bacterial infections increase the risk of *Candida* infections.

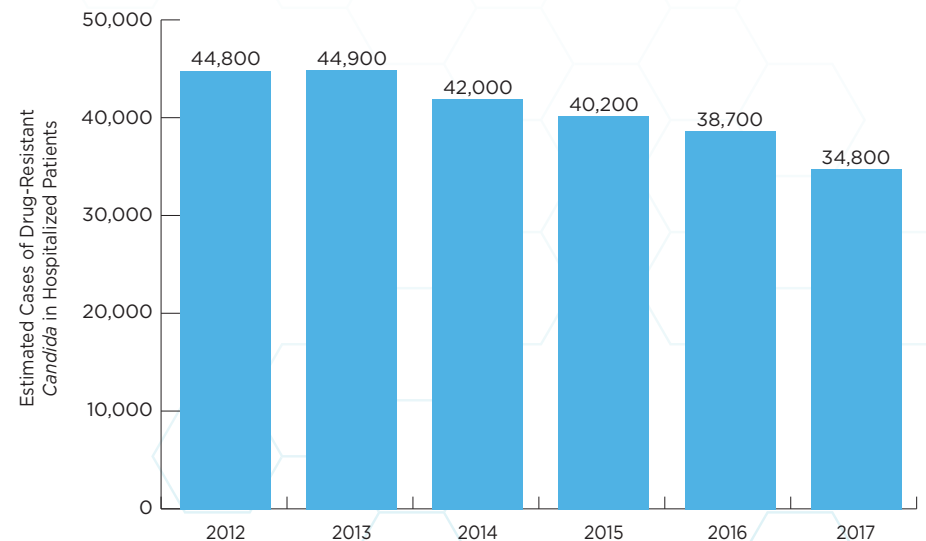
All data represented excludes *C. auris*.



**U.S. Department of  
Health and Human Services**  
Centers for Disease  
Control and Prevention

## CASES OVER TIME

Resistant *Candida* are commonly detected in hospitalized patients. About 7% of bloodstream infections are resistant to antifungals.





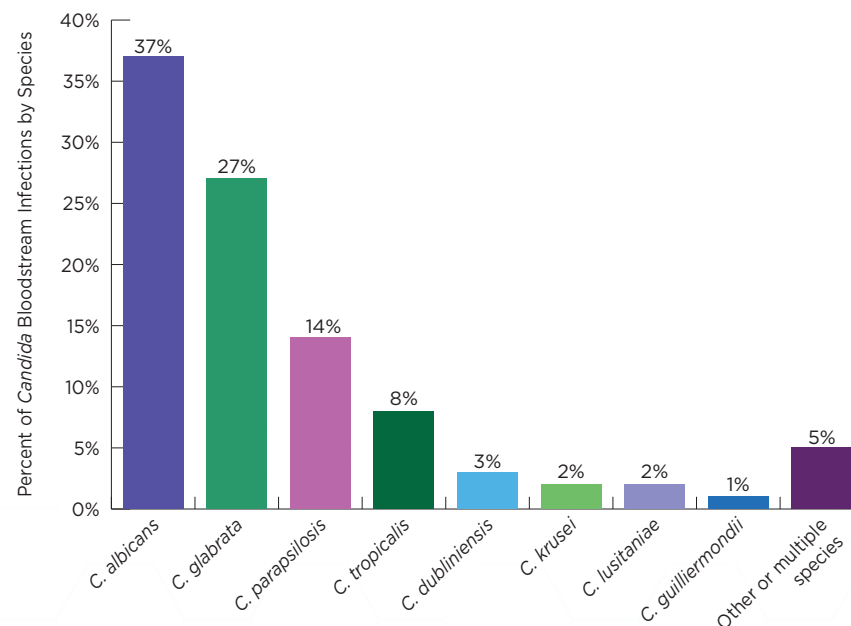
## DIFFICULT TO DETECT THREAT

*Candida* species are well known for causing infections in our mouth, skin, and vagina, but these germs are also a common cause of life-threatening bloodstream infections in hospitals. Most *Candida* infections in people are caused by *Candida albicans*, which has very low levels of drug resistance. However, other types of *Candida*, including *Candida glabrata*, are frequently resistant and more deadly.

Many clinical laboratories do not have the capacity to test *Candida* for drug resistance, limiting the ability to guide treatment and track resistance. Additionally, new, highly resistant species, such as *Candida auris*, are emerging and can also be difficult to identify. CDC's Antibiotic Resistance Laboratory Network helps clinical labs across the United States identify emerging *Candida* species and test for antifungal resistance. This helps lab professionals and healthcare providers rapidly and correctly identify the threat and stop its spread.

## BLOODSTREAM INFECTIONS

*Candida* species are a common cause of bloodstream infections and can be drug resistant and difficult to treat.



## ONLINE RESOURCES

### About *Candida* infections

[www.cdc.gov/fungal/diseases/candidiasis/index.html](http://www.cdc.gov/fungal/diseases/candidiasis/index.html)

### About antifungal resistance

[www.cdc.gov/fungal/antifungal-resistance.html](http://www.cdc.gov/fungal/antifungal-resistance.html)

# EXTENDED-SPECTRUM BETA-LACTAMASE (ESBL) PRODUCING ENTEROBACTERIACEAE

THREAT LEVEL **SERIOUS**



**197,400**

Estimated cases in hospitalized patients in 2017



**9,100**

Estimated deaths in 2017



**\$1.2B**

Estimated attributable healthcare costs in 2017

ESBL-producing Enterobacteriaceae (a family of different types of bacteria) are a concern in healthcare settings and the community. They can spread rapidly and cause or complicate infections in healthy people.

## WHAT YOU NEED TO KNOW

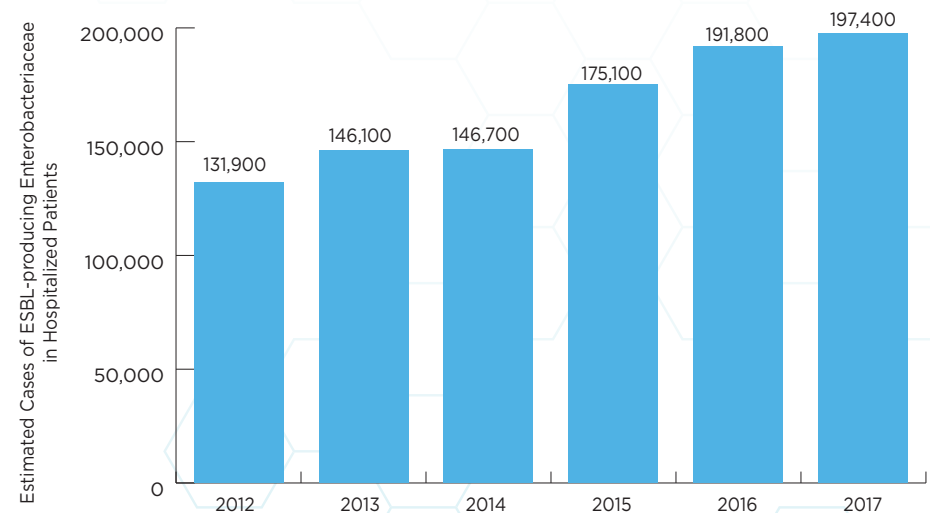
- ESBLs are enzymes that break down commonly used antibiotics, such as penicillins and cephalosporins, making them ineffective.
- ESBL-producing Enterobacteriaceae often cause infections in otherwise healthy people. About one-quarter of patients with these infections had no known underlying health conditions.
- Antibiotic options to treat ESBL-producing Enterobacteriaceae infections are limited. Healthcare providers often have to use intravenous (IV) carbapenem antibiotics to treat infections that used to be treated with oral antibiotics.



U.S. Department of  
Health and Human Services  
Centers for Disease  
Control and Prevention

## CASES OVER TIME

CDC and partners are working to assess and address why cases of ESBL-producing Enterobacteriaceae have increased since 2012.



## RESISTANCE SPREADS QUICKLY

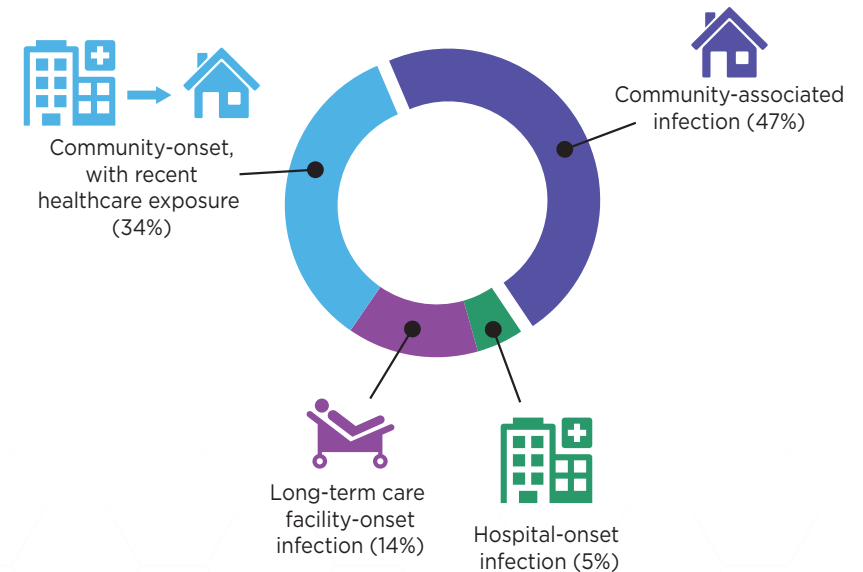
The Enterobacteriaceae family includes *Escherichia coli* (*E. coli*). Certain strains (types) of *E. coli*, such as ST131, have quickly spread in the community and among healthcare settings. These strains often cause more severe infections and spread more easily. Additionally, a particular ESBL enzyme, called CTX-M, appears to be spreading in the United States and around the world. The CTX-M enzyme can be shared through DNA (genes) between different Enterobacteriaceae species. When CTX-M and ST131 combine, they are a dangerous combination that can rapidly spread resistance.

In many cases, even common infections caused by ESBL-producing germs require more complex treatments. Instead of taking oral antibiotics at home, patients with these infections might require hospitalization and IV carbapenem antibiotics. The more we rely on carbapenem antibiotics, the greater the possibility of resistance developing to this important class of antibiotics.



## WHERE INFECTIONS CAN HAPPEN

Almost half of ESBL-producing Enterobacteriaceae infections occur in people who have not had recent inpatient healthcare exposure or an invasive medical procedure. These infections are called community-associated infections.



Data shows infections by epidemiological classification (the setting where patients most likely got the infection based on clinical information).

## ONLINE RESOURCES

About Healthcare-associated infections  
[www.cdc.gov/hai](http://www.cdc.gov/hai)

CDC Healthcare-associated Infection Guidelines and Recommendations  
[www.cdc.gov/infectioncontrol/guidelines/index.html](http://www.cdc.gov/infectioncontrol/guidelines/index.html)



# VANCOMYCIN-RESISTANT **ENTEROCOCCI** (VRE)

THREAT LEVEL **SERIOUS**



**54,500**  
Estimated cases  
in hospitalized  
patients in 2017



**5,400**  
Estimated  
deaths in 2017



**\$539M**  
Estimated attributable  
healthcare costs in 2017

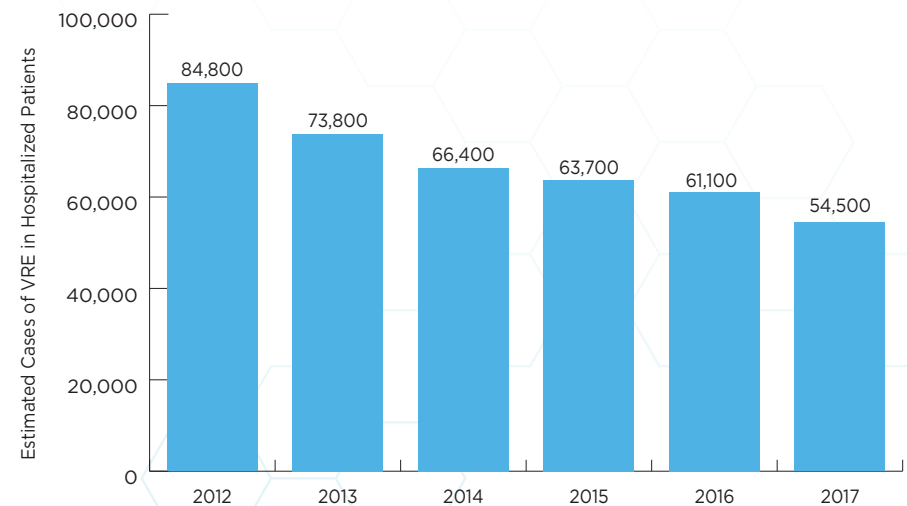
Enterococci, a type of bacteria, can cause serious infections for patients in healthcare settings, including bloodstream, surgical site, and urinary tract infections.

## WHAT YOU NEED TO KNOW

- About 30% of all healthcare-associated enterococcal infections are resistant to vancomycin, reducing treatment options.
- Nearly all VRE infections happen in patients with healthcare exposures. Risk factors for VRE infection include stays in long-term care hospitals or intensive care units (ICUs), undergoing organ transplant, or receiving treatment for certain types of cancer.
- VRE is increasingly resistant to additional antibiotics, raising concern that the remaining drugs to treat VRE may become less effective.

