

Salmonella, Shigella, and Yersinia



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KEYWORDS

• *Salmonella* • *Shigella* • *Yersinia* • Enteric • Gram-negative bacilli • Gastroenteritis

KEY POINTS

- The global disease burden from *Salmonella/Shigella/Yersinia*, organisms reportable to public health departments, is quite high, with significant but fewer infections in the developed world.
- Although there is a broad spectrum of disease associated with these pathogens, infