**CDFA AUS Multi-Year Report on the California-Specific NARMS Data—2014-2023**
***Enterococcus***

Prepared by:

California Department of Food and Agriculture
Antimicrobial Use and Stewardship Program

October 2025

*Suggested citation:*

California Department of Food and Agriculture. Antimicrobial Use and Stewardship Program. (2025). CDFA AUS Multi-Year Report on the California-Specific NARMS Data—2014-2023: *Enterococcus*

To access this report online: [https://www.cdfa.ca.gov/ahfss/AUS/](https://www.cdfa.ca.gov/ahfss/AUS/)

**Scope of Report and California Significance:** A core mission of the California Department of Food and Agriculture (CDFA) Antimicrobial Use and Stewardship (AUS) program is to inform efforts to mitigate antibiotic resistance and identify emerging areas of concern and potential public health threats. To support this mission, and as data is available, AUS will generate regular reports to monitor antibiotic resistance and susceptibility trends of four common bacteria, some of which cause foodborne illnesses in humans, and others that are monitored as indicators through the National Antimicrobial Resistance Monitoring System (NARMS). The NARMS data for these reports will be sourced from samples collected from food-producing animals at the time of slaughter in California.

**Disclaimer**: Antibiotic resistance, which includes measures of reduced susceptibility, is a highly complex problem influenced by many factors. The data CDFA AUS have presented here can be used to monitor several years of bacterial resistance and susceptibility to drugs important in human medicine. These bacteria can be common causes of foodborne illness or may be monitored as indicator bacteria; both are found in samples from livestock slaughtered in California. These data are best used to monitor trends over multiple years; yet, drawing conclusions to prompt specific interventions should be avoided. Additionally, caution should be applied when making broad generalizations or host species comparisons, understanding these data's limitations in reflecting differences in production practices for these animal species. Finally, caution must be applied when interpreting these data, as they are not representative of on-farm resistance profiles due to cross-contamination during transport, animal holding, and processing.[1-3] They, therefore, should **not** be used as a surrogate to reflect the impact of on-farm antibiotic use on public health.

## TABLE OF CONTENTS

## LIST OF FIGURES AND TABLES

## Introduction

Antibiotics are life-saving drugs vital to protect people and animals from bacterial infections. Antibiotic resistance occurs when bacteria evolve, rendering the antibiotics ineffective. Resistance can be intrinsic due to specific structural or functional properties of the bacteria, but it can also occur naturally secondary to environmental pressures and can be acquired from other bacteria. Resistance to antibiotics makes common infections in people and animals a challenge, or even impossible, to treat. While the number of human deaths in the US from antibiotic resistance has decreased since 2013, there remain approximately 2.8 million antibiotic-resistant infections diagnosed per year, causing 35,000 fatalities.[4] Monitoring antibiotic-resistant infections, particularly those that commonly cause hospital-acquired infections or foodborne infections necessitating medical treatment, is critically important for public health. Beyond their potential role in causing disease, some bacteria are used as indicator organisms to monitor environmental contamination, adherence to food safety performance standards, track emerging resistance patterns, and estimate risks to human and animal health.[5-7] Indicator bacteria serve as an early warning sign that can signal the onset and potential spread of antibiotic resistance.[8] By closely observing and monitoring emerging resistance patterns in these indicator bacteria, it is possible to identify trends that may reveal the potential for new or widespread resistance. Routine surveillance of indicator bacteria helps to monitor the current efficacy of antibiotics. Surveillance plays a pivotal role in informing stewardship programs designed to combat the spread of antibiotic-resistant bacteria and the development of targeted infection control programs.[9,10] Leveraging some bacteria as sentinels can aid in understanding when and how resistance evolves and spreads, helping public health officials implement more effective strategies to preserve the effectiveness of existing antibiotics and protect public health.

In response to the global concern of antibiotic-resistant bacteria, the National Antimicrobial Resistance and Monitoring System (NARMS) program was developed. NARMS is a collaboration between the Centers for Disease Control and Prevention (CDC), the Food and Drug Administration (FDA), and the US Department of Agriculture (USDA) Food Safety and Inspection Services (FSIS). The purpose of NARMS is to provide national surveillance in the US of drug-resistant bacteria that cause foodborne illness and indicator bacteria to monitor the broader antibiotic-resistant environment by collecting samples from clinically ill humans (CDC), retail meats (FDA), and food animals at the time of slaughter (USDA-FSIS). NARMS' data are regularly published on their online dashboard.[11]

In a concurrent effort to monitor antibiotic resistance trends, the California Department of Food and Agriculture (CDFA) established the Antimicrobial Use and Stewardship (AUS) program. This first-in-the-nation program implements the directives of Food and Agricultural Code (FAC) 14400-14408 to provide educational tools for veterinarians and producers on disease prevention and optimal antibiotic use in food animals and to conduct and disseminate evidence-based research on antibiotic resistance trends.

CDFA AUS generates California-specific reports summarizing NARMS information from USDA-FSIS sampling, as provided to CDFA AUS via Freedom of Information Act (FOIA) requests. These reports aim to evaluate antibiotic resistance trends in the most-reported bacterial causes of foodborne illness, as well as key indicator bacteria, in samples collected from food animals slaughtered in California and in fulfillment of the mandates of FAC 14405 (a) and (b). This CDFA AUS Multi-Year *Enterococcus* Report provides summary data for USDA-FSIS NARMS *Enterococcus* samples collected from 2014 through 2023 from animals slaughtered in California.

## NARMS Methodology

The complete sampling and laboratory methodologies used by FSIS processing facilities for sample collection and processing can be found online or by contacting USDA FSIS.[12,13]

### Sample Collection

Samples are collected for the NARMS program at FSIS-regulated slaughter facilities across the United States. Only data from FSIS-regulated slaughter facilities in California are included in the California-specific results presented in this report. Notably, these data represent cattle, poultry, and swine that are both raised and slaughtered in California, as well as animals raised in other states but slaughtered in California.

Bacteria identified from testing conducted on NARMS samples by the USDA's Agricultural Research Service are *Salmonella*, *Escherichia coli* (*E. coli*), *Enterococcus*, and *Campylobacter*. *Salmonella* and *Campylobacter* are important causes of foodborne illness in people, whereas *Enterococcus* and *E. coli* are used as indicator bacteria by NARMS to monitor resistance patterns to antibiotics utilized in the treatment of gram-positive and gram-negative bacterial infections, respectively, within the food supply. USDA FSIS collects samples at slaughter for the NARMS Cecal Sample Program, which are taken from the intestinal contents of cattle (including dairy and beef cows, steers, heifers, and veal), swine (market swine and sows), chickens, and turkeys. These samples, collected early in the slaughter process, are referred to as "cecal samples" throughout the report. The approach used by NARMS for sample collection, along with their data reporting methods, and differing management, husbandry, and antibiotic use practices for various food animal species, complicates both the separation of NARMS data by commodity type for some species (e.g. beef vs. dairy cattle) and the grouping of other species, such as chickens and turkeys, into a single poultry category. Therefore, in this report, AUS presents the NARMS data categorized solely by animal species: adult cattle, chicken, turkey, and swine. This categorization aims to reduce inaccuracies in data reporting.

FSIS also collects samples as part of its routine verification testing program for Pathogen Reduction/Hazard Analysis Critical Control Point (PR/HACCP). These HACCP samples are taken after the point in the slaughter process where specific practices designed to prevent or eliminate contamination from disease-causing bacteria have already been implemented. Please note that these data are not included in this report.

## Antibiotic Susceptibility Testing

The cecal samples collected for NARMS are tested for four target bacteria: *Salmonella*, *Campylobacter*, generic *E. coli*, and *Enterococcus*. The purified bacteria isolated from these samples are referred to as bacterial isolates. These isolates undergo further testing, known as antibiotic susceptibility testing (AST). Details on the corresponding AST methodology for each antibiotic type used for *Enterococcus* isolate testing are available in **Appendix A.** AST testing identifies whether the bacterial isolate is considered susceptible to a panel of antibiotics. This is accomplished by determining the tested concentration of an antibiotic that inhibits bacterial growth, known as the minimum inhibitory concentration (MIC). The MIC value can be used to categorize the bacteria based on their relation to established cutoff values. NARMS utilizes standardized cutoff values, called breakpoints, established by the Clinical and Laboratory Standards Institute (CLSI) for *Enterococcus, Salmonella,* and *E. Coli* or, in the case of *Campylobacter,* epidemiological cut-off values (ECOFFs),[14] to interpret MIC values. CLSI breakpoints categorize bacterial isolates as susceptible, intermediate, or resistant to a tested antibiotic based on clinical, pharmacological, and microbiological data. In contrast, ECOFFs, which are also specific to the bacterial species-antibiotic combination, do not factor in clinical parameters or host species into the interpretation of results and distinguish bacterial populations as wild-type and non-wild-type strains. NARMS classifies *Enterococcus* isolates as either susceptible, intermediate, or resistant using the interpretive criteria as described in **Appendix B.** When tested using a standardized antibiotic dosage, susceptible means that the drug is likely to be therapeutically effective against the bacterial isolate when using the same drug dose and route of administration. In contrast, a resistant isolate indicates that the drug is unlikely to be effective at achievable concentrations, while intermediate implies possible antibiotic effectiveness under specific dosing or site-of-infection conditions, but with less certainty. To avoid ambiguity associated with the intermediate category, this report will focus on reporting the percent resistance data only. Additionally, while AST results provide information regarding the susceptibility of a bacterial isolate to an antibiotic, it is important to note that this is a laboratory-based test with limitations and does not account for other factors that may impact bacterial susceptibility or resistance to a drug in a clinical setting.

The specific NARMS antibiotic panel used for testing depends on the bacteria being analyzed. The NARMS antibiotic panel used to test *Enterococcus* isolates can be found in **Appendix C** of this report. Although the NARMS antibiotic panel and interpretive criteria are specific to human medicine, some of the antibiotics included in this panel are used therapeutically in food animals, while others are not.[15] For those antibiotics that are not used in food animals, alternative drug formulations within the same antibiotic class may still be approved for such use. Additional details regarding this information are provided in **Appendix C**.

### Whole Genome Sequencing

Whole genome sequencing (WGS) is a methodology used to enhance antibiotic resistance surveillance by identifying known antibiotic resistance genes that bacteria may possess. While for some bacteria, WGS may correlate highly with the resistance observed in the environment, not all antibiotic resistance is caused by genetic alterations; and bacteria carrying resistance genes do not necessarily display resistance in laboratory testing or a clinical setting.

## *Enterococcus*

### General Overview

*Enterococcus* species, especially *Enterococcus faecalis* and *Enterococcus faecium*, are types of bacteria that live in the gastrointestinal tracts of people and animals. While typically harmless in healthy individuals, human health experts consider some *Enterococcus* bacteria a serious threat due to their role in causing infections in people with weakened immune systems and for their ability to acquire and spread resistance to critically important antibiotics.[4] In people, infections caused by *Enterococcus* typically occur in healthcare settings.[7] They often develop from the patient's own intestinal flora, through person-to-person transmission, or via contaminated surfaces.[7,16] Common infection types include bloodstream infections, urinary tract infections, and surgical site infections.[4,17,18] In the U.S. in 2017, drug-resistant *Enterococcus* was associated with an estimated 54,500 infections and 5,400 deaths in hospitalized patients.[4]

Although infections in people are typically due to human-associated strains, there are rare instances where infections can be transmitted from animals to humans.[19,20] These cases are infrequent, and the strains associated with livestock are usually genetically different from those that infect humans.[19] Enterococci, while not among the primary causes of foodborne illnesses, can pose a health risk when acquired through food, particularly when meat is contaminated and either undercooked or mishandled during preparation.[21] Individuals with weakened immune systems may be especially vulnerable to such infections.[21] Additionally, while agricultural runoff has the potential to contribute to human infections, such occurrences are uncommon.[22]

Similar to people, *Enterococcus* exists as part of the normal gastrointestinal tract in food animals.[22] Like people, enterococci infections in livestock can be caused in animals with weakened immune systems and frequently occur when hygiene is suboptimal or when animals are stressed.[23,24] It can also be associated with infections such as mastitis, neonatal diarrhea, lameness, or bloodstream infections.[25] Like other enteric bacteria, they may also be transferred through direct animal contact or through contaminated surfaces, water, or feed.[26,27] The shedding of *Enterococcus* bacteria in livestock feces can lead to contamination of meat during slaughter or environmental dissemination.[28]

Treating enterococcal infections can be challenging due to high rates of antibiotic resistance, and in humans, it is guided by AST results. Intrinsic resistance, or widespread lack of clinical efficacy of certain drugs, occurs across most species of enterococci and includes resistance to aztreonam, polymyxin B/colistin, nalidixic acid, most generations of cephalosporins, trimethoprim-sulfamethoxazole, clindamycin, and low-level aminoglycoside resistance, with *E. faecalis* resistant to quinupristin/dalfopristin and demonstrating low-level quinolone resistance.[15,22] While many enterococci are inherently resistant to several antibiotics, they also have the ability to acquire additional resistance readily. In general, infections with *E. faecalis* are typically more susceptible to antibiotics than those caused by *E. faecium*.[16] First-line therapy against vancomycin-susceptible enterococci includes a β-lactam antibiotic, such as ampicillin or penicillin.[29] Multidrug-resistant strains may require treatment with vancomycin, linezolid, daptomycin, or other last-resort antibiotics, all of which are of high concern due to limited therapeutic alternatives and the further development of resistant strains.[29] *Enterococcus faecium*, in particular, is known for its resistance to vancomycin—a drug often considered a last-resort treatment for gram-positive infections—earning it the designation vancomycin-resistant enterococci (VRE). These VRE strains are frequently treated with linezolid or daptomycin, with other options depending on susceptibility, including quinupristin/dalfopristin or tigecycline.[29] For both vancomycin-susceptible and vancomycin-resistant strains, combination therapy is often required for serious infections.[29]

Many of the critical drugs used to treat resistant enterococcal infections in humans—such as vancomycin, daptomycin, quinupristin/dalfopristin, tigecycline, and linezolid—are **not approved for use in food animals** in the United States. While penicillin and some drugs that fall within the aminoglycoside class are approved for use in food animals, they are generally administered to animals suffering from diseases that pose significant risks to their health and welfare if left untreated. For more detailed information on approved antimicrobials in food animals and their use, please refer to **Appendix C**.

Importantly, *Enterococcus* species are used as an indicator of fecal contamination. When identified in food and water, its presence is suggestive of possible contamination by other harmful gastrointestinal bacterial and viral pathogens.[30] Human sewage is the primary contributor of *E. faecium* and *E. faecalis* fecal pollution in both freshwater and marine recreational waters, representing a potential source of transmission of not only harmful pathogens to people, but also a reservoir of resistance genes.[30,31] Contaminated water sources, including irrigation, livestock drinking water, and water used in agricultural practices, can also spread these bacteria to crops and food for human consumption and to animals.[6,27] Additionally, during animal processing and slaughter, contamination of the food products with animal fecal material can occur. As such, monitoring enterococcal bacterial counts during the processing of animals for food can help ensure that food safety performance standards are being met and contamination risks are minimized.

*Enterococcus* species are also commonly used as indicator organisms for antibiotic resistance and One Health surveillance programs.[8] Their abilities to persist in the environment and to easily acquire and transfer resistance genes to other bacteria make them ideal for this purpose. Since they can be found in human feces, animal manure, food, and water, they provide a valuable means of monitoring resistance trends at the interface between humans, animals, and the environment.[20,22] As a reservoir for mobile resistance genes that can spread to other bacteria, regularly monitoring enterococcal resistance has become a crucial strategy, particularly for tracking resistance to numerous antibiotic classes.

## Number of Samples Screened and Isolates That Underwent AST

The number of samples screened as part of the NARMS Cecal Sample Program is facility-dependent and based on the production volume and the target number of bacterial isolates needed for AST as determined by NARMS, while aiming to make the data representative of the industry.[13] Cecal samples are obtained from individual cattle and swine, but are combined from five birds for chicken and turkey sampling procedures.[13]

The total number of NARMS cecal samples collected from food animals slaughtered in California, screened, and *Enterococcus* isolates obtained, and the number of isolates that underwent AST, are presented in **Tables 1 and 2**, respectively. A total of 981 *Enterococcus* isolates were obtained from 3,561 screened NARMS cecal samples collected from adult cattle, chickens, turkeys, and swine slaughtered in California between 2014 and 2023, and underwent AST. Of these isolates, 670 from adult cattle, 71 from chickens, 66 from turkeys, and 174 from swine underwent AST testing during this time period.

**The yearly number of *Enterococcus* isolates from each animal species used for AST from California-slaughtered food animals, except cattle in some cases, is typically below 30 isolates. Thirty is the threshold AUS uses for statistical validity and improved predictive value when evaluating cumulative susceptibility data, as recommended by the CLSI M39 guidelines**.[32] This means that, due to low numbers, the *Enterococcus* AST data for isolates from California-slaughtered food animals tested through NARMS each year may not be representative of the larger population of *Enterococcus* in animals slaughtered in California. Indeed, variations in resistance rates may result from analyzing a limited number of isolates rather than reflecting true changes in susceptibility.[33] While the data showing the percent of resistant isolates are presented for each animal species below, interpretations of population trends in *Enterococcus* susceptibility for isolates obtained from chickens, turkeys, swine, and, in some cases, cattle cannot be made due to the limited number of isolates tested for these host species.

*Table 1. Number of NARMS Cecal Samples from California-Slaughtered Food Animals Screened for Enterococcus and Screening Results, 2014-2023, by Animal Species.*

| Year | | Cattle* | Chickens | Turkeys | Swine |
|---|---|---|---|---|---|
| 2014 | Null | 216 | 11 | 7 | 38 |
| | Negative | 3 | 0 | 0 | 2 |
| | Positive | 47 | 2 | 6 | 9 |
| 2015 | Null | 170 | 15 | 9 | 21 |
| | Negative | 4 | 0 | 0 | 1 |
| | Positive | 47 | 3 | 6 | 12 |
| 2016 | Null | 154 | 9 | 4 | 31 |
| | Negative | 8 | 0 | 1 | 2 |
| | Positive | 93 | 4 | 10 | 30 |
| 2017 | Null | 181 | 10 | 10 | 27 |
| | Negative | 12 | 0 | 0 | 0 |
| | Positive | 110 | 6 | 3 | 38 |
| 2018 | Null | 202 | 14 | 11 | 32 |
| | Negative | 23 | 0 | 1 | 0 |
| | Positive | 136 | 14 | 6 | 36 |
| 2019 | Null | 239 | 12 | 4 | 24 |
| | Negative | 21 | 1 | 0 | 2 |
| | Positive | 95 | 16 | 11 | 14 |
| 2020 | Null | 188 | 7 | 3 | 13 |
| | Negative | 3 | 0 | 0 | 0 |
| | Positive | 38 | 1 | 1 | 9 |
| 2021 | Null | 221 | 6 | 2 | 7 |
| | Negative | 9 | 0 | 0 | 0 |
| | Positive | 31 | 2 | 1 | 2 |
| 2022 | Null | 266 | 15 | 4 | 30 |
| | Negative | 10 | 0 | 0 | 1 |
| | Positive | 37 | 6 | 8 | 12 |
| 2023 | Null | 233 | 13 | 7 | 12 |
| | Negative | 3 | 0 | 0 | 0 |
| | Positive | 51 | 7 | 6 | 10 |
| Total | | 2851 | 174 | 121 | 415 |

*The cattle category does not include bob veal due to the lack of CA-specific isolates for this cattle group.

***Table 2. Number of NARMS Enterococcus Isolates from California-Slaughtered Food Animals that Underwent AST, 2014-2023, by Animal Species.***

| Year | Cattle* | Chickens | Turkeys | Swine |
|---|---|---|---|---|
| 2014 | 47 | 1 | 6 | 9 |
| 2015 | 44 | 2 | 6 | 11 |
| 2016 | 89 | 4 | 10 | 26 |
| 2017 | 101 | 6 | 2 | 34 |
| 2018 | 127 | 13 | 6 | 34 |
| 2019 | 81 | 17 | 11 | 15 |
| 2020 | 53 | 5 | 4 | 17 |
| 2021 | 42 | 10 | 7 | 6 |
| 2022 | 35 | 6 | 8 | 12 |
| 2023 | 51 | 7 | 6 | 10 |
| Total | 670 | 71 | 66 | 174 |

*The cattle category does not include bob veal due to the lack of CA-specific isolates for this cattle group. Note: NARMS does not conduct AST on all positive samples. The complete sampling and laboratory methodologies used by USDA FSIS processing facilities for sample collection and processing can be found online or by contacting USDA FSIS.

## Number of *Enterococcus* Isolates by Species

There are over 60 species of *Enterococcus*, but only a few are clinically important or relevant from an epidemiological perspective, particularly in relation to humans, animals, food safety, and monitoring antibiotic resistance. The two most significant species, responsible for more than 90% of human enterococcal infections, are *E. faecalis* and *E. faecium*.[22] Both species are present in humans and food-producing animals, making them critical to One Health initiatives on antibiotic resistance. In contrast, *E. hirae* is mainly associated with animals, particularly livestock such as cattle.[22] Although *E. hirae* is not a major human pathogen, it is commonly used as an indicator organism for monitoring antibiotic resistance in animals and food products, helping to track the transfer of resistance within a One Health framework.

**Table 3** below presents the distribution of *Enterococcus* species identified in the NARMS dataset for all food animal species slaughtered in California combined, including adult cattle, chickens, turkeys, and swine. This data is further broken down by animal species in **Tables 4 through 7**. Although *E. faecalis* and *E. faecium* have distinct susceptibility profiles,[32] the low number of isolates of these enterococcal species that were obtained and tested across all animal classes limits the ability to draw meaningful conclusions. As such, with the exception of *E. hirae* in cattle, the line graphs presented below represent the results for all enterococci species reported combined within each host animal class. This approach enables the interpretation of more meaningful fluctuations and relationships over time, while limiting the overemphasis on *Enterococcus* species-specific variability that may not be significant. Instead, separate heat maps for *E. faecalis and E. faecium* are provided for each animal class to enhance visual clarity regarding broad resistance patterns for these two clinically and epidemiologically important enterococcal species. However, it is still essential to exercise caution when interpreting heat maps for years characterized by low isolate counts.

***Table 3. Total Enterococcus Species Identified by NARMS That Underwent AST Across All Animal Classes in California-Slaughtered Food Animals, 2014-2023.***

| Species | Isolates |
|---|---|
| *avium* | 1 |
| *casseliflavus* | 42 |
| *durans* | 79 |
| *entero* | 2 |
| *faecalis* | 309 |
| *faecium* | 117 |
| *gallinarum* | 126 |
| *hirae* | 289 |
| *mundtii* | 8 |
| spp. | 8 |
| Total | 981 |

***Table 4. Total Enterococcus Species Identified by NARMS That Underwent AST in California-Slaughtered Cattle, 2014-2023.***

| Year | *casseliflavus* | *durans* | *entero* | *faecalis* | *facium* | *gallinarum* | *hirae* | *mundtii* | *spp.* |
|---|---|---|---|---|---|---|---|---|---|
| 2014 | 4 | 4 | 2 | 7 | 3 | 1 | 24 | 2 | 0 |
| 2015 | 1 | 5 | 0 | 7 | 3 | 12 | 14 | 0 | 2 |
| 2016 | 3 | 14 | 0 | 12 | 7 | 21 | 32 | 0 | 0 |
| 2017 | 7 | 9 | 0 | 4 | 25 | 18 | 37 | 0 | 1 |
| 2018 | 4 | 12 | 0 | 14 | 15 | 25 | 57 | 0 | 0 |
| 2019 | 6 | 7 | 0 | 8 | 12 | 22 | 24 | 0 | 2 |
| 2020 | 3 | 5 | 0 | 7 | 8 | 7 | 23 | 0 | 0 |
| 2021 | 8 | 4 | 0 | 6 | 4 | 1 | 19 | 0 | 0 |
| 2022 | 3 | 2 | 0 | 9 | 3 | 3 | 14 | 1 | 0 |
| 2023 | 3 | 1 | 0 | 10 | 8 | 0 | 24 | 4 | 1 |
| Total | 42 | 63 | 2 | 84 | 88 | 110 | 268 | 7 | 6 |

***Table 5. Total Enterococcus Species Identified by NARMS That Underwent AST in California-Slaughtered Chickens, 2014-2023.***

| Year | *durans* | *faecalis* | *faecium* | *gallinarum* | *spp.* |
|---|---|---|---|---|---|
| 2014 | 0 | 1 | 0 | 0 | 0 |
| 2015 | 0 | 2 | 0 | 0 | 0 |
| 2016 | 1 | 2 | 1 | 0 | 0 |
| 2017 | 1 | 3 | 1 | 0 | 0 |
| 2018 | 5 | 7 | 0 | 1 | 1 |
| 2019 | 0 | 14 | 1 | 0 | 0 |
| 2020 | 0 | 5 | 0 | 2 | 0 |
| 2021 | 1 | 9 | 0 | 0 | 0 |
| 2022 | 0 | 6 | 0 | 0 | 0 |
| 2023 | 1 | 6 | 0 | 0 | 0 |
| Total | 9 | 55 | 3 | 3 | 1 |

***Table 6. Total Enterococcus Species Identified by NARMS That Underwent AST in California-Slaughtered Turkeys, 2014-2023.***

| Year | *durans* | *faecalis* | *faecium* | *gallinarum* | *hirae* | *mundtii* |
|---|---|---|---|---|---|---|
| 2014 | 0 | 4 | 1 | 0 | 0 | 1 |
| 2015 | 0 | 2 | 3 | 1 | 0 | 0 |
| 2016 | 1 | 7 | 2 | 0 | 0 | 0 |
| 2017 | 0 | 2 | 0 | 0 | 0 | 0 |
| 2018 | 0 | 4 | 2 | 0 | 0 | 0 |
| 2019 | 0 | 9 | 1 | 0 | 1 | 0 |
| 2020 | 0 | 4 | 0 | 0 | 0 | 0 |
| 2021 | 0 | 7 | 0 | 0 | 0 | 0 |
| 2022 | 0 | 8 | 0 | 0 | 0 | 0 |
| 2023 | 0 | 6 | 0 | 0 | 0 | 0 |
| Total | 1 | 53 | 9 | 1 | 1 | 1 |

*Table 7. Total Enterococcus Species Identified by NARMS That Underwent AST in California-Slaughtered Swine, 2014-2023.*

| Year | *avium* | *durans* | *faecalis* | *facium* | *gallinarum* | *hirae* | *spp.* |
|---|---|---|---|---|---|---|---|
| 2014 | 0 | 0 | 5 | 1 | 1 | 2 | 0 |
| 2015 | 0 | 1 | 8 | 1 | 0 | 0 | 1 |
| 2016 | 1 | 1 | 17 | 1 | 5 | 1 | 0 |
| 2017 | 0 | 2 | 23 | 2 | 0 | 7 | 0 |
| 2018 | 0 | 1 | 21 | 6 | 2 | 4 | 0 |
| 2019 | 0 | 0 | 10 | 1 | 2 | 2 | 0 |
| 2020 | 0 | 0 | 13 | 1 | 2 | 1 | 0 |
| 2021 | 0 | 0 | 4 | 1 | 0 | 1 | 0 |
| 2022 | 0 | 0 | 10 | 1 | 0 | 1 | 0 |
| 2023 | 0 | 1 | 6 | 2 | 0 | 1 | 0 |
| Total | 1 | 6 | 117 | 17 | 12 | 20 | 1 |

## Trends in Resistance to Antibiotics Using AST

### Cattle

**Figure 1** displays the percentage of all *Enterococcus* isolates that underwent AST by year, from screened NARMS cecal samples that were collected from cattle slaughtered in California and categorized as resistant to the antibiotics included in the NARMS *Enterococcus* AST panel. Since 2018, the percentage of antibiotic-resistant isolates has remained below 10% for most of the antibiotics tested. This includes those drugs used as first-line therapies for treating enterococcal infections in humans, as well as for most antibiotics used against vancomycin-resistant strains. In fact, none of the tested isolates were resistant to vancomycin in any year. The percentage of isolates resistant to quinupristin/dalfopristin, which is not approved for use or used in food animals, has remained higher than other second-line therapies but has decreased since 2019 and is most recently below 30%. Additionally, tetracycline resistance has continued to fluctuate annually and was below 20% in 2023.

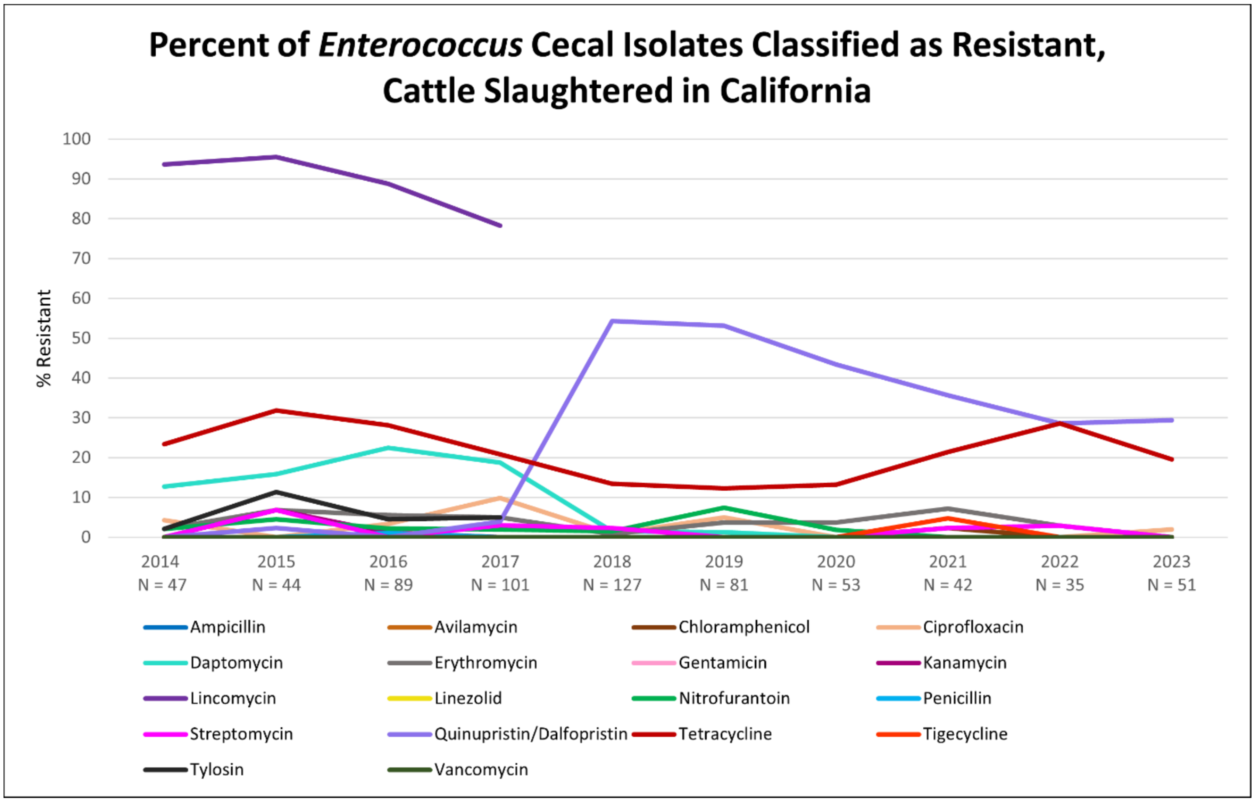



***Figure 1. Data Trends in the Percent Resistant Enterococcus Isolates from Cattle Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.***
N indicates the number of isolates tested in a given year.

The percentage of resistant isolate data for screened NARMS cecal samples collected from cattle slaughtered in California that underwent AST for all *Enterococcus* species combined, and *Enterococcus faecalis* and *Enterococcus faecium* displayed separately, are presented as heat maps in **Figures 2, 3**, **and 4**, respectively. For these and all subsequent heat maps, antibiotics are listed on the y-axis, and the years of sample collection are on the x-axis. The color of each cell represents the percentage of isolates classified as resistant: blue shades represent a lower percentage of resistant isolates, while red shades represent a higher percentage of resistant isolates, with darker red shades showing the highest percentage of resistant isolates. The number inside each cell represents the exact percentage of resistant isolates, making it easier to identify broad trends in susceptibility over time and to compare deviations in resistance across different drugs. The interpretation of the heat map for all *Enterococcus* species combined is the same as **Figure 1.** Since the number (N) of *Enterococcus faecalis* (**Figure 3**) and *Enterococcus faecium* (**Figure 4**) isolates that underwent AST per year is below the CLSI-recommended threshold of 30 isolates, meaningful trends in susceptibility for all years in these datasets cannot be determined. As such, an interpretation of the broader cattle cecal data for *E. faecalis* and *E. faecium* across California cannot be provided.

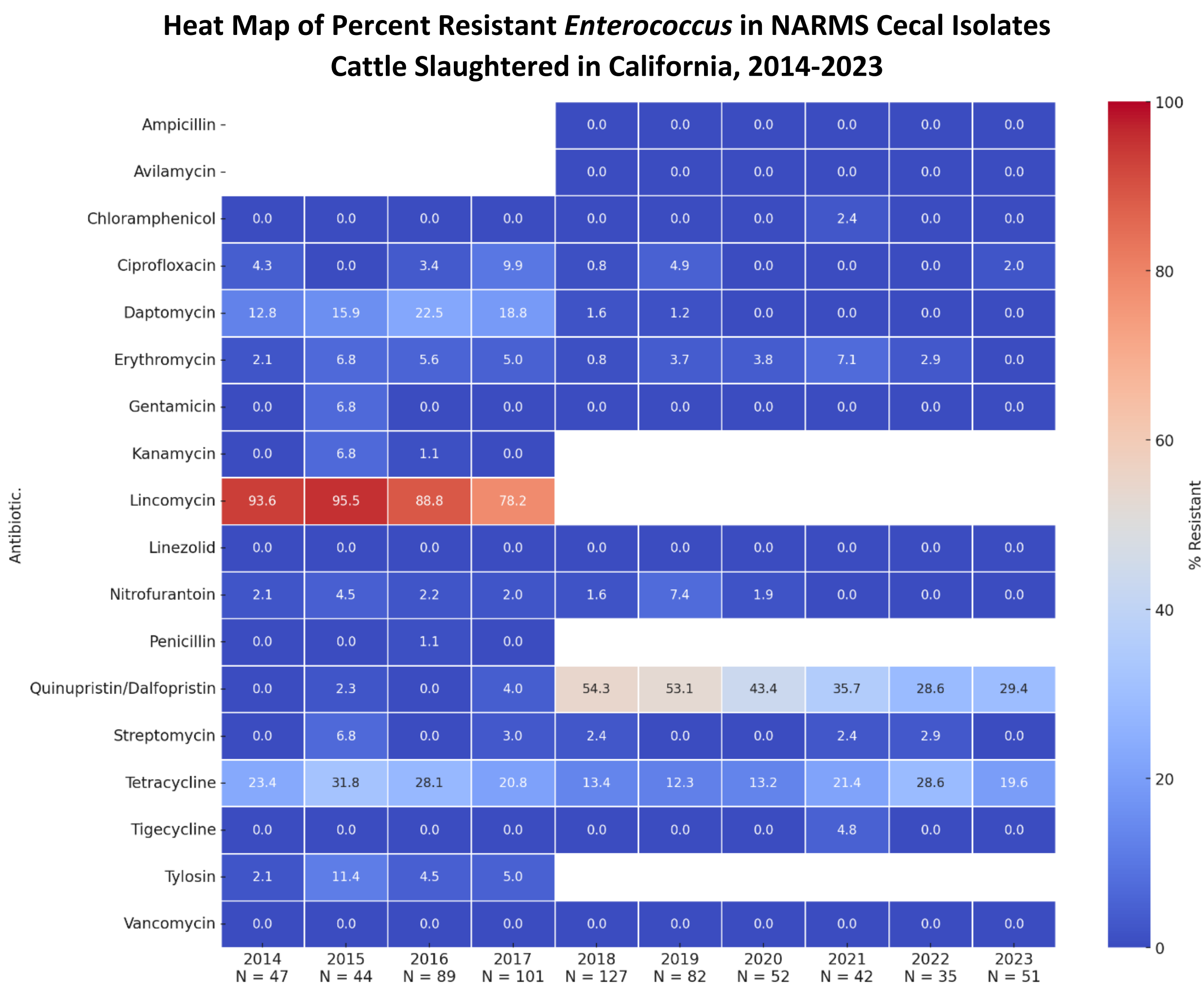
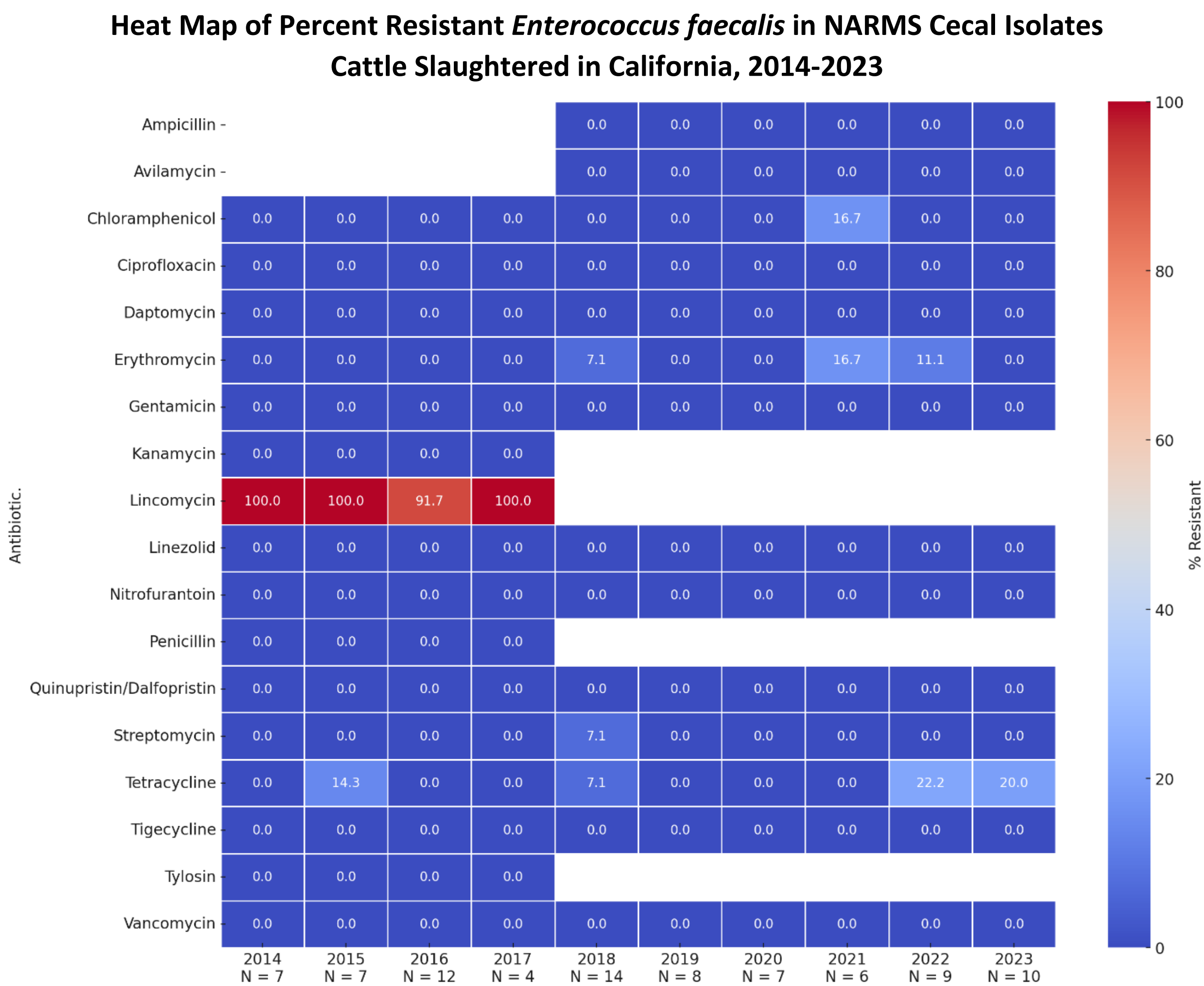



***Figure 2. Heat Map Displaying Trends in the Percent Resistant Enterococcus Isolates from Cattle Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.*** *N* indicates the number of isolates tested in a given year.




| Antibiotic | 2014 N = 7 | 2015 N = 7 | 2016 N = 12 | 2017 N = 4 | 2018 N = 14 | 2019 N = 8 | 2020 N = 7 | 2021 N = 6 | 2022 N = 9 | 2023 N = 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Ampicillin | | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Avilamycin | | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Chloramphenicol | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 16.7 | 0.0 | 0.0 |
| Ciprofloxacin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Daptomycin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Erythromycin | 0.0 | 0.0 | 0.0 | 0.0 | 7.1 | 0.0 | 0.0 | 16.7 | 11.1 | 0.0 |
| Gentamicin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Kanamycin | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | |
| Lincomycin | 100.0 | 100.0 | 91.7 | 100.0 | | | | | | |
| Linezolid | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Nitrofurantoin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Penicillin | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | |
| Quinupristin/Dalfopristin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Streptomycin | 0.0 | 0.0 | 0.0 | 0.0 | 7.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tetracycline | 0.0 | 14.3 | 0.0 | 0.0 | 7.1 | 0.0 | 0.0 | 0.0 | 22.2 | 20.0 |
| Tigecycline | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tylosin | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | |
| Vancomycin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

***Figure 3. Heat Map Displaying Trends in the Percent Resistant Enterococcus faecalis Isolates from Cattle Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.***

N indicates the number of isolates tested in a given year. Since less than 30 isolates were tested yearly, these numbers should be interpreted with caution and are not considered representative of the broader population of cattle raised or slaughtered in California.

**Heat Map of Percent Resistant *Enterococcus faecium* in NARMS Cecal Isolates Cattle Slaughtered in California, 2014-2023**

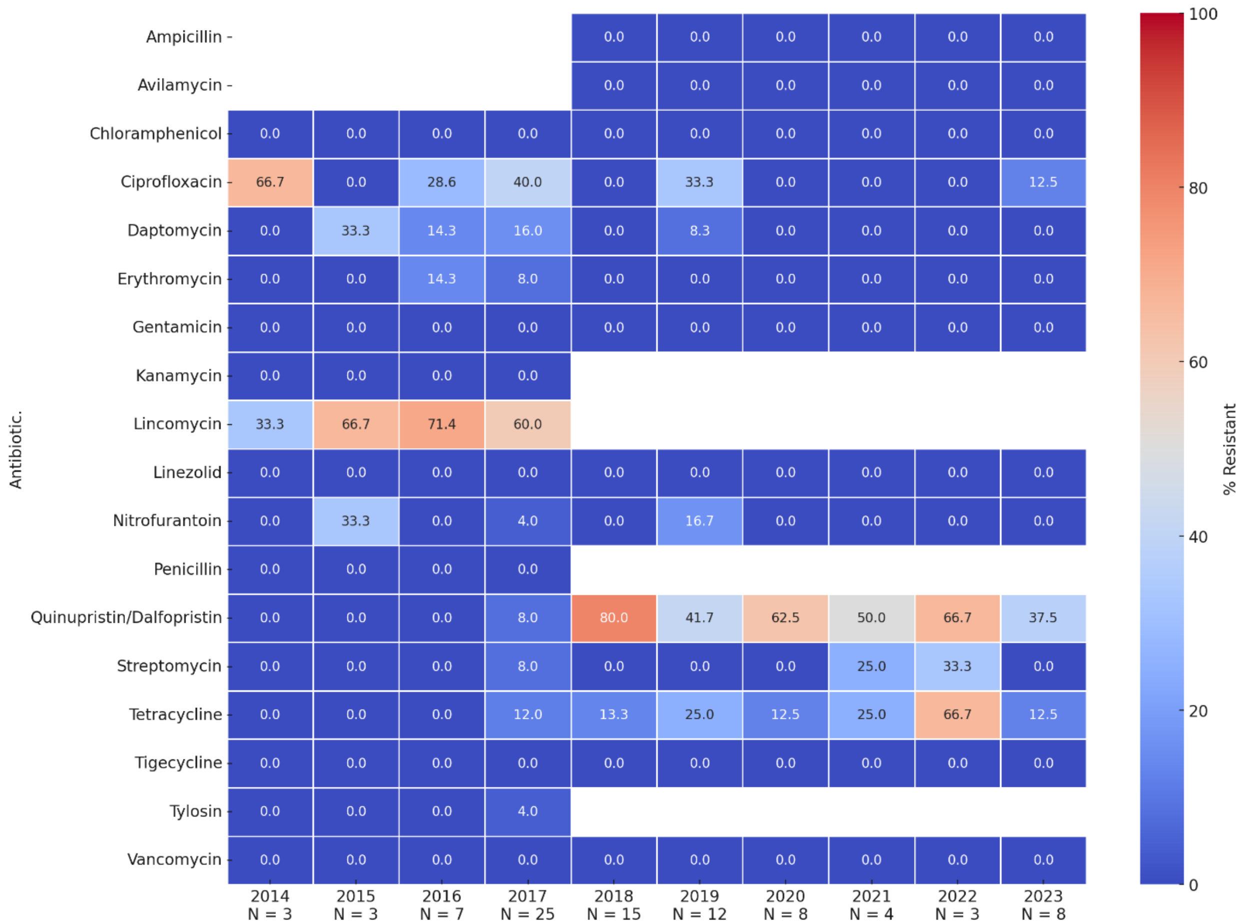



***Figure 4. Heat Map Displaying Trends in the Percent Resistant Enterococcus faecium Isolates from Cattle Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.***

N indicates the number of isolates tested in a given year. Since less than 30 isolates were tested yearly, these numbers should be interpreted with caution and are not considered representative of the broader population of cattle raised or slaughtered in California.

The percentage of *Enterococcus hirae* isolates from screened NARMS cecal samples collected from cattle slaughtered in California that were classified as resistant to the antibiotics included in the NARMS *Enterococcus* AST panel by year are displayed in **Figures 5** and **6**. Since the number (N) of bacterial isolates that underwent AST for all years, except 2016 through 2018, is below the CLSI-recommended threshold of 30 isolates, meaningful trends in resistance over time for this dataset cannot be determined. As such, an interpretation cannot be provided.

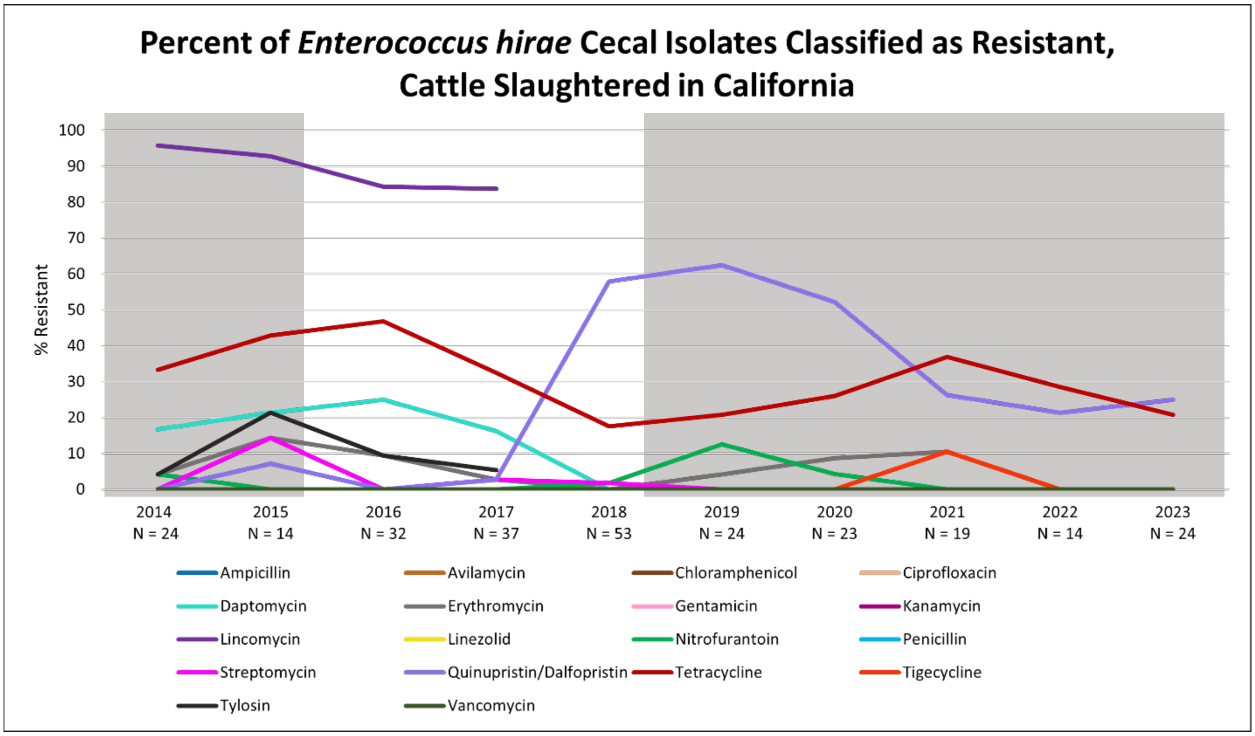



***Figure 5. Data Trends in the Percent Resistant Enterococcus hirae Isolates from Cattle Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.***

N indicates the number of isolates tested in a given year. Years and sample numbers shaded in gray indicate less than 30 isolates; therefore, these numbers should be interpreted with caution and are not considered representative of the broader population of cattle raised or slaughtered in California.

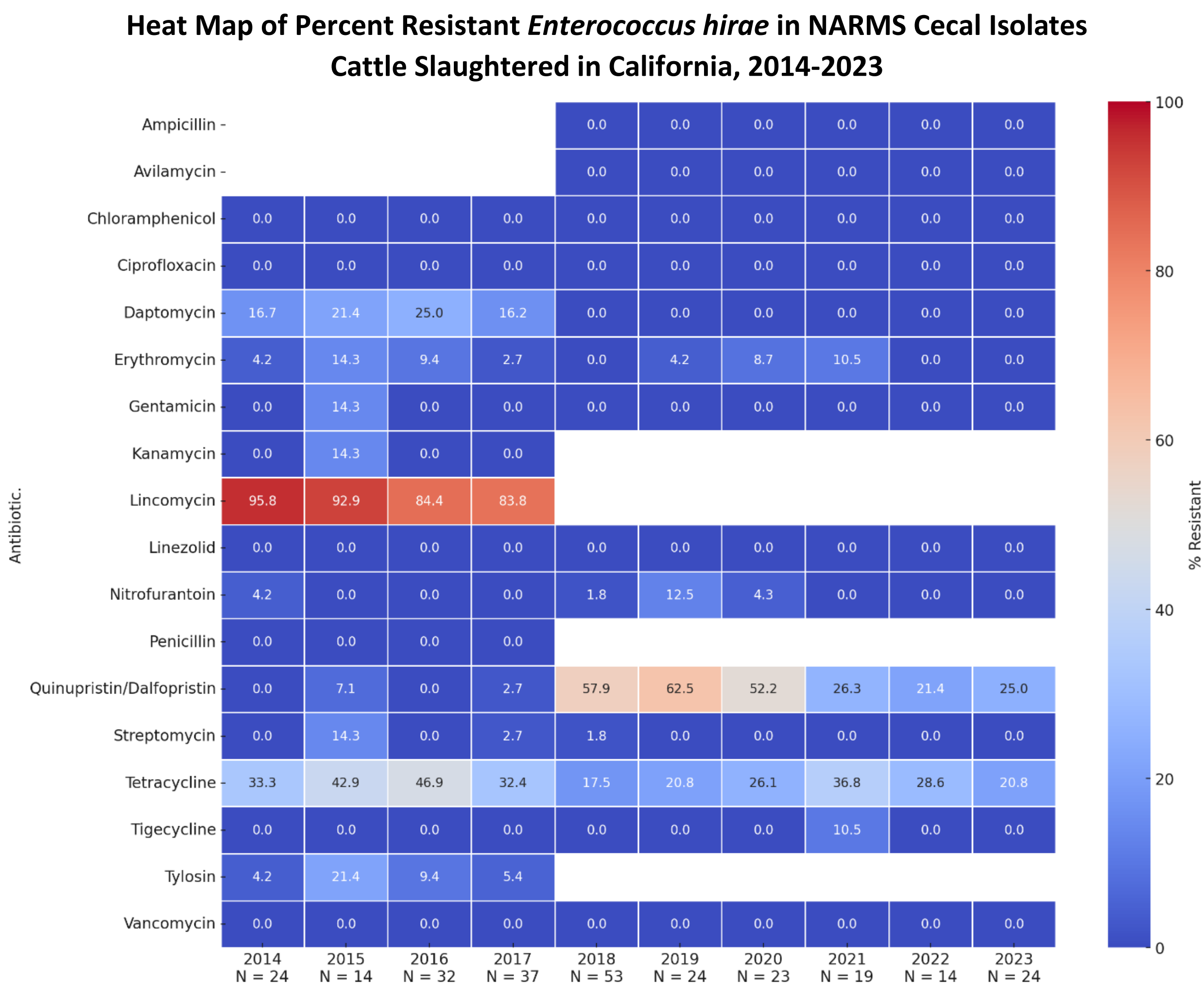



***Figure 6. Heat Map Displaying Trends in the Percent Resistant Enterococcus hirae Isolates from Cattle Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.*** N indicates the number of isolates tested in a given year. When less than 30 isolates were tested, numbers for these years should be interpreted with caution and are not considered representative of the broader population of cattle raised or slaughtered in California.

## Chickens

The percentage of *Enterococcus* isolates from screened NARMS cecal samples collected from chickens slaughtered in California that were classified as resistant in relation to the antibiotics included in the NARMS *Enterococcus* AST panel by year is displayed in **Figures 7 to 10**. Since the number (N) of bacterial isolates that underwent AST each year is below the CLSI-recommended threshold of 30 isolates, meaningful trends in susceptibility for all years in this dataset cannot be determined. As such, an interpretation of the broader chicken cecal data across California cannot be provided.

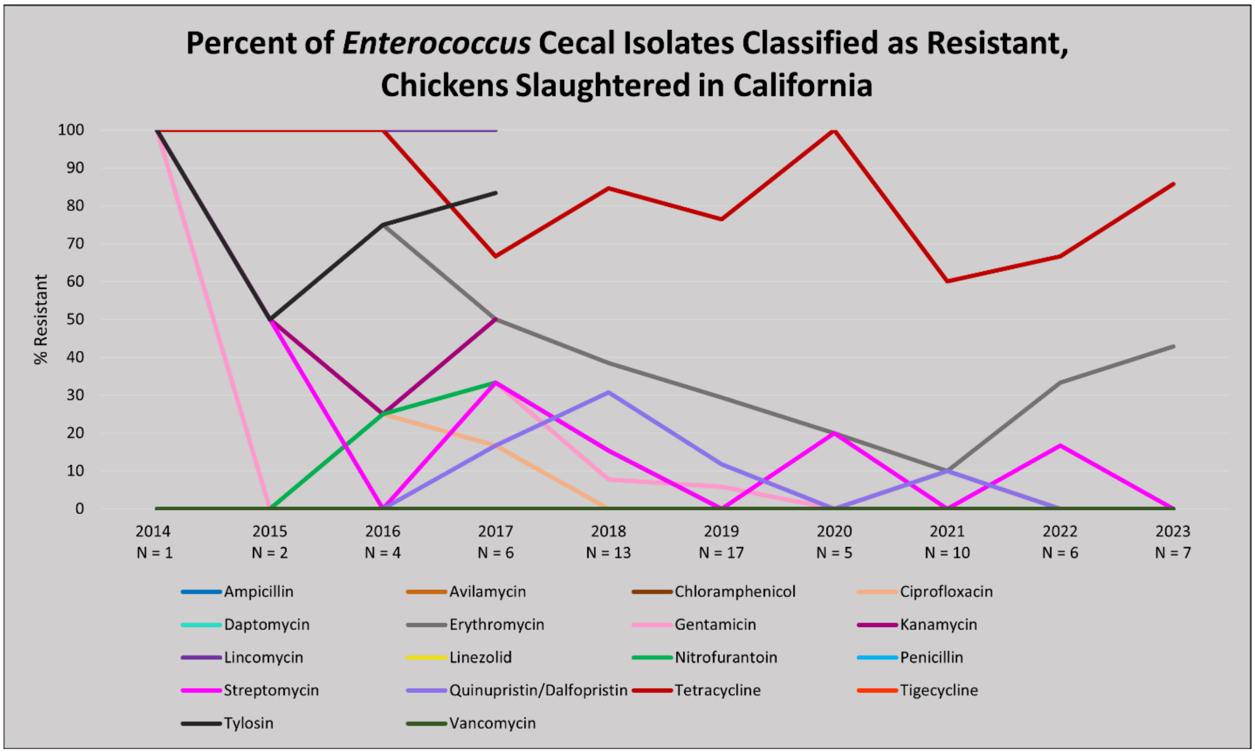



***Figure 7. Data Trends in the Percent Resistant Enterococcus Isolates from Chickens Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.***

N indicates the number of isolates tested in a given year. Years and sample numbers shaded in gray indicate less than 30 isolates; therefore, these numbers should be interpreted with caution and are not considered representative of the broader population of chickens raised or slaughtered in California.

## Heat Map of Percent Resistant *Enterococcus* in NARMS Cecal Isolates Chickens Slaughtered in California, 2014-2023

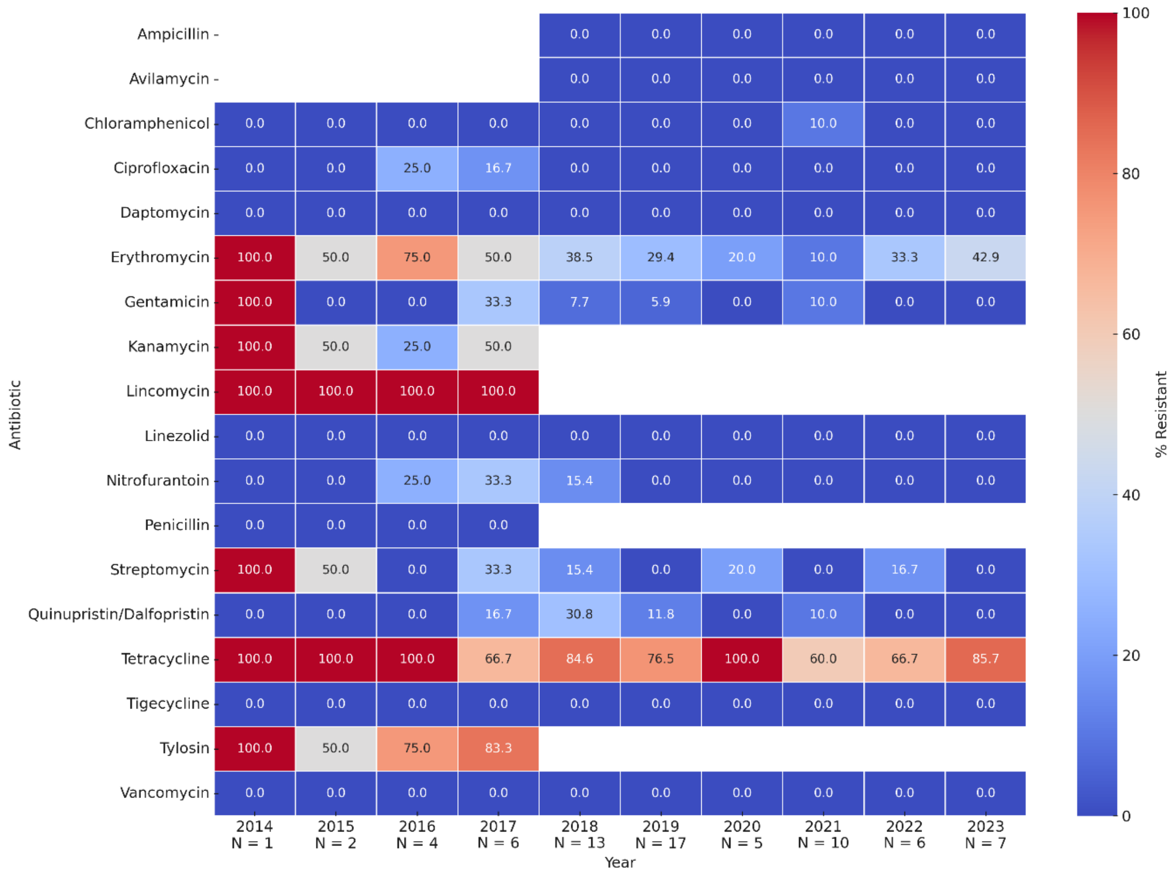



***Figure 8. Heat Map Displaying Trends in the Percent Resistant Enterococcus Isolates from Chickens Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.*** N indicates the number of isolates tested in a given year. Since less than 30 isolates were tested yearly, these numbers should be interpreted with caution and are not considered representative of the broader population of chickens raised or slaughtered in California.

**Heat Map of Percent Resistant *Enterococcus faecalis* in NARMS Cecal Isolates Chickens Slaughtered in California, 2014-2023**

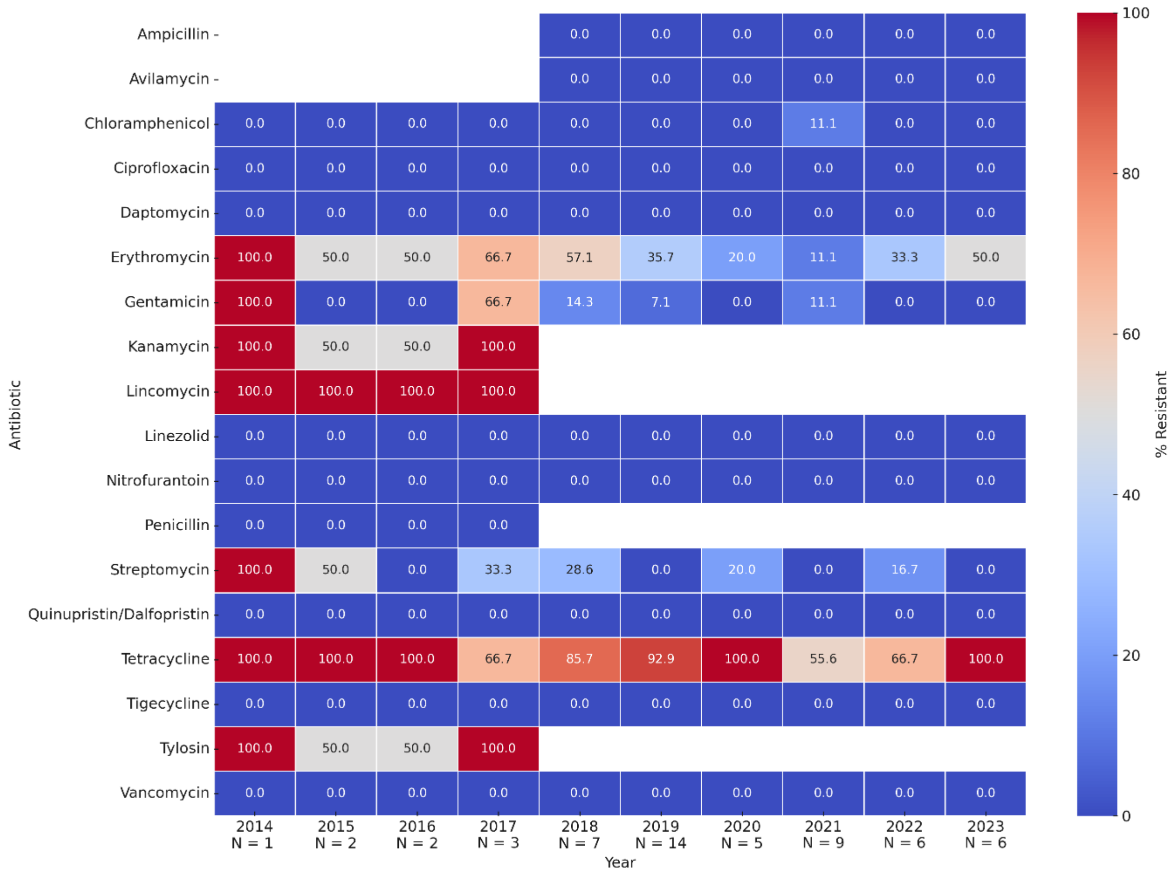



***Figure 9. Heat Map Displaying Trends in the Percent Resistant Enterococcus faecalis Isolates from Chickens Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.***

N indicates the number of isolates tested in a given year. Since less than 30 isolates were tested yearly, these numbers should be interpreted with caution and are not considered representative of the broader population of chickens raised or slaughtered in California.

**Heat Map of Percent Resistant *Enterococcus faecium* in NARMS Cecal Isolates Chickens Slaughtered in California, 2014-2023**

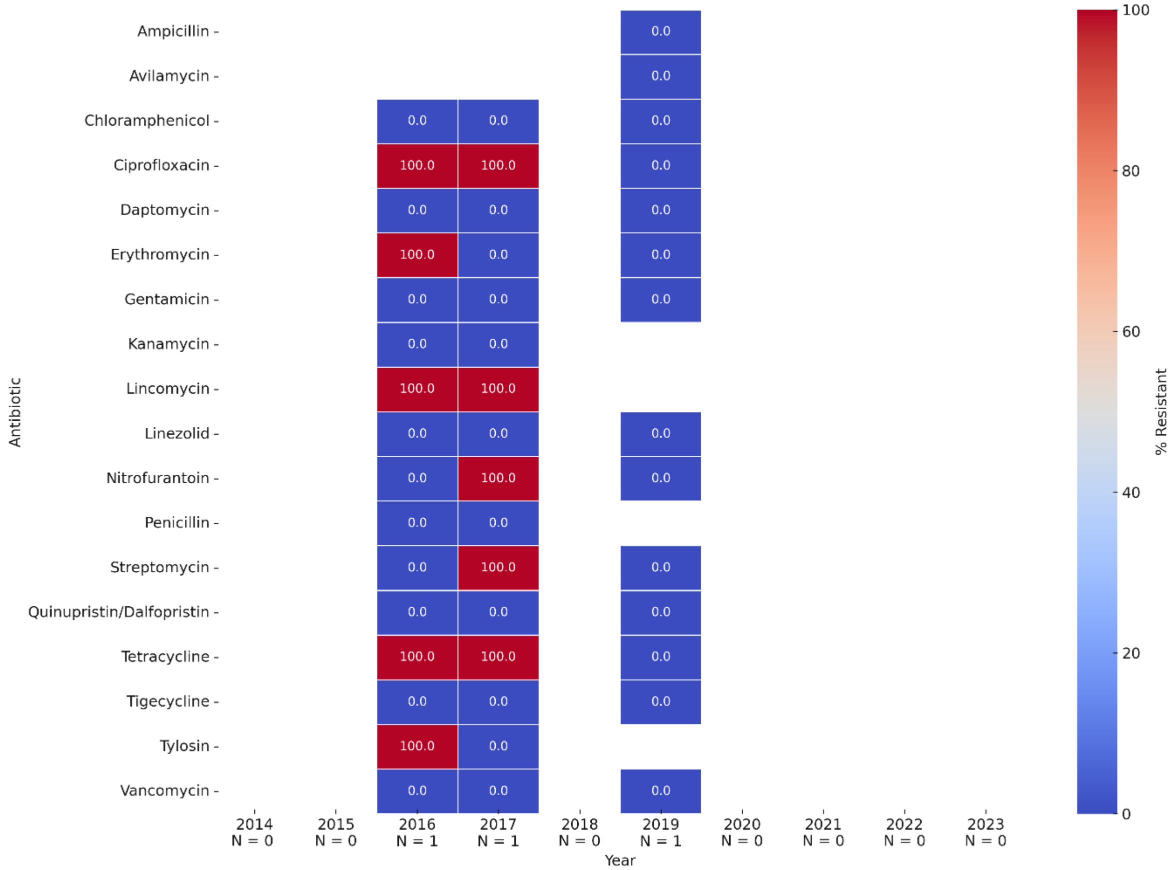



***Figure 10. Heat Map Displaying Trends in the Percent Resistant Enterococcus faecium Isolates from Chickens Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.***

N indicates the number of isolates tested in a given year. Since less than 30 isolates were tested yearly, these numbers should be interpreted with caution and are not considered representative of the broader population of chickens raised or slaughtered in California.

## Turkeys

The percentage of *Enterococcus* isolates from screened NARMS cecal samples collected from turkeys slaughtered in California that were classified as resistant in relation to the antibiotics included in the NARMS *Enterococcus* AST panel by year is displayed in **Figures 11** to **14**. Since the number (N) of bacterial isolates that underwent AST each year is below the CLSI-recommended threshold of 30 isolates, meaningful trends in susceptibility for all years in this dataset cannot be determined. As such, an interpretation of the broader turkey cecal data across California cannot be provided.

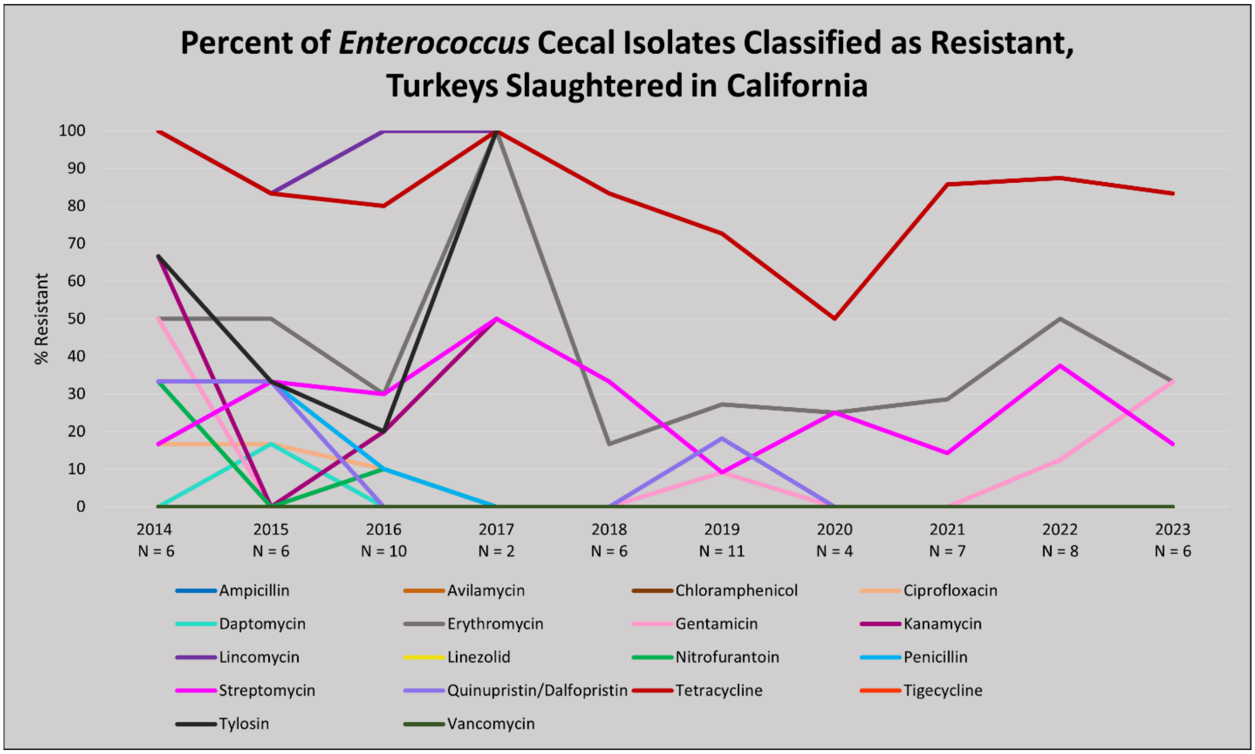



***Figure 11. Data Trends in the Percent Resistant Enterococcus Isolates from Turkeys Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.***

N indicates the number of isolates tested in a given year. Years and sample numbers shaded in gray indicate less than 30 isolates; therefore, these numbers should be interpreted with caution and are not considered representative of the broader population of turkeys raised or slaughtered in California.

## Heat Map of Percent Resistant *Enterococcus* in NARMS Cecal Isolates Turkeys Slaughtered in California, 2014-2023

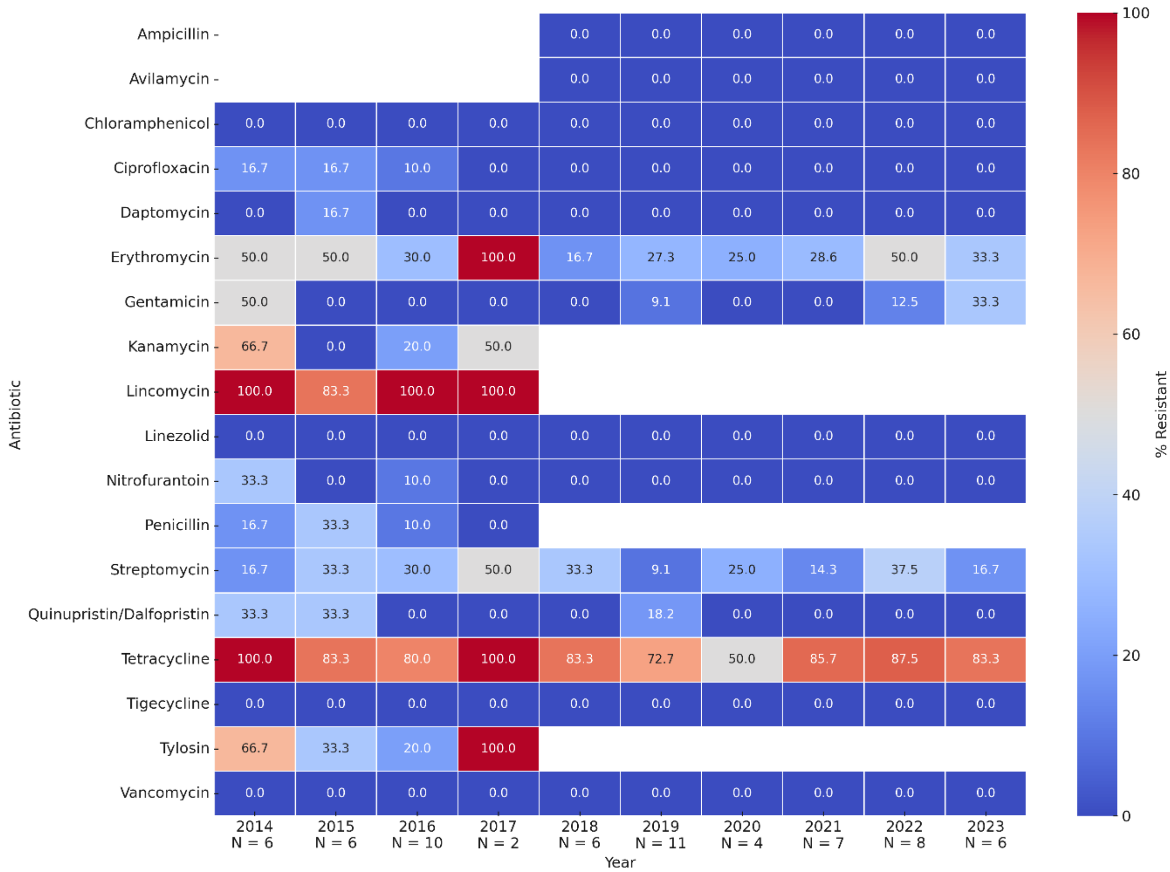



***Figure 12. Heat Map Displaying Trends in the Percent Resistant Enterococcus Isolates from Turkeys Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.*** N indicates the number of isolates tested in a given year. Since less than 30 isolates were tested yearly, these numbers should be interpreted with caution and are not considered representative of the broader population of turkeys raised or slaughtered in California.

## Heat Map of Percent Resistant *Enterococcus faecalis* in NARMS Cecal Isolates Turkeys Slaughtered in California, 2014-2023

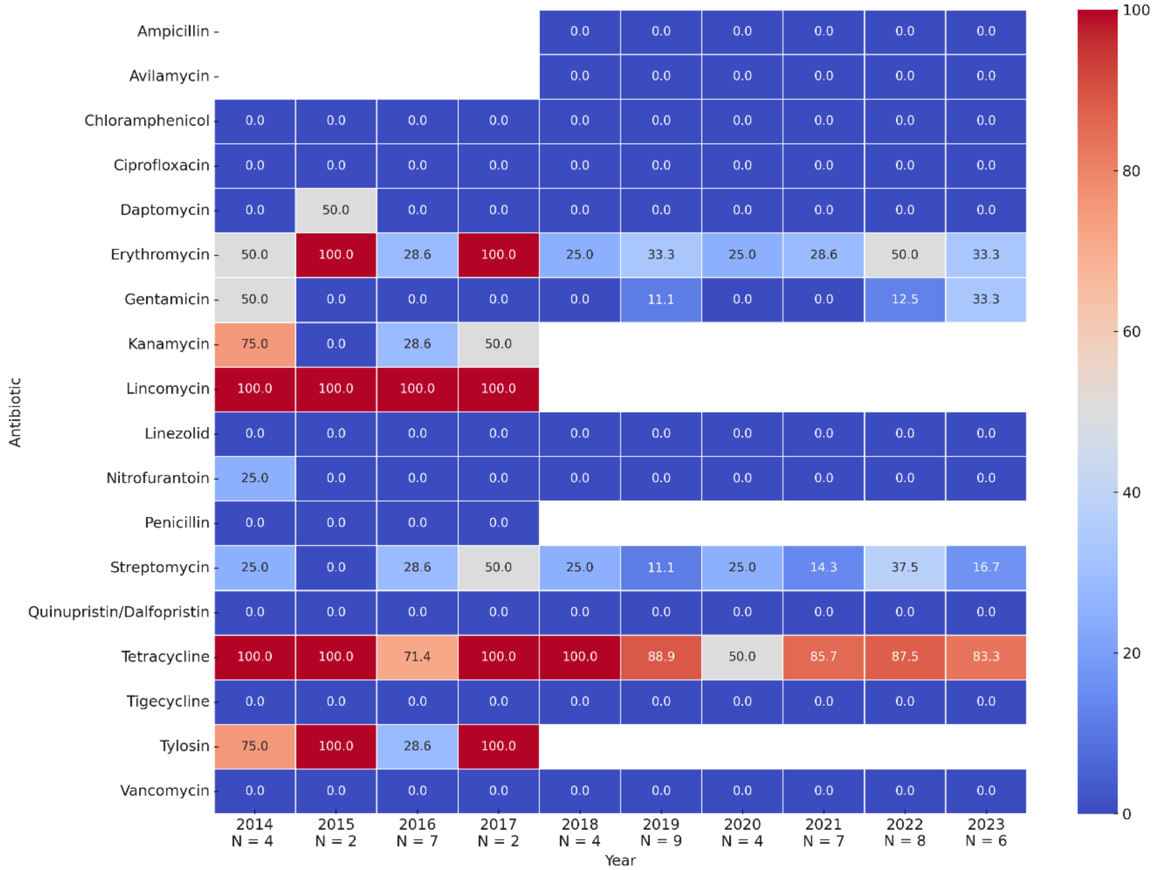



***Figure 13. Heat Map Displaying Trends in the Percent Resistant Enterococcus faecalis Isolates from Turkeys Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.***

N indicates the number of isolates tested in a given year. Since less than 30 isolates were tested yearly, these numbers should be interpreted with caution and are not considered representative of the broader population of turkeys raised or slaughtered in California.

**Heat Map of Percent Resistant *Enterococcus faecium* in NARMS Cecal Isolates Turkeys Slaughtered in California, 2014-2023**

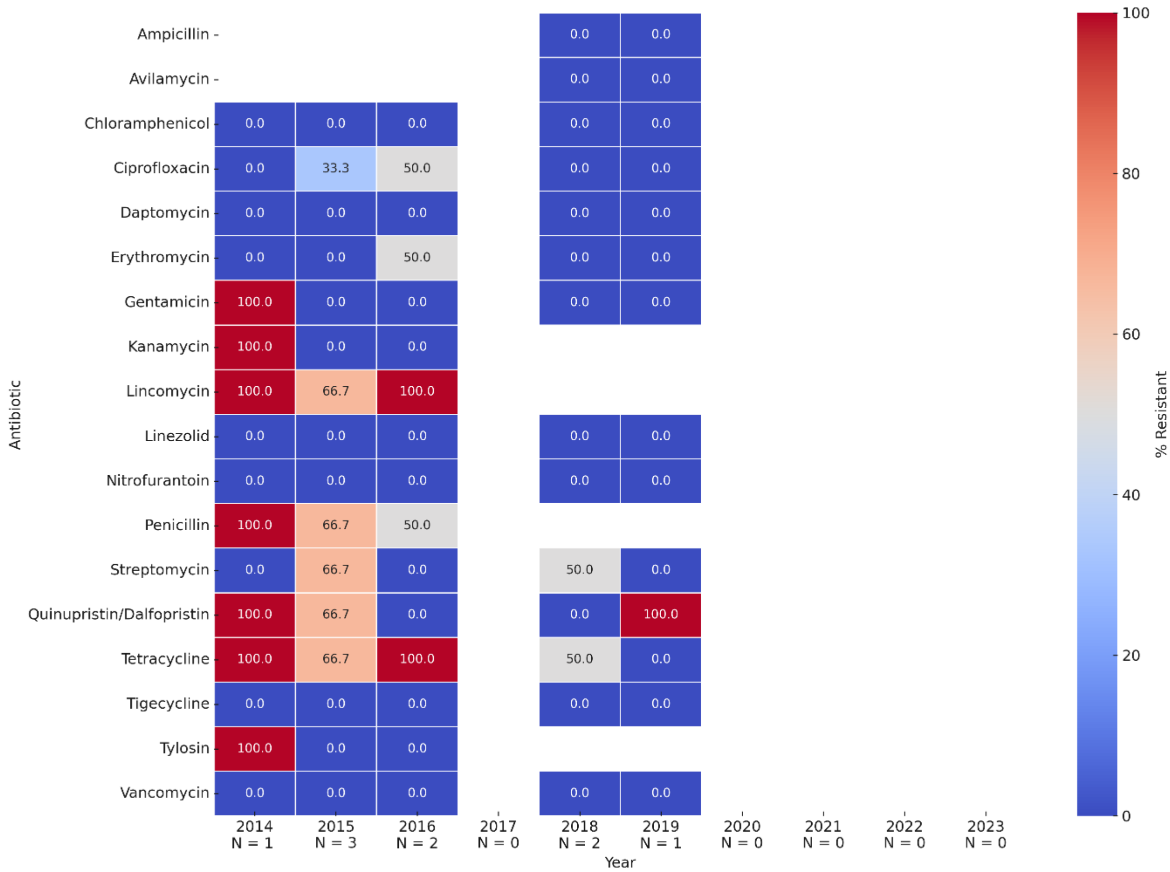



***Figure 14. Heat Map Displaying Trends in the Percent Resistant Enterococcus faecium Isolates from Turkeys Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.***

N indicates the number of isolates tested in a given year. Since less than 30 isolates were tested yearly, these numbers should be interpreted with caution and are not considered representative of the broader population of turkeys raised or slaughtered in California.

## Swine

The percentage of *Enterococcus* isolates from screened NARMS cecal samples collected from swine slaughtered in California that were classified as resistant in relation to the antibiotics included in the NARMS *Enterococcus* AST panel by year is displayed in **Figures 15 through 18**. Since the number (N) of bacterial isolates that underwent AST each year is below the CLSI-recommended threshold of 30 isolates, meaningful trends in susceptibility for all years in this dataset cannot be determined. As such, an interpretation of the broader swine cecal data across California cannot be provided.

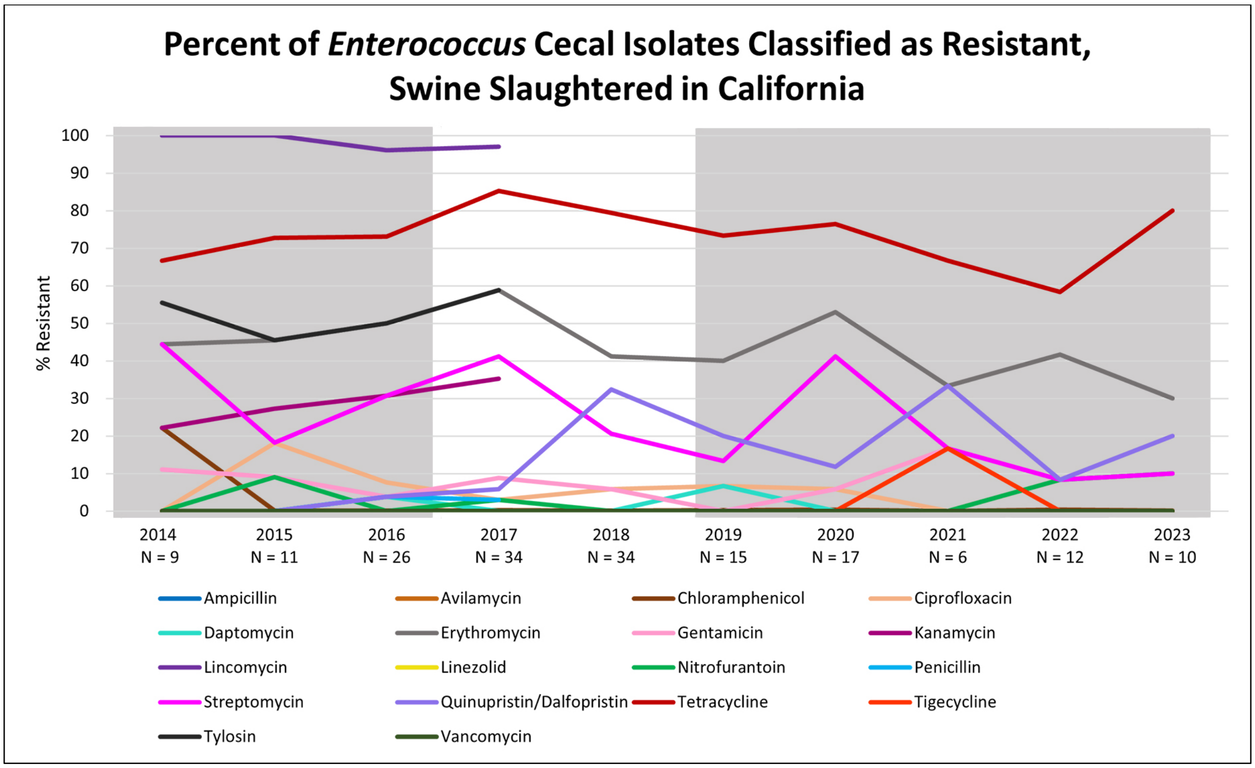



***Figure 15. Data Trends in the Percent Resistant Enterococcus Isolates from Swine Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.***

N indicates the number of isolates tested in a given year. Years and sample numbers shaded in gray indicate less than 30 isolates; therefore, these numbers should be interpreted with caution and are not considered representative of the broader population of swine raised or slaughtered in California.

## Heat Map of Percent Resistant *Enterococcus* in NARMS Cecal Isolates Swine Slaughtered in California, 2014-2023

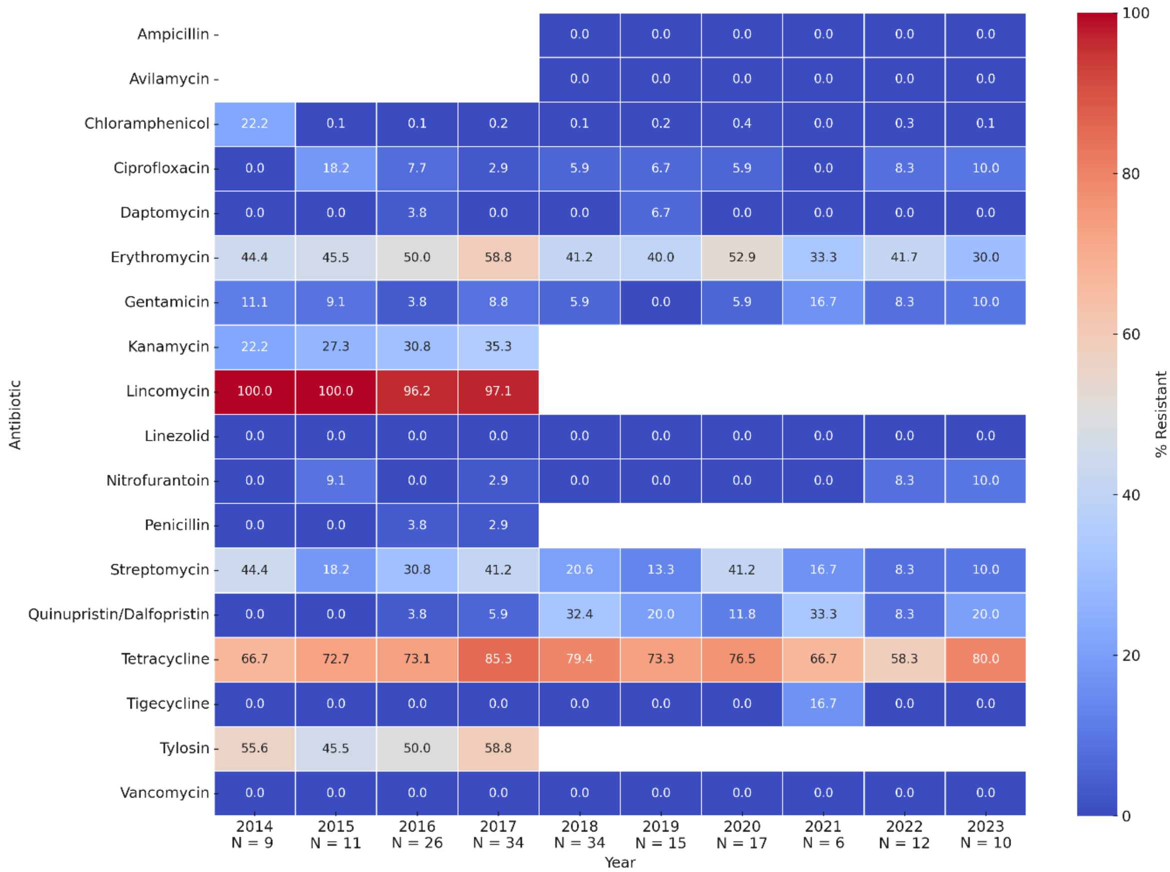
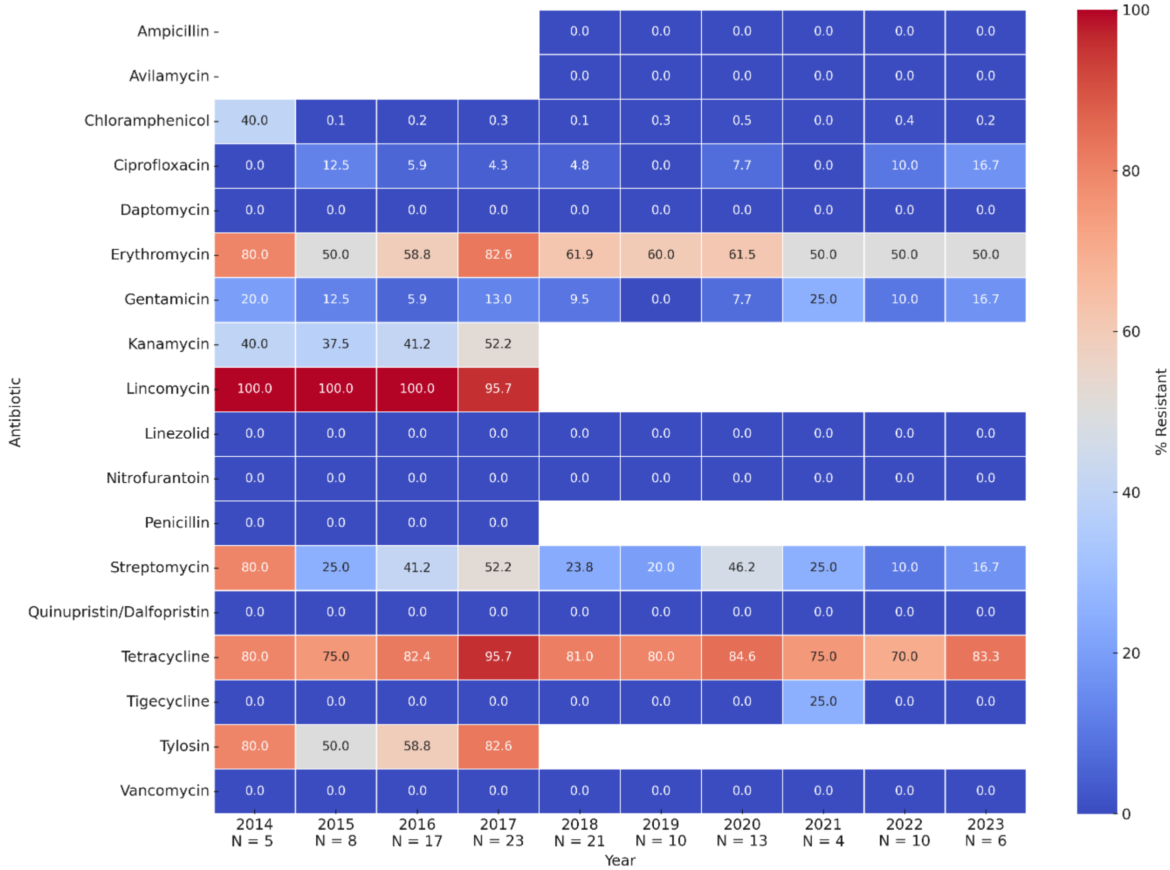



***Figure 16. Heat Map Displaying Trends in the Percent Resistant Enterococcus Isolates from Swine Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.*** N indicates the number of isolates tested in a given year. Since less than 30 isolates were tested yearly, these numbers should be interpreted with caution and are not considered representative of the broader population of swine raised or slaughtered in California.

## Heat Map of Percent Resistant *Enterococcus faecalis* in NARMS Cecal Isolates Swine Slaughtered in California, 2014-2023




| Antibiotic | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| Ampicillin | | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Avilamycin | | | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Chloramphenicol | 40.0 | 0.1 | 0.2 | 0.3 | 0.1 | 0.3 | 0.5 | 0.0 | 0.4 | 0.2 |
| Ciprofloxacin | 0.0 | 12.5 | 5.9 | 4.3 | 4.8 | 0.0 | 7.7 | 0.0 | 10.0 | 16.7 |
| Daptomycin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Erythromycin | 80.0 | 50.0 | 58.8 | 82.6 | 61.9 | 60.0 | 61.5 | 50.0 | 50.0 | 50.0 |
| Gentamicin | 20.0 | 12.5 | 5.9 | 13.0 | 9.5 | 0.0 | 7.7 | 25.0 | 10.0 | 16.7 |
| Kanamycin | 40.0 | 37.5 | 41.2 | 52.2 | | | | | | |
| Lincomycin | 100.0 | 100.0 | 100.0 | 95.7 | | | | | | |
| Linezolid | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Nitrofurantoin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Penicillin | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | |
| Streptomycin | 80.0 | 25.0 | 41.2 | 52.2 | 23.8 | 20.0 | 46.2 | 25.0 | 10.0 | 16.7 |
| Quinupristin/Dalfopristin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Tetracycline | 80.0 | 75.0 | 82.4 | 95.7 | 81.0 | 80.0 | 84.6 | 75.0 | 70.0 | 83.3 |
| Tigecycline | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 25.0 | 0.0 | 0.0 |
| Tylosin | 80.0 | 50.0 | 58.8 | 82.6 | | | | | | |
| Vancomycin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

***Figure 17. Heat Map Displaying Trends in the Percent Resistant Enterococcus faecalis Isolates from Swine Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.***

N indicates the number of isolates tested in a given year. Since less than 30 isolates were tested yearly, these numbers should be interpreted with caution and are not considered representative of the broader population of swine raised or slaughtered in California.

## Heat Map of Percent Resistant *Enterococcus faecium* in NARMS Cecal Isolates Swine Slaughtered in California, 2014-2023

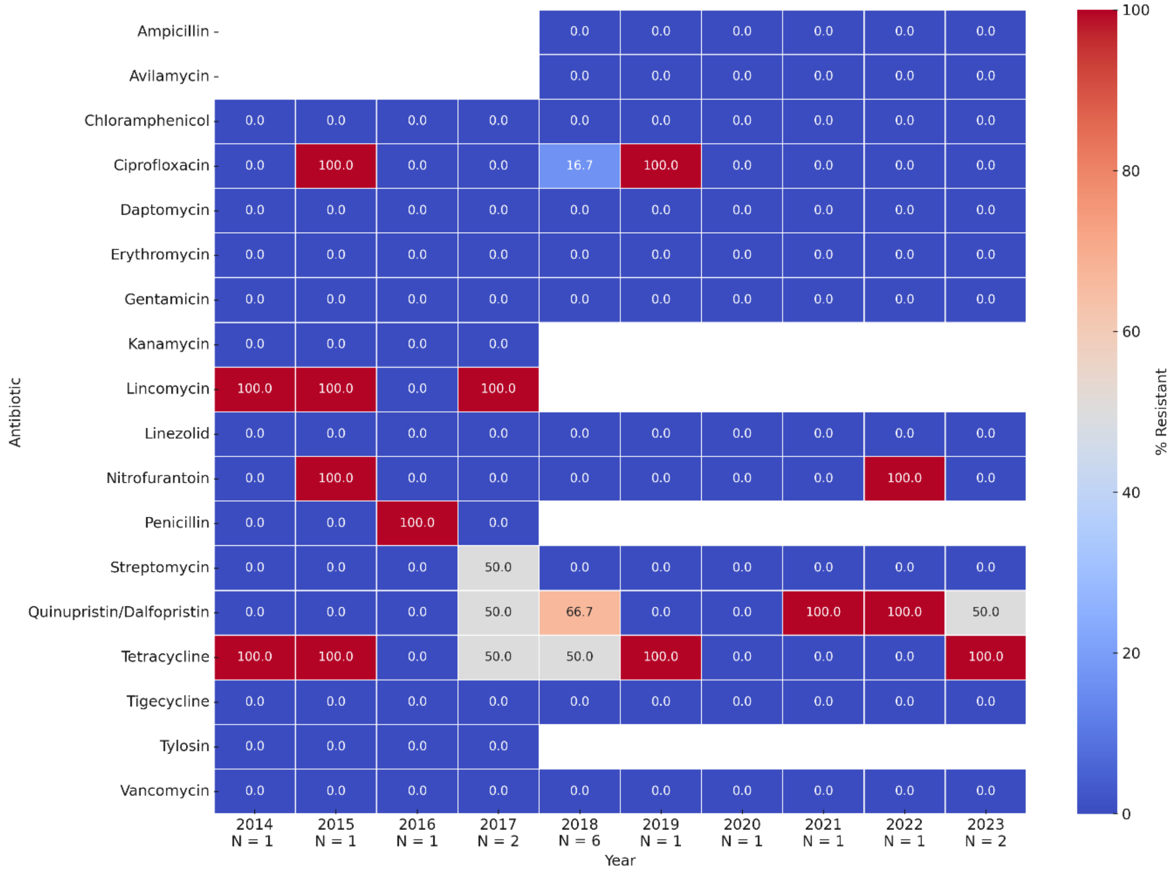


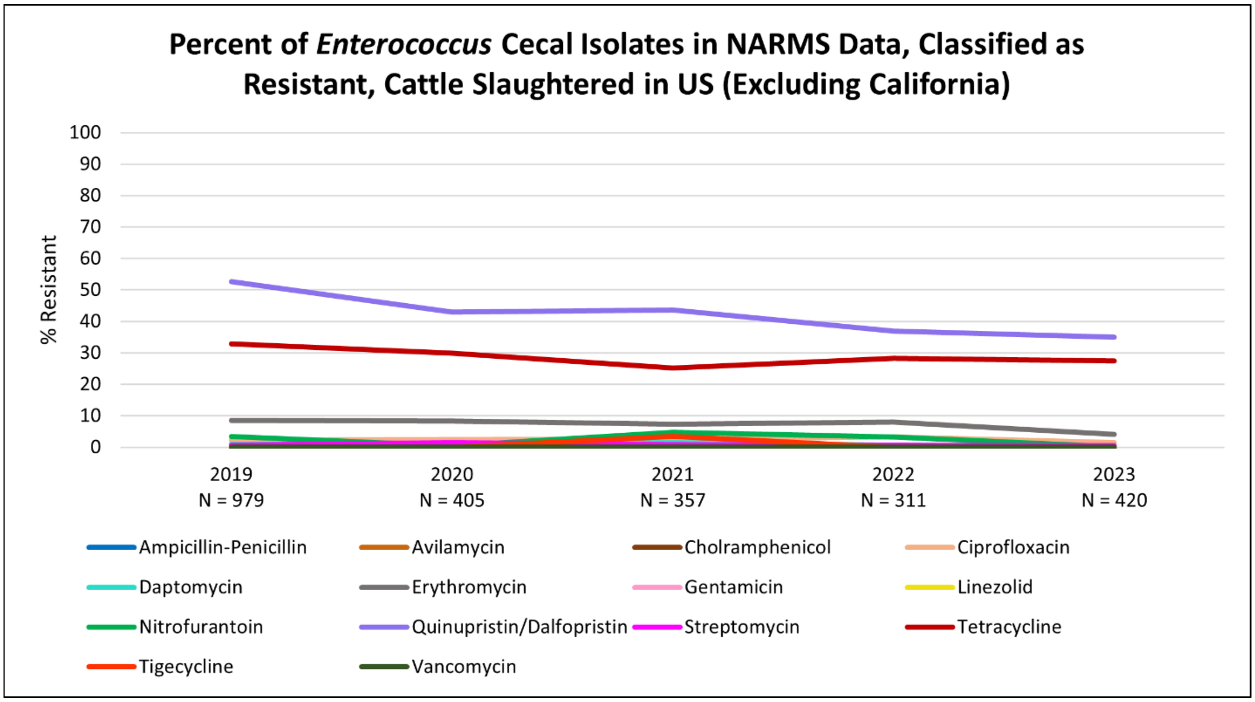

***Figure 18. Heat Map Displaying Trends in the Percent Resistant Enterococcus faecium Isolates from Swine Slaughtered in California, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2014-2023.***

N indicates the number of isolates tested in a given year. Since less than 30 isolates were tested yearly, these numbers should be interpreted with caution and are not considered representative of the broader population of swine raised or slaughtered in California.

## Comparison of California-Specific Antibiotic Susceptibility Trends to Other NARMS-Participating States

Data across all NARMS-participating states was obtained from the NARMS Now Integrated Data portal.[11] Below, trends in percent resistance among NARMS *Enterococcus* species cecal isolates from cattle slaughtered in California are compared side-by-side with cattle data from other states contributing to the NARMS Cecal Sampling Program (excluding California data) for antibiotics available in the NARMS Now Integrated Data portal from 2019-2023. To further illustrate California's alignment or divergence from resistance trends observed in cattle isolates from other states participating in the NARMS Cecal Sampling Program, we also present a heat map. Although the national data (excluding California) for NARMS *Enterococcus* species cecal isolates from chickens, turkeys, and swine are displayed below, side-by-side comparisons with California-specific data and heat maps are not provided due to the low number of isolates from California, which limits meaningful interpretations.

**Figure 19** illustrates that *Enterococcus* isolates from NARMS cecal samples collected from cattle slaughtered both nationwide (excluding California) and in California continue to show low levels of resistance to most antibiotics tested in the NARMS antibiotic panel. Although resistance to quinupristin/dalfopristin was initially relatively high in 2019, it has declined steadily through 2023 for both the U.S and California data, with California-slaughtered cattle isolates consistently demonstrating a lower percentage of resistant isolates than the national data. Nationally, isolates resistant to tetracycline have remained moderate at around 30% over the years displayed. In contrast, resistant isolates recovered exclusively from cattle slaughtered in California have remained consistently lower than the national average, with the exception of 2022, in which the percentage of resistant isolates was comparable between the two datasets. The remaining antibiotics have consistently shown levels of resistant isolates below 10%, with only minor fluctuations from year to year, and 0% resistant isolates reported for vancomycin.



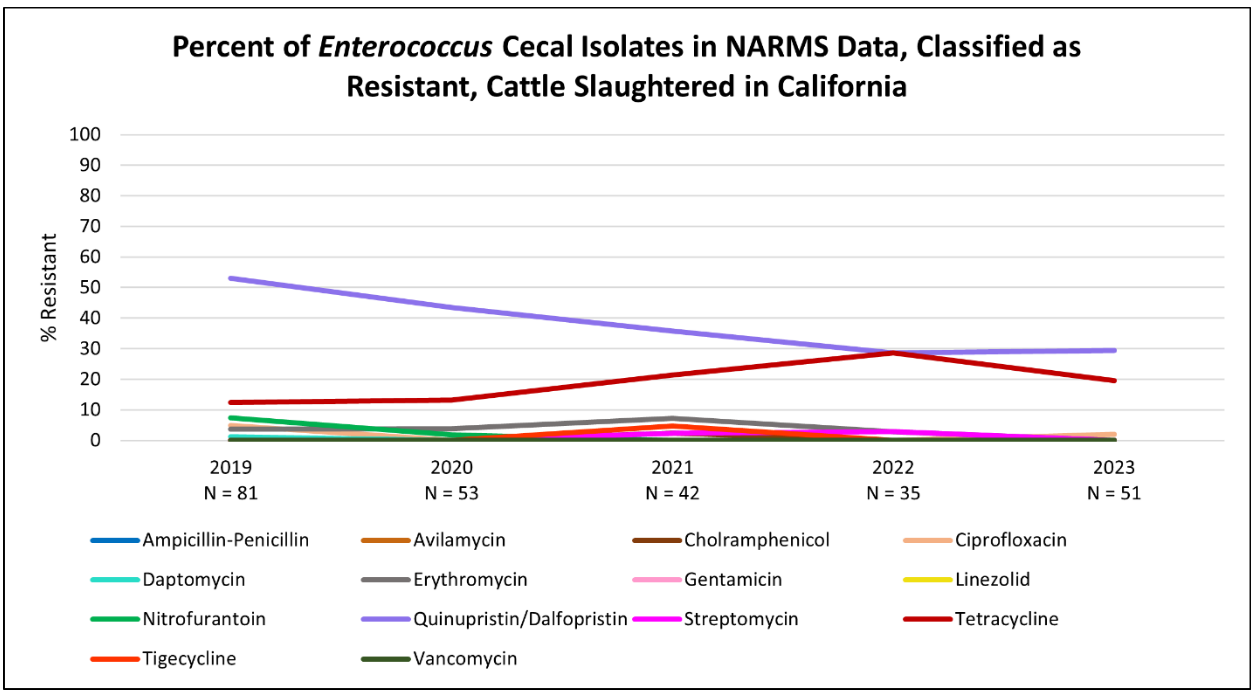




***Figure 19. Comparison of Trends in the Percent Resistant Enterococcus Isolates from US NARMS Cattle Data (excluding California) and Cattle Slaughtered in California Data, NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2019-2023.***

N indicates the number of isolates tested in a given year.

**Figure 20** is a heat map comparison of NARMS cecal *Enterococcus* isolates from cattle. This comparison graph illustrates the percentage difference in resistance of NARMS *Enterococcus* isolates to the NARMS antibiotic panel in California-slaughtered cattle versus other states participating in the NARMS program, by year. Red tones, or positive differences, indicate higher percentages of resistant isolates in California-slaughtered cattle samples, while blue tones, or negative differences, reflect lower percentages of resistant isolates in California-slaughtered cattle samples, as compared to other participating states. California generally showed lower resistant percentages for antibiotics such as tetracycline and erythromycin, especially in 2023. A notable difference was seen for quinupristin/dalfopristin yearly since 2021, indicating consistently lower percentages of resistant isolates in California. Conversely, only minor or no differences were observed for several other drugs, suggesting overall alignment with national trends for most tested antibiotics.

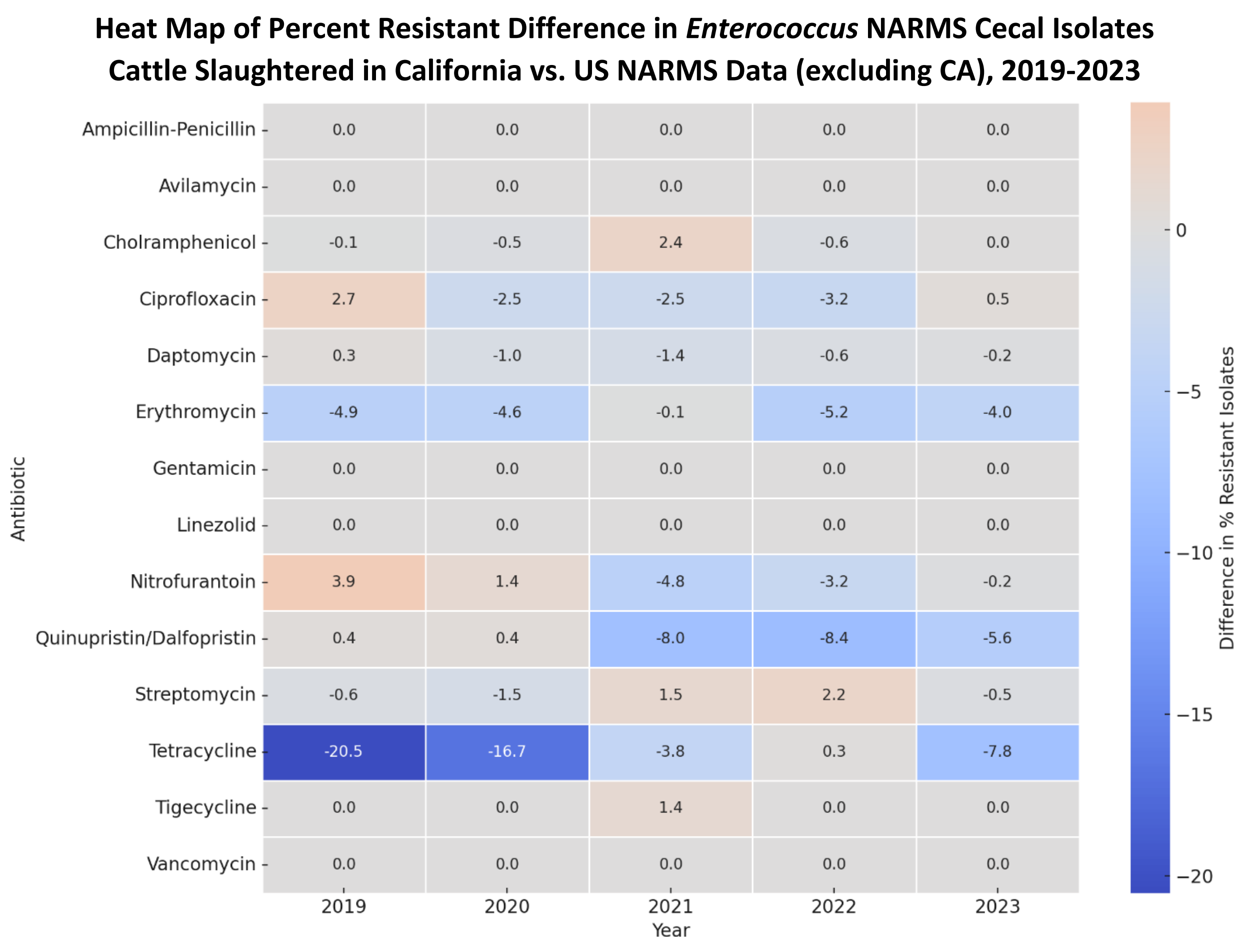



***Figure 20. Heat Map Displaying Trends in the Percent Resistant Enterococcus Isolates from US NARMS Cattle Data (excluding California) and Cattle Slaughtered (California-only Data), NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2019-2023.***

The *Enterococcus* resistance data for chickens, turkeys, and swine slaughtered in other states participating in the NARMS program, excluding California, are presented in **Figures 21, 22, and 23**. However, the number of California-specific bacterial isolates that underwent AST per year for these species remained below the recommended threshold of 30 isolates necessary to compare trends in percentage of resistant isolates between datasets. As a result, side-by-side comparison and the interpretation of these data cannot be provided.

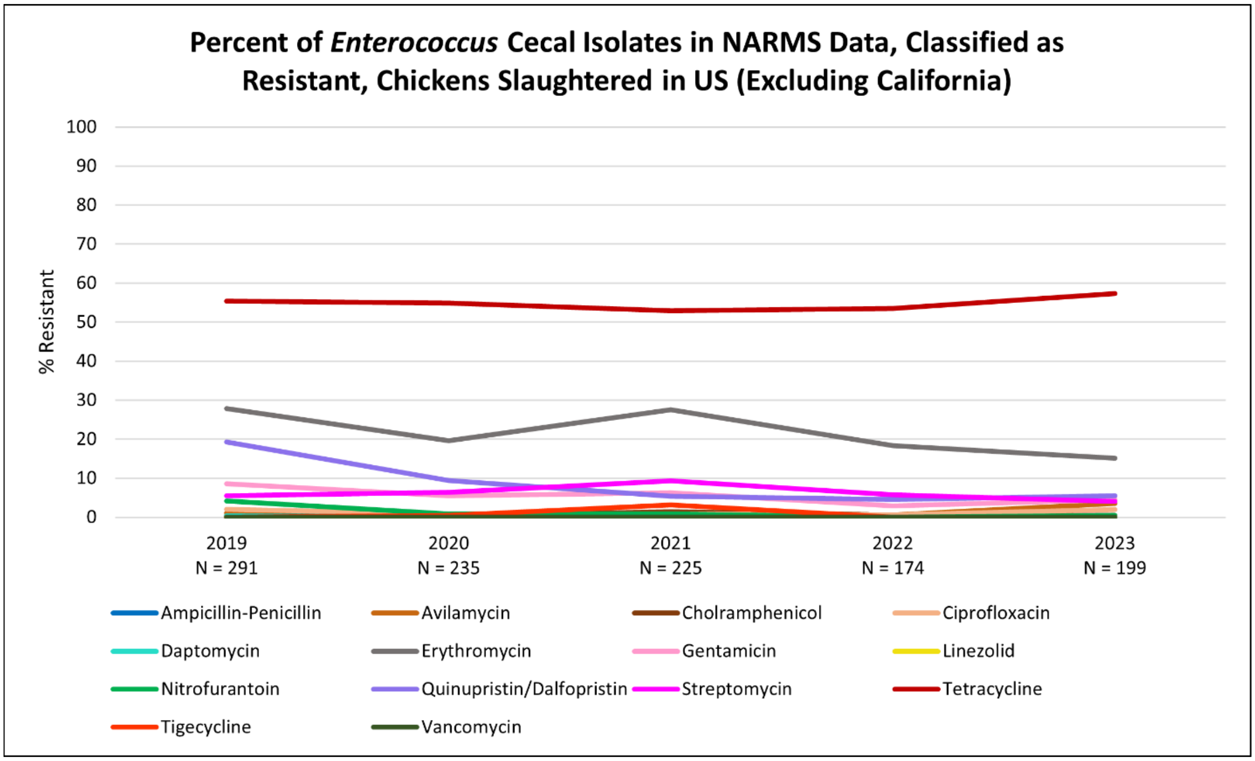



***Figure 21. The Percent Resistant Enterococcus Isolates in Chickens, US NARMS Data (excluding California), NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2019-2023.***
N indicates the number of isolates tested in a given year.

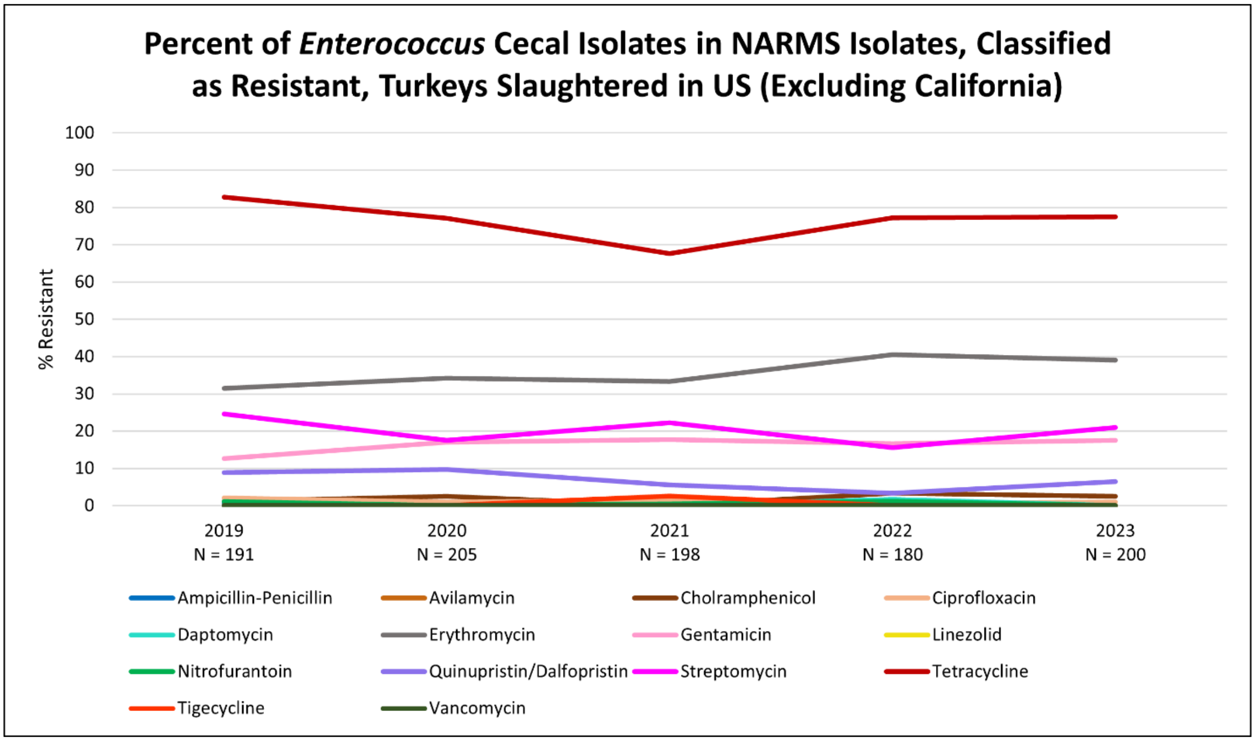



***Figure 22. The Percent Resistant Enterococcus Isolates in Turkeys, US NARMS Data (excluding California), NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2019-2023.***
N indicates the number of isolates tested in a given year.

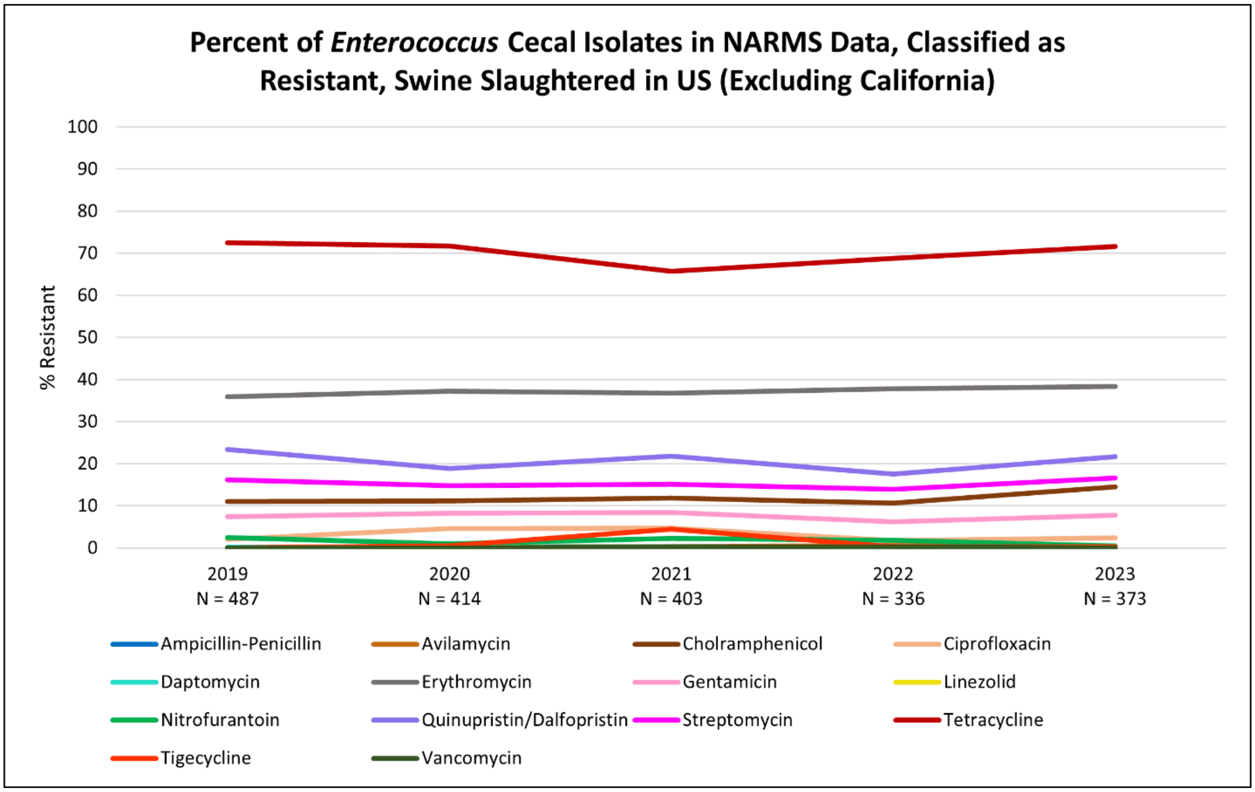



***Figure 23. The Percent Resistant Enterococcus Isolates in Swine, US NARMS Data (excluding California), NARMS Cecal Isolates Tested with the NARMS Antibiotic Panel, 2019-2023.***
N indicates the number of isolates tested in a given year.

## Future Directions

NARMS continues to expand its usage of WGS to predict antimicrobial resistance profiles and has transitioned toward using WGS to predict antimicrobial susceptibility in most non-cecal isolates, moving away from traditional phenotypic AST.[34] As a result, future NARMS reports may present susceptibility data based on genomic prediction models rather than interpretations of laboratory-derived MICs. This shift may lead to changes in how susceptibility classifications are reported, potentially affecting trend comparisons over time.

To date, AUS has published a California-specific report on *Campylobacter* and, now, *Enterococcus*. In the future, AUS plans to publish California-specific pathogen reports for NARMS data on *Salmonella* and *E. coli* cecal isolates. While these reports will present comparable information, the format and specific content may differ by pathogen due to variations in NARMS AST methodology and interpretive criteria, and the number of isolates obtained from California. Additionally, AUS intends to release a cattle-focused report that will include data on all four enteric pathogens monitored in the NARMS database. Finally, AUS is committed to overcoming the inherent challenges of static reports and is actively exploring innovative solutions to provide stakeholders with an interactive dashboard. This user-driven experience will ensure that all data is easily accessible and readily available, empowering our stakeholders to make informed and timely decisions.

# Acknowledgements

CDFA AUS would like to thank USDA-FSIS and NARMS for providing access to these valuable data specific to California and general consultation on the dataset organization and NARMS program procedures.

# Appendix A

Antimicrobial Agents and Antimicrobial Susceptibility Testing Methods for *Enterococcus* Isolates, 2001-2024[1].[35]

| | Method | Broth Microdilution | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sensititre® Plate Name | CMV4ACDC[2] / CMV5ACDC | CMV5ACDC | CMV1AGPF | CMV1AGPF[3] / CMV2AGPF | CMV2AGPF | CMV3AGPF | CMV4AGPF |
| | Year | 2001 | 2002 - 2003 | 2004 | 2005 | 2006 - 2008 | 2009 - 2017 | 2018-Current |
| **Antimicrobial Class** | **Antimicrobial Agent** | | | | | | | |
| **Aminoglycosides** | Gentamicin | √ | √ √ | √ | √ | √ | √ | √ |
| | Kanamycin | √ | √ √ | √ | √ | √ | √ | |
| | Streptomycin | √ | √ √ | √ | √ | √ | √ | √ |
| **Glycopeptides** | Vancomycin | √ | √ √ | √ | √ | √ | √ | √ |
| **Glycylcyclines** | Tigecycline | | | | √ | √ | √ | √ |
| **Ionophores** | Salinomycin | √ | √ | | | | | |
| **Lincosamides** | Lincomycin | √ | √ | √ | √ | √ | √ | |
| **Lipopeptides** | Daptomycin | | | √ | √ | √ | √ | √ |
| **Macrolides** | Erythromycin | √ | √ | √ | √ | √ | √ | √ |
| | Tylosin | √ | √ | √ | √ | √ | √ | |
| **Nitrofurans** | Nitrofurantoin | √ | √ | √ | √ | √ | √ | √ |
| **Oxazolidinones** | Linezolid | √ | √ | √ | √ | √ | √ | √ |
| **Orthosomycin** | Avilamycin | | | | | | | √ |
| **Penicillins** | Penicillin/Ampicillin[5] | √ | √ | √ | √ | √ | √ | √ |
| **Phenicols** | Chloramphenicol | √ | √ | √ | √ | √ | √ | √ |
| **Phosphoglycolipids** | Flavomycin | √ | √ | √ | √ | √[4] | | |
| **Polypeptides** | Bacitracin | √ | √ | √ | √ | | | |
| **Quinolones** | Ciprofloxacin | √ | √ | √ | √ | √ | √ | √ |
| **Streptogramins** | Quinupristin-Dalfopristin | √ | √ | √ | √ | √ | √ | √ |
| | Virginiamycin | √ | | | | | | |
| **Tetracyclines** | Tetracycline | √ | √ | √ | √ | √ | √ | √ |

[1] Testing of *Enterococcus* isolates from retail meats and chickens began in 2002 and 2003, respectively. A study of *Enterococcus* isolates from people in the community began in 2001

[2] In 2001, most isolates were tested using Sensititre® plate CMV5ACDC, but a few isolates were tested using Sensititre® plate CMV4ACDC

[3] In 2005, isolates from chickens and most isolates from humans were tested with Sensititre® plate CMV1AGPF, while isolates from retail meats were tested with Sensititre® plate CMV2AGPF

[4] Flavomycin was not available for all of the plates used to test isolates from 2008

[5] Ampicillin replaced penicillin in CMV5AGPF

## Appendix B

Table B1. Interpretive Criteria Used for Susceptibility Testing of *Enterococcus*[1].[35]

| Antimicrobial Class | Antimicrobial Agent | Profile Abbreviaton | Breakpoints (µg/ml) | | |
|---|---|---|---|---|---|
| | | | Susceptible | Intermediate | Resistant |
| **Aminoglycosides** | Gentamicin | Gen | ≤ 500 | N/A | >500 |
| | Kanamycin[2] | Kan | ≤ 512 | N/A | ≥ 1024 |
| | Streptomycin | Str | ≤ 512 | N/A | ≥ 1000 |
| **Glycopeptides** | Vancomycin | Van | ≤ 4 | 8 -16 | ≥ 32 |
| **Glycylcycline** | Tigecycline[2,3] | Tig | ≤ 0.25 | N/A | ≥ 0.5 |
| **Lincosamides** | Lincomycin[2] | Lin | ≤ 2 | 4 | ≥ 8 |
| **Lipopeptides** | Daptomycin[4] | Dap | ≤ 2 | 4 | ≥ 8 |
| **Macrolides** | Erythromycin | Ery | ≤ 0.5 | 1 - 4 | ≥ 8 |
| | Tylosin[2] | Tyl | ≤ 8 | 16 | ≥ 32 |
| **Nitrofurans** | Nitrofurantoin | Nit | ≤ 32 | 64 | ≥ 128 |
| **Oxazolidinones** | Linezolid | Lzd | ≤ 2 | 4 | ≥ 8 |
| **Orthosomycin** | Avilamycin[5] | Avi | N/A | N/A | ≥ 32 |
| **Penicillins** | Penicillin/Ampicillin[6] | Pen/Amp | ≤ 8 | N/A | ≥ 16 |
| **Phenicols** | Chloramphenicol | Chl | ≤ 8 | 16 | ≥ 32 |
| **Quinolone** | Ciprofloxacin | Cip | ≤ 1 | 2 | ≥ 4 |
| **Streptogramins** | Quinupristin/ Dalfopristin[7] | Syn | ≤ 1 | 2 | ≥ 4 |
| **Tetracyclines** | Tetracycline | Tet | ≤ 4 | 8 | ≥ 16 |

[1] Breakpoints were adopted from CLSI (Clinical and Laboratory Standards Institute) M100-S22 document, where available.

[2] No CLSI interpretive criteria for this bacterium/antimicrobial combination currently available.

[3] Only a susceptible breakpoint (≤0.25 µg/ml) has been established. Isolates with an MIC ≥0.5 µg/ml are reported as resistant.

[4] For *E*. faecium only: susceptible ≤4 and resistant is ≥ 8

[5] The resistant breakpoint for *E*. faecalis is ≥ 16

[6] Ampicillin replaced penicillin in 2020

[7] Enterococcus faecalis is intrinsically resistant to Quinupristin/Dalfopristin - interpretations are entered as 'NA'

## Appendix C

Table C1. NARMS *Enterococcus* AST Panel and Uses in Food Animals.

| Antimicrobial Class | Antimicrobial Formulation | FDA GFI 152 Classification | Human or Food Animal Use | Approved Animal Use |
|---|---|---|---|---|
| **Aminoglycosides** | Gentamicin | Critically Important | Both | Water (swine), Oral Solution (swine) IM (swine), SC (swine, chickens, turkeys), OU (calves) |
| | Kanamycin | Critically Important | Human | Not approved for use in food animals |
| | Streptomycin | Critically Important | Both | Water (calves, chickens, swine), Alternative Formulation: IM (cattle, swine) |
| **Glycopeptides** | Vancomycin | Highly Important | Human | Not approved for use in food animals |
| **Glycylcycline** | Tigecylcine | Not Classified | Human | Not approved for use in food animals |
| **Lincosamides** | Lincomycin | Not Classified | Both | Feed (chickens, swine), Water (chickens, swine), IM (swine) |
| **Lipopeptides** | Daptomycin | Critically Important | Humans | Not approved for use in food animals |
| **Macrolides** | Erythromycin | Critically Important | Both | IM (cattle), IMM (cattle), Water (chickens, turkeys), Feed (chickens, turkeys) |
| | Tylosin | Critically Important | Animals | Feed (cattle, swine), Water (swine, chickens, turkeys), IM (cattle, swine) |
| **Nitrofurans** | Nitrofurantoin | Not Classified | Humans | Not approved for use in food animals |
| **Oxazolidinones** | Linezolid | Highly Important | Humans | Not approved for use in food animals |
| **Orthosomycin** | Avilamycin | Not Classified | Both | Feed (chickens, swine) |
| **Penicillins** | Penicillin/Ampicillin | Highly Important | Both | IM (cattle, swine, chickens, turkeys), IMM (cattle) |
| **Phenicols** | Chloramphenicol | Highly Important | Humans | Not approved for use in food animals |
| **Quinolones** | Ciprofloxacin | Critically Important | Humans | Not approved for use in food animals |
| **Streptogramins** | Quinupristin/Dalfopristin | Critically Important | Humans | Not approved for use in food animals |
| **Tetracyclines** | Tetracycline | Highly Important | Both | Alternative Formulation: Feed (cattle, swine, chickens, turkeys), Water (cattle, swine, chickens, turkey), IM (cattle, swine), PO (cattle), TOP (cattle, swine) |

*Antibiotics above are those included in the NARMS antibiotic panel for *Enterococcus* AST. Food animal approved use of these drugs and other drug formulations within the antibiotic class approved per the Code of Federal Regulations, and as of publication, for use in food animals are listed. Classification of drugs per GFI #152 is listed.

| | | | |
|---|---|---|---|
| Feed: medicated feed | IM: intramuscular | SCi: subcutaneous implant | AU: otic |
| Water: medicated water | IV: intravenous | TOP: topical | OU: ocular |
| PO: oral bolus | SC: subcutaneous | | |

## References


1. Feng Q, Frana T, Logue CM, et al. Comparison of Antimicrobial Resistance Profiles in Salmonella spp. from Swine Upon Arrival and Postslaughter at the Abattoir. *Microb Drug Resist* 2021;27:1144-1154.
2. Koutsoumanis K, Allende A, Álvarez-Ordóñez A, et al. Transmission of antimicrobial resistance (AMR) during animal transport. *Efsa j* 2022;20:e07586.
3. Gaire TN, Odland C, Zhang B, et al. Slaughtering processes impact microbial communities and antimicrobial resistance genes of pig carcasses. *Science of The Total Environment* 2024;946:174394.
4. CDC. Antibiotic resistance threats in the United States, 2019. Atlanta, Georgia: U.S. Department of Health and Human Services, CDC, 2019.
5. Byappanahalli Muruleedhara N, Nevers Meredith B, Korajkic A, et al. Enterococci in the Environment. *Microbiology and Molecular Biology Reviews* 2012;76:685-706.
6. Ibekwe AM, Obayiuwana AC, Murinda SE. Enterococcus Species and Their Antimicrobial Resistance in an Urban Watershed Affected by Different Anthropogenic Sources. *Water*, 2024.
7. Ramos S, Silva V, Dapkevicius MLE, et al. Enterococci, from Harmless Bacteria to a Pathogen. *Microorganisms* 2020;8.
8. Zaidi S-e-Z, Zaheer R, Zovoilis A, et al. Enterococci as a One Health indicator of antimicrobial resistance. *Canadian Journal of Microbiology* 2024;70:303-335.
9. WHO. Integrated surveillance of antimicrobial resistance in foodborne bacteria: application of a one health approach: guidance from the WHO Advisory Group on Integrated Surveillanec of Antimicrobial Resistance (AGISAR). Geneva, 2017.
10. Boccella M, Santella B, Pagliano P, et al. Prevalence and Antimicrobial Resistance of Enterococcus Species: A Retrospective Cohort Study in Italy. *Antibiotics (Basel)* 2021;10.
11. FDA. NARMS Now. Rockville, MD: U.S. Department of Health and Human Services.
12. FDA. The National Antimicrobial Resistance Monitoring System Manual of Laboratory Methods. 4th ed, 2020.
13. FDA. NARMS Methodology. *NARMS Supplemental Material*, 2023.
14. FDA. Interpretive Criteria for Susceptibility Testing. *NARMS Supplemental Material*, 2023.
15. CLSI. Performance Standards for Antimicrobial Susceptibility Testing. M100. 35th ed. 35 ed: Clinical and Laboratory Standards Institute, 2020.
16. Hota S, Patil SR, Mane PM. Enterococcus: Understanding Their Resistance Mechanisms, Therapeutic Challenges, and Emerging Threats. *Cureus* 2025;17:e79628.
17. Levitus M, Rewane A, Perera TB. Vancomycin-Resistant Enterococci. *StatPearls*. Treasure Island (FL), 2025.
18. Agudelo Higuita NI, Huycke MM. Enterococcal Disease, Epidemiology, and Implications for Treatment In: Gilmore MS, Clewell DB, Ike Y, et al., eds. *Enterococci: From Commensals to Leading Causes of Drug Resistant Infection*. Boston, 2014.

19. Bortolaia V, Guardabassi L. Zoonotic Transmission of Antimicrobial-Resistant Enterococci: A Threat to Public Health or an Overemphasized Risk? In: Sing A, ed. *Zoonoses: Infections Affecting Humans and Animals*. Cham: Springer International Publishing, 2022;1-33.

20. Monteiro Marques J, Coelho M, Santana AR, et al. Dissemination of Enterococcal Genetic Lineages: A One Health Perspective. *Antibiotics (Basel)* 2023;12.

21. Ferchichi M, Sebei K, Boukerb AM, et al. Enterococcus spp.: Is It a Bad Choice for a Good Use-A Conundrum to Solve? *Microorganisms* 2021;9.

22. Zaheer R, Cook SR, Barbieri R, et al. Surveillance of Enterococcus spp. reveals distinct species and antimicrobial resistance diversity across a One-Health continuum. *Sci Rep* 2020;10:3937.

23. Schreier J, Rychlik I, Karasova D, et al. Influence of heat stress on intestinal integrity and the caecal microbiota during Enterococcus cecorum infection in broilers. *Veterinary Research* 2022;53:110.

24. Hogan J, Smith KL. Managing Environmental Mastitis. *Veterinary Clinics: Food Animal Practice* 2012;28:217-224.

25. Morris C, Wickramasingha D, Abdelfattah EM, et al. Prevalence of antimicrobial resistance in fecal Escherichia coli and Enterococcus spp. isolates from beef cow-calf operations in northern California and associations with farm practices. *Front Microbiol* 2023;14:1086203.

26. Hammerum AM. Enterococci of animal origin and their significance for public health. *Clin Microbiol Infect* 2012;18:619-625.

27. Mubarak AG, El-Zamkan MA, Younis W, et al. Phenotypic and genotypic characterization of Enterococcus faecalis and Enterococcus faecium isolated from fish, vegetables, and humans. *Sci Rep* 2024;14:21741.

28. Krawczyk B, Wityk P, Gałęcka M, et al. The Many Faces of Enterococcus spp.-Commensal, Probiotic and Opportunistic Pathogen. *Microorganisms* 2021;9.

29. Kristich CJ, Rice LB, Arias CA. Enterococcal Infection-Treatment and Antibiotic Resistance In: Gilmore MS, Clewell DB, Ike Y, et al., eds. *Enterococci: From Commensals to Leading Causes of Drug Resistant Infection*. Boston, 2014.

30. Boehm AB, Sassoubre LM. Enterococci as Indicators of Environmental Fecal Contamination In: Gilmore MS, Clewell DB, Ike Y, et al., eds. *Enterococci: From Commensals to Leading Causes of Drug Resistant Infection*. Boston, 2014.

31. Castillo-Rojas G, Mazari-Hiríart M, Ponce de León S, et al. Comparison of Enterococcus faecium and Enterococcus faecalis Strains isolated from water and clinical samples: antimicrobial susceptibility and genetic relationships. *PLoS One* 2013;8:e59491.

32. CLSI. Analysis and Presentation of Cumulative Antimicrobial Susceptibility Test Data. 5th ed. CLSI guideline M39: Clinical and Laboratory Standards Institute, 2022.

33. Tran C, Hargy J, Hess B, et al. Estimated Impact of Low Isolate Numbers on the Reliability of Cumulative Antibiogram Data. *Microbiol Spectr* 2023;11:e0393922.

34. USDA. Food Safety and Inspection Service  Annual Sampling Plan Fiscal Year 2025., 2025.

35. USDA. California Specific FSIS NARMS data from 1/1/2013 through 12/31/2023. Obtained through FOIA request no. 2024-FSIS-00198, recived June 2024. Unpublished data.