## CASES OVER TIME

Continued infection control and appropriate antibiotic use are important to maintain decreases in VRE infections.



**U.S. Department of  
Health and Human Services**  
Centers for Disease  
Control and Prevention

## PATIENTS AT RISK

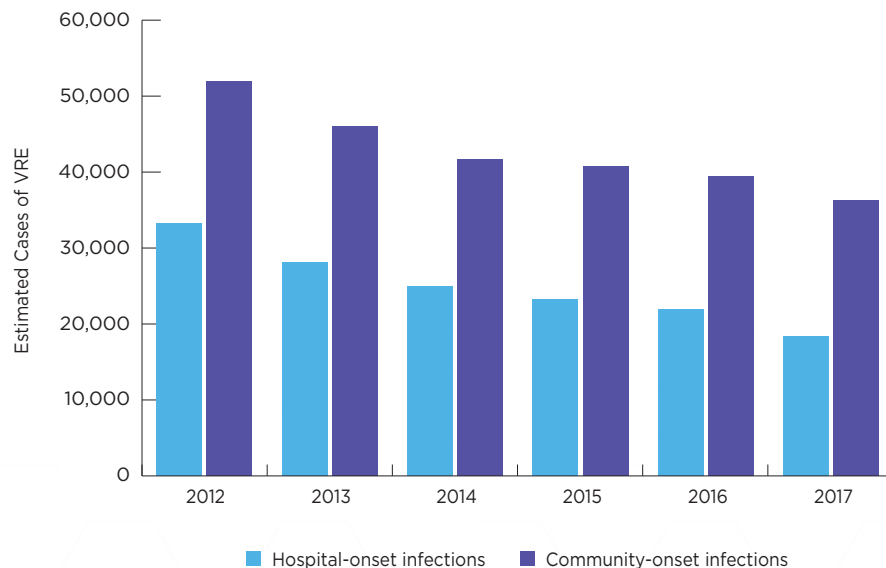
Patients at high risk for VRE infections include those who are undergoing complex or prolonged healthcare (such as patients in long-term acute care hospitals or ICUs) or patients with weakened immune systems (such as patients undergoing cancer treatment or with organ transplants).

In solid organ transplant units, one type of VRE—*Enterococcus faecium* (*E. faecium*)—is the most common cause of central line-associated bloodstream infections (CLABSIs), according to CDC’s National Healthcare Safety Network. More than 70% of these *E. faecium* are resistant to vancomycin, a mainstay for treating these infections. This makes healthcare providers reliant on other antibiotics.

Maintaining and improving infection prevention and control interventions, such as hand hygiene and surface disinfection, is critical to further reduce the number of VRE infections and protect vulnerable patient populations.

## COMMUNITY AND HOSPITAL CASES

There were significant decreases in hospital- and community-onset VRE cases—around 30,400 fewer cases in 2017 compared to 2012.



Community-onset infections include infections in patients with recent healthcare exposure and infections in people without prior healthcare exposure.



## ONLINE RESOURCES

### About VRE in Healthcare Settings

[www.cdc.gov/hai/organisms/vre/vre.html](http://www.cdc.gov/hai/organisms/vre/vre.html)

# MULTIDRUG-RESISTANT *PSEUDOMONAS AERUGINOSA*

THREAT LEVEL **SERIOUS**



**32,600**  
Estimated cases  
in hospitalized  
patients in 2017



**2,700**  
Estimated  
deaths in 2017



**\$767M**  
Estimated attributable  
healthcare costs in 2017

*Pseudomonas aeruginosa* (*P. aeruginosa*) causes many types of healthcare-associated infections, including pneumonia, bloodstream infections, urinary tract infections, and surgical site infections.

## WHAT YOU NEED TO KNOW

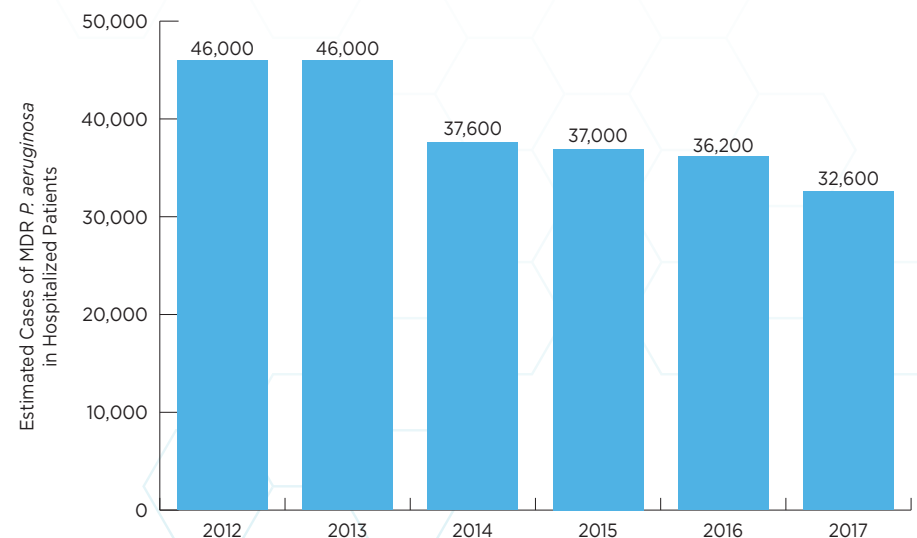
- *P. aeruginosa* infections usually occur in people in the hospital or with weakened immune systems. It is particularly dangerous for patients with chronic lung diseases.
- Some types of multidrug-resistant (MDR) *P. aeruginosa* are resistant to nearly all antibiotics, including carbapenems.
- Two to 3% of carbapenem-resistant *P. aeruginosa* carry a mobile genetic element that makes a carbapenemase enzyme. This enzyme makes carbapenem antibiotics ineffective. Mobile genetic elements are easily shared between bacteria, rapidly spreading resistance that destroys these important drugs.



U.S. Department of  
Health and Human Services  
Centers for Disease  
Control and Prevention

## CASES OVER TIME

Continued infection control and appropriate antibiotic use are important to maintain decreases in MDR *P. aeruginosa* infections.





## STOPPING SPREAD

In 2018, CDC's Antibiotic Resistance Laboratory Network identified an outbreak of carbapenem-resistant *P. aeruginosa* with an unusual form of resistance. The outbreak included more than 20 people across several states. Health departments reviewed the patients' medical histories, determining that many had undergone surgery at one hospital in Mexico. Most of the patients had surgical site infections and some required prolonged hospitalization in the United States.

CDC and partners took immediate action to implement the Containment Strategy. CDC coordinated a patient notification to U.S. health departments, Canadian and Mexican public health authorities, and the World Health Organization. Hundreds of patients were notified of their risk for possible exposure to carbapenem-resistant *P. aeruginosa*, helping to protect these patients and contain spread.



## CDC'S CONTAINMENT STRATEGY

CDC's Containment Strategy helps public health teams launch early, aggressive responses at the first sign of new or unusual resistance.



## ONLINE RESOURCES

### About *P. aeruginosa* in Healthcare Settings

[www.cdc.gov/hai/organisms/pseudomonas.html](http://www.cdc.gov/hai/organisms/pseudomonas.html)

### Tracking Resistant *P. aeruginosa* in the United States

[www.cdc.gov/hai/organisms/pseudomonas/tracking.html](http://www.cdc.gov/hai/organisms/pseudomonas/tracking.html)

# DRUG-RESISTANT NONTYPHOIDAL *SALMONELLA*

THREAT LEVEL **SERIOUS**



**212,500**  
Estimated infections  
each year



**70**  
Estimated deaths  
each year

Nontyphoidal *Salmonella* can cause diarrhea (sometimes bloody), fever, and abdominal cramps. Some infections spread to blood and can have life-threatening complications.

## WHAT YOU NEED TO KNOW

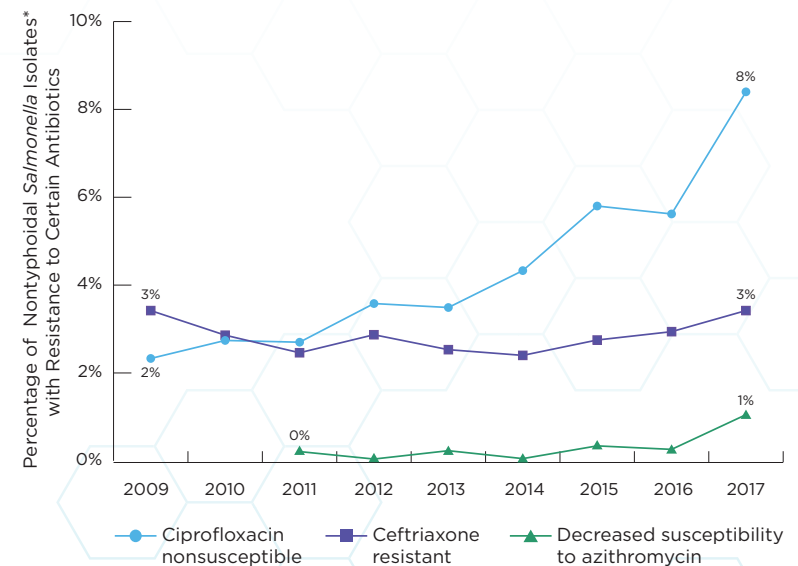
- Nontyphoidal *Salmonella* causes an estimated 1.35 million infections, 26,500 hospitalizations, and 420 deaths each year in the United States, resulting in an estimated \$400 million in direct medical costs.
- People can get *Salmonella* from eating contaminated food products or from contact with feces from infected people or animals (including touching animals or their surroundings).
- Antibiotics such as ciprofloxacin, azithromycin, and ceftriaxone are sometimes needed to treat patients with severe *Salmonella* infections. Resistant *Salmonella* infections can be more severe and have higher hospitalization rates.



U.S. Department of  
Health and Human Services  
Centers for Disease  
Control and Prevention

## RESISTANCE OVER TIME

Antibiotic-resistant nontyphoidal *Salmonella* infections are on the rise and approaching 10% for ciprofloxacin in 2017.



\*Isolates are pure samples of a germ

## RESISTANT *SALMONELLA* EMERGES IN THE FOOD CHAIN





Resistance continuously emerges. In 2014, the U.S. Food and Drug Administration (FDA) segment of the National Antimicrobial Resistance Monitoring System (NARMS) collected a chicken breast sample during routine monitoring. The sample was tested using whole genome sequencing—a lab technique that provides genetic information—and identified a multidrug-resistant strain (type) of nontyphoidal *Salmonella* serotype Infantis. This strain included an additional gene that was not common among *Salmonella* from chicken in the United States. However, the CDC segment of NARMS initially identified this strain among ill people returning from travel to South America.

This resistant strain spread rapidly. In 2018, it accounted for 25% of *Salmonella* Infantis infections in people. Most of these infected people had no travel history but had recently eaten chicken. At the same time, the U.S. Department of Agriculture (USDA) segment of NARMS increasingly identified this strain in chicken samples. This strain, along with other types of resistant *Salmonella* linked to foodborne illness from pork, turkey, and beef, leaves healthcare providers with few options to treat patients with severe infections.



## RESISTANCE SNAPSHOT

Some nontyphoidal *Salmonella* are becoming less susceptible to essential antibiotics, jeopardizing options to treat severe infections.

	  PERCENTAGE OF ALL NONTYPHOIDAL <i>SALMONELLA</i> *	 ESTIMATED NUMBER OF INFECTIONS PER YEAR	 ESTIMATED INFECTIONS PER 100,000 U.S. POPULATION
CEFTRIAXONE RESISTANCE	3%	41,000	10
CIPROFLOXACIN NONSUSCEPTIBLE	7%	89,200	30
DECREASED SUSCEPTIBILITY TO AZITHROMYCIN	0.5%	7,400	Less than 5
RESISTANT TO AT LEAST ONE ESSENTIAL ANTIBIOTIC†	16%	212,500	70
RESISTANT TO 3 OR MORE ESSENTIAL ANTIBIOTICS†	2%	20,800	10

Antibiotic susceptibility helps describe how sensitive germs are to particular antibiotics. An antibiotic can stop the growth of or kill a susceptible germ.

\*Average (2015–2017)

†Represents the following: ciprofloxacin nonsusceptible, decreased susceptibility to azithromycin, resistance to ceftriaxone, ampicillin, or trimethoprim-sulfamethoxazole.

## ONLINE RESOURCES

**NARMSNow: Human Data, *Salmonella***

[www.cdc.gov/NARMSNow](http://www.cdc.gov/NARMSNow)

**About *Salmonella***

[www.cdc.gov/salmonella](http://www.cdc.gov/salmonella)



# DRUG-RESISTANT *SALMONELLA* SEROTYPE TYPHI

THREAT LEVEL **SERIOUS**



**4,100**  
Estimated  
infections  
each year



**Less than 5**  
Estimated  
deaths  
each year

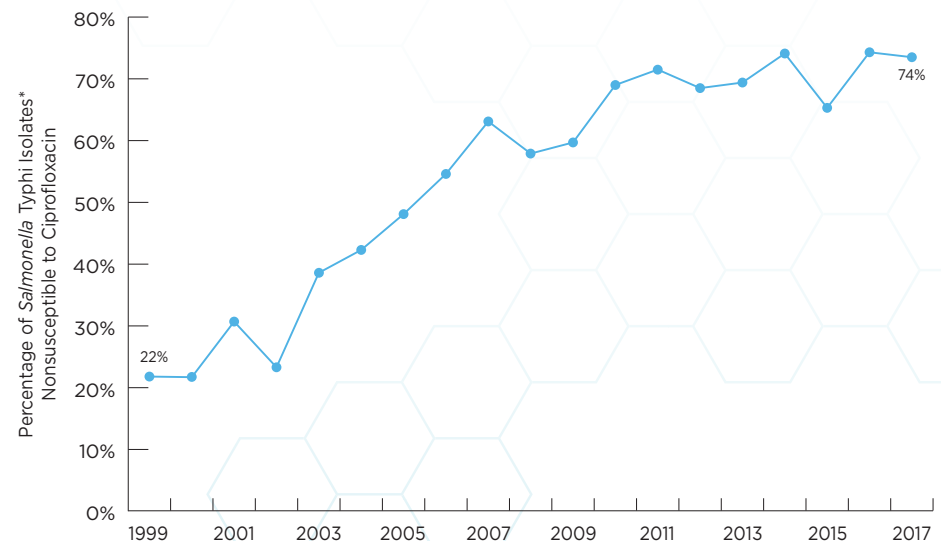
*Salmonella* Typhi bacteria cause typhoid fever, a potentially life-threatening disease. Symptoms include high fever, abdominal pain, and headache. Infection can lead to bowel rupture, shock, and death.

## WHAT YOU NEED TO KNOW

- *Salmonella* Typhi causes an estimated 5,700 infections and 620 hospitalizations each year in the United States. Worldwide, an estimated 11 to 21 million infections occur each year.
- Typhoid fever requires treatment with antibiotics, which is complicated by increasing resistance.
- Most people in the United States become infected while traveling to countries where the disease is common (places with poor sanitation and lack of safe drinking water). Vaccination before travel to countries where the disease is common may prevent typhoid fever.

## RESISTANCE OVER TIME

The percent of *Salmonella* Typhi infections nonsusceptible to ciprofloxacin reached 74% in 2017, severely limiting treatment options.



\*Isolates are pure samples of a germ



U.S. Department of  
Health and Human Services  
Centers for Disease  
Control and Prevention

## XDR TYPHOID FEVER IN TRAVELERS

Over the past decade, several strains (types) of *Salmonella* Typhi have become resistant to multiple antibiotics. One recently emerging strain of extensively drug-resistant (XDR) *Salmonella* Typhi is resistant to all but two antibiotic classes recommended for treatment (macrolides and carbapenems). Since 2016, an ongoing outbreak of XDR typhoid fever has sickened more than 5,000 people in Pakistan, and 11 children in the United States who traveled to or from Pakistan.

CDC is working with public health partners across the globe, including Pakistani health authorities, to strengthen prevention efforts, including vaccination. In the United States, healthcare providers, state and local public health officials, and scientists at CDC are closely monitoring emerging resistance among *Salmonella* Typhi strains to identify it quickly and ensure that patients get appropriate antibiotic treatment. Without improved sanitation and access to safe drinking water, this germ and its resistance will continue to pose a risk and spread. U.S. travelers should get vaccinated before going to areas where the disease is common.



## RESISTANCE SNAPSHOT

*Salmonella* Typhi strains are often nonsusceptible to ciprofloxacin, so antibiotic treatment options are diminishing.

CIPROFLOXACIN  
NONSUSCEPTIBLE



PERCENTAGE OF  
ALL *SALMONELLA* TYPHI\*

71%



ESTIMATED NUMBER OF  
INFECTIONS PER YEAR

4,100



ESTIMATED INFECTIONS  
PER 100,000  
U.S. POPULATION

Less than 5

Antibiotic susceptibility helps describe how sensitive germs are to particular antibiotics. An antibiotic can stop the growth of or kill a susceptible germ.

\*Average (2015-2017)

## ONLINE RESOURCES

### About Typhoid fever

[www.cdc.gov/Typhoid-Fever](http://www.cdc.gov/Typhoid-Fever)

### CDC's MMWR Publication on Emergence of XDR *Salmonella* Typhi Infections Among Travelers

[www.cdc.gov/MMWR/Volumes/68/wr/mm6801a3.htm](http://www.cdc.gov/MMWR/Volumes/68/wr/mm6801a3.htm)



# DRUG-RESISTANT *SHIGELLA*

THREAT LEVEL **SERIOUS**



**77,000**  
Estimated infections  
each year



**Less than 5**  
Estimated deaths  
each year

*Shigella* bacteria can cause diarrhea, fever, abdominal pain. These bacteria spread in feces through contact between people, including sexual activity, or through contaminated food, water, or surfaces.

## WHAT YOU NEED TO KNOW

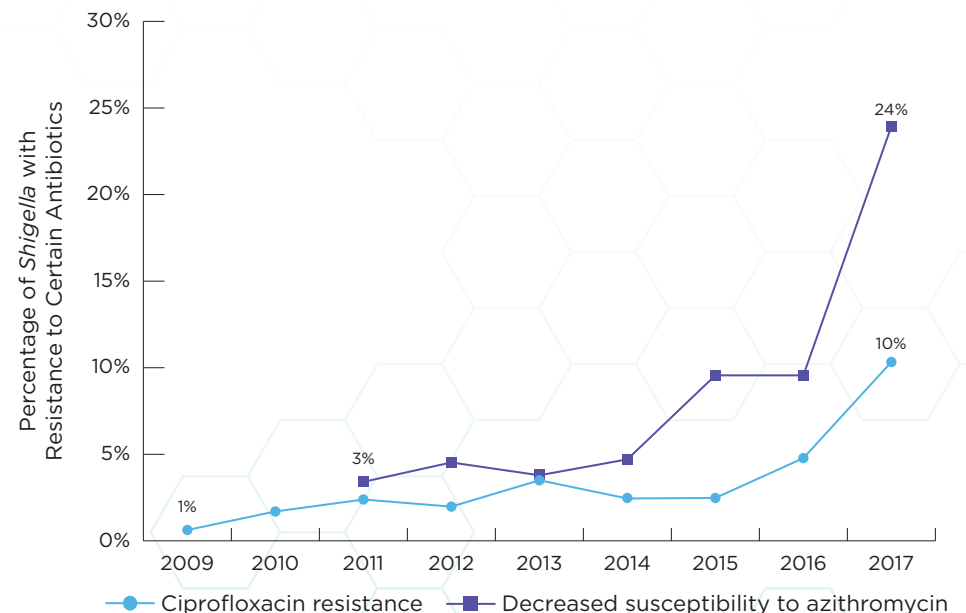
- *Shigella* causes about 450,000 infections each year, and an estimated \$93 million in direct medical costs.
- High-risk groups include young children, men who have sex with men, people with weakened immune systems, and travelers to countries with unsafe water and inadequate sanitation.
- Most *Shigella* infections resolve on their own without treatment. Antibiotics such as azithromycin and ciprofloxacin help treat patients with severe infection or weakened immune system, and reduce the spread of germs by decreasing the number of days the patient has diarrhea.



U.S. Department of  
Health and Human Services  
Centers for Disease  
Control and Prevention

## RESISTANCE OVER TIME

Resistant *Shigella* infections have increased notably since 2013.



\*Isolates are pure samples of a germ

## NEW PREVENTION EFFORTS NEEDED

*Shigella* infections have become increasingly resistant since 2013. *Shigella* is difficult to control because it spreads easily and rapidly between people, including through sexual activity. Of particular concern are frequently reported outbreaks of multidrug-resistant *Shigella* among men who have sex with men. Most *Shigella* surveillance systems do not routinely collect sexual behavior information.

Routine case investigation and follow-up strategies used for sexually transmitted diseases (STD) could be adapted to strengthen prevention efforts for *Shigella*. Public health experts can work to develop innovative strategies to control and prevent the spread of multidrug-resistant *Shigella* infections by collaborating with STD experts and engaging communities of high-risk groups, including men who have sex with men.

## RESISTANCE SNAPSHOT

Among *Shigella*, emerging resistance to important drugs threatens available treatment options.



PERCENTAGE OF ALL SHIGELLA\*



ESTIMATED NUMBER OF INFECTIONS PER YEAR



ESTIMATED INFECTIONS PER 100,000 U.S. POPULATION

	PERCENTAGE OF ALL SHIGELLA*	ESTIMATED NUMBER OF INFECTIONS PER YEAR	ESTIMATED INFECTIONS PER 100,000 U.S. POPULATION
CIPROFLOXACIN RESISTANCE	6%	26,300	10
DECREASED SUSCEPTIBILITY TO CIPROFLOXACIN	17%	74,100	20
DECREASED SUSCEPTIBILITY TO AZITHROMYCIN (DSA)	14%	64,500	20
CIPROFLOXACIN RESISTANCE <b>OR</b> DSA	17%	77,000	20
CIPROFLOXACIN RESISTANCE <b>AND</b> DSA	3%	13,900	Less than 5

Antibiotic susceptibility helps describe how sensitive germs are to particular antibiotics. An antibiotic can stop the growth of or kill a susceptible germ.

\*Average (2015–2017)



## ONLINE RESOURCES

**NARMSNow: Human Data, *Shigella***

[www.cdc.gov/NARMSNow](http://www.cdc.gov/NARMSNow)

**About *Shigella***

[www.cdc.gov/shigella](http://www.cdc.gov/shigella)

# METHICILLIN-RESISTANT *STAPHYLOCOCCUS AUREUS*

THREAT LEVEL **SERIOUS**



**323,700**

Estimated cases  
in hospitalized  
patients in 2017



**10,600**

Estimated  
deaths in 2017



**\$1.7B**

Estimated attributable  
healthcare costs in 2017

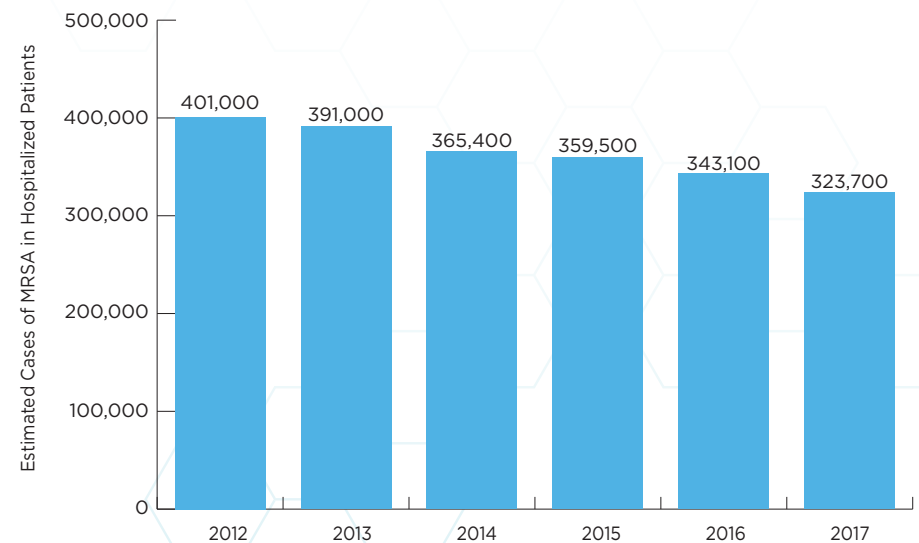
*Staphylococcus aureus* (*S. aureus*) are common bacteria that spread in healthcare facilities and the community. Methicillin-resistant *S. aureus* (MRSA) can cause difficult-to-treat staph infections because of resistance to some antibiotics.

## WHAT YOU NEED TO KNOW

- Although several treatments are still available, MRSA has become resistant to many first-line antibiotics.
- While MRSA infections overall are dropping, progress to prevent MRSA bloodstream infections in healthcare is slowing.
- People who inject drugs are 16 times more likely to develop a serious (invasive) MRSA infection than those who do not.

## CASES OVER TIME

Cases represented do not include the many skin infections that happen, but are not cultured and diagnosed.



U.S. Department of  
Health and Human Services  
Centers for Disease  
Control and Prevention



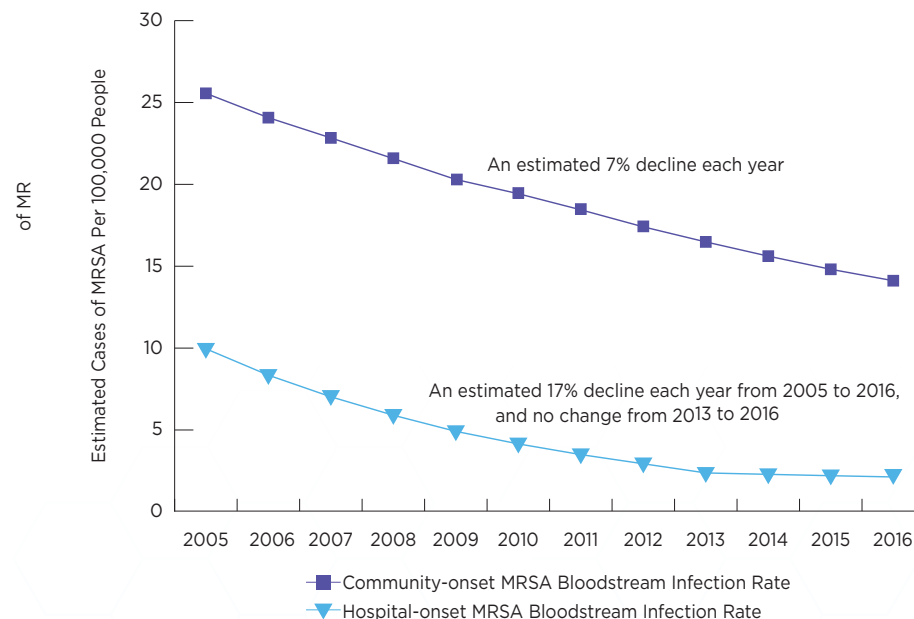
## MRSA INFECTIONS CAN BE PREVENTED

MRSA infections are preventable and many lives have been saved through effective infection control interventions. Veterans Affairs (VA) medical centers reduced rates of MRSA by 55% between 2005 and 2017. This success was driven by the implementation of CDC-recommended interventions at 153 VA hospitals across the country. The VA took steps to prevent the spread of MRSA and device- and procedure-associated infections. This included screening all patients for MRSA on admission, tracking MRSA infections, using Contact Precautions (such as gloves and gowns) for people with MRSA, and increasing the emphasis on hand hygiene.

Success was also driven by a change in institutional culture, which made preventing MRSA infections the responsibility of any VA employee taking care of patients. Employee adherence to infection prevention practices was tracked. Many hospitals outside of the VA system have also successfully reduced MRSA rates by assessing facility data and implementing CDC-recommended prevention strategies.

## REDUCTIONS IN HOSPITALS HAVE STALLED

New strategies in healthcare, along with current CDC recommendations could prevent MRSA. MRSA infections in communities may be connected to the opioid crisis.



Adjusted bloodstream infection rates from population-based surveillance in six CDC Emerging Infections Program sites. Community-onset infections include those in people who have not had recent inpatient healthcare exposure or an invasive medical procedure.



## ONLINE RESOURCES

### About MRSA

[www.cdc.gov/mrsa/index.html](http://www.cdc.gov/mrsa/index.html)

### CDC Vital Signs: Staph Infections Can Kill

[www.cdc.gov/vitalsigns/staph/index.html](http://www.cdc.gov/vitalsigns/staph/index.html)



# DRUG-RESISTANT *STREPTOCOCCUS PNEUMONIAE*

THREAT LEVEL **SERIOUS**



**900,000**  
Estimated  
infections in  
2014



**3,600**  
Estimated  
deaths in  
2014

*Streptococcus pneumoniae* (pneumococcus) is a leading cause of bacterial pneumonia and meningitis in the United States. It also is a common cause of bloodstream infections, and ear and sinus infections.

## WHAT YOU NEED TO KNOW

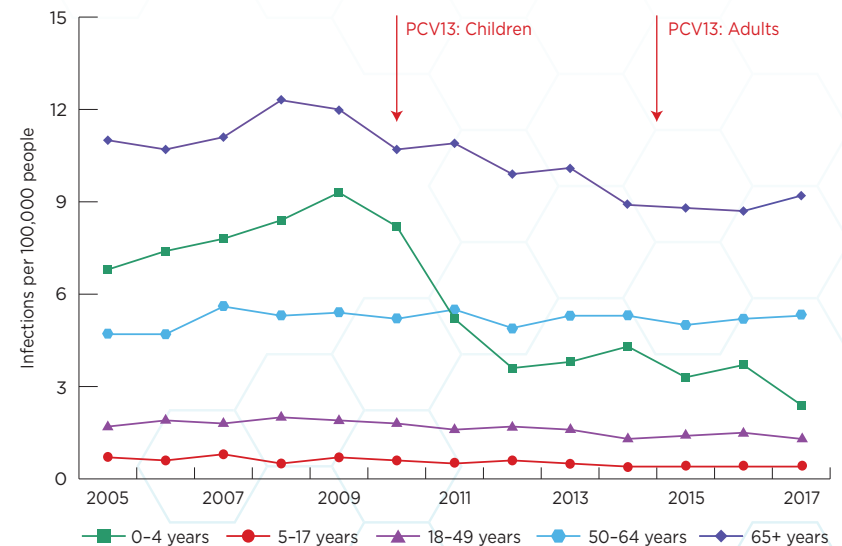
- Overall, there are more than 2 million pneumococcal infections each year in the United States, resulting in more than 6,000 deaths and \$4 billion in total costs. In more than 30% of infections, the bacteria are resistant to one or more clinically relevant antibiotics.
- Pneumococcal pneumonia leads to an estimated 150,000 hospitalizations for adults each year and accounts for \$1.3 billion in direct medical costs (65% of direct costs for all adult pneumococcal disease treatment).
- Drug-resistant *S. pneumoniae* is one of the only germs listed in this report with an effective vaccine to prevent infections, called pneumococcal conjugate vaccine (PCV).



U.S. Department of  
Health and Human Services  
Centers for Disease  
Control and Prevention

## INFECTIONS OVER TIME BY AGE

Rates of antibiotic-resistant invasive pneumococcal infections have decreased across age groups in the United States from 2005 to 2017.



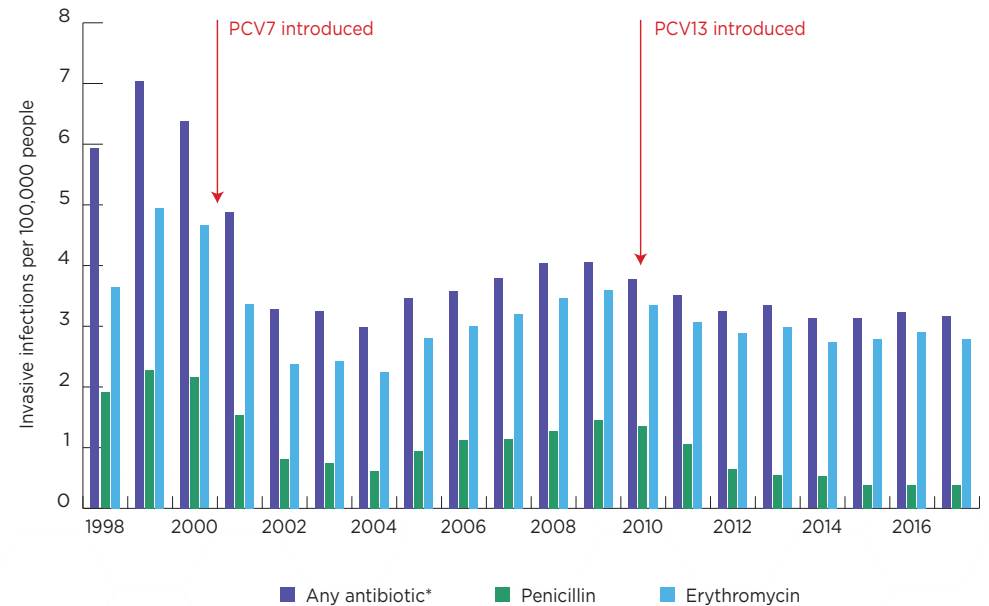
## VACCINE: AN EFFECTIVE TOOL

Pneumococcal conjugate vaccine (PCV) helps prevent infections and slow the development of pneumococcal resistance. PCV has reduced pneumococcal infections caused by vaccine strains, most of which were resistant, by more than 90% in children. It has also decreased the spread of resistant *S. pneumoniae* strains, because vaccinated people do not spread the bacteria. Blocking the spread reduces resistant infections among children, as well as adults, through vaccine indirect effects (or “herd immunity”). From 2000 to 2009, PCV7 provided protection against seven pneumococcal strains. These strains caused more than 83% of the antibiotic-resistant invasive infections in children prior to PCV7 introduction. Beginning in 2010, use of PCV13 expanded that protection to 13 strains, one of which—serotype 19A—accounted for more than 30% of resistant infections prior to PCV13 introduction. Since PCV introduction among U.S. children in 2000, the rates of antibiotic-resistant invasive pneumococcal infections caused by vaccine strains decreased by 97% among children younger than 5 years old and by more than 60% among adults. Achieving high vaccination coverage and encouraging appropriate antibiotic use will slow the spread of pneumococcal resistance.



## INFECTIONS OVER TIME BY ANTIBIOTIC

Antibiotic-resistant invasive pneumococcal infections have decreased in the United States since PCVs were introduced.



\*Any antibiotic includes germs not susceptible (not sensitive) to at least one of the following antibiotics: penicillin, amoxicillin, erythromycin, cefotaxime, ceftriaxone, cefuroxime, tetracycline, vancomycin, or levofloxacin.

## ONLINE RESOURCES

### About Drug-resistant Pneumococcal Disease

[www.cdc.gov/Pneumococcal/Drug-Resistance.html](http://www.cdc.gov/Pneumococcal/Drug-Resistance.html)

### Bact Facts Interactive: Data from Active Bacterial Core Surveillance

[wwwn.cdc.gov/BactFacts/Index.html](http://wwwn.cdc.gov/BactFacts/Index.html)

# DRUG-RESISTANT TUBERCULOSIS (TB)

THREAT LEVEL **SERIOUS**



**847**  
Cases  
in 2017



**62**  
Deaths  
in 2017



**\$164,000**  
Per MDR case  
**\$526,000**  
Per XDR case

TB is caused by *Mycobacterium tuberculosis*, bacteria that usually attack the lungs. Drug-resistant TB develops when the antibiotics used to treat TB are misused or mismanaged, and it can spread.

## WHAT YOU NEED TO KNOW

- TB spreads from person to person through the air. It is one of the world's most deadly infectious diseases.
- In most cases, TB is curable; however, people with TB can die without proper treatment. Treatment for drug-resistant TB is costly, lengthy, disrupts lives, and can have life-threatening side effects.
- MDR TB is resistant to two first-line antibiotics. XDR TB is resistant to some first- and second-line antibiotics.
- The number of drug-resistant TB cases in the United States remain stable due to effective control strategies.

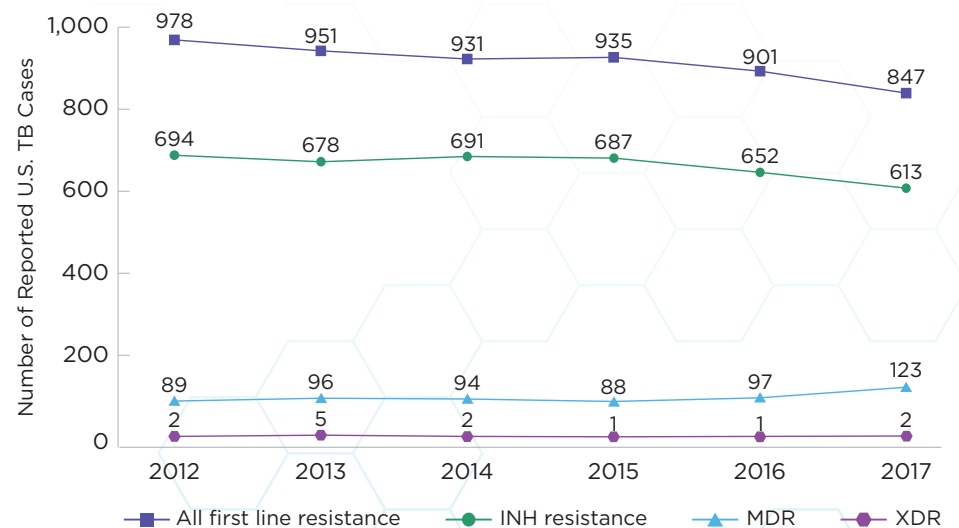
Data represents U.S. cases only. MDR: multidrug-resistant. XDR: extensively drug-resistant.



**U.S. Department of Health and Human Services**  
Centers for Disease Control and Prevention

## CASES OVER TIME

TB is most commonly resistant to isoniazid, one of the first-line TB antibiotics (called INH resistance).





## TOXIC SIDE EFFECTS FROM TB TREATMENT

Dr. Dalene von Delft was a newly qualified doctor in South Africa when her dreams of becoming a pediatric surgeon were shattered. Dalene contracted MDR TB. Treatment took 19 harrowing months.



Dalene had to inject toxic second-line antibiotics that can cause severe side effects. She took 30 pills a day—24 for TB and six for the side effects of TB treatment. The treatment made her so ill that she started to go deaf. Dalene had to make potentially life-threatening decisions to stop treatment to preserve her hearing and career. She often listened to music, worried the songs would be the last she ever heard.

MDR TB affects people in the United States and around the world. Dalene recovered due to a new treatment that was in development. She founded a campaign to help protect healthcare workers and medical students against work hazards. CDC continues to work to stop the spread of TB and protect the health of all people.

## TYPES OF RESISTANCE

TB treatment requires four first-line antibiotics: rifampin, isoniazid, pyrazinamide, and ethambutol. When TB becomes resistant to any of these drugs, it limits treatment options and puts the patient at risk for untreatable TB.



### DRUG-RESISTANT TB

**Resistant to 1 of 4** first-line antibiotics used to treat TB. The most common is INH-resistant TB, which is resistant to isoniazid.



### MDR TB

**Resistant to 2 of 4** first-line antibiotics, isoniazid and rifampin—the most potent drugs to treat TB.



### XDR TB

Rare type of MDR TB that is also **resistant to at least 1 of the 3** second-line antibiotics, including fluoroquinolones. Second-line antibiotics can be toxic and cause severe side effects.



First-line antibiotics



Second-line antibiotics



## ONLINE RESOURCES

### About Drug-resistant TB

[www.cdc.gov/TB/Topic/DRTB](http://www.cdc.gov/TB/Topic/DRTB)

### TB Personal Stories

[www.cdc.gov/TB/Topic/Basics/PersonalStories.htm](http://www.cdc.gov/TB/Topic/Basics/PersonalStories.htm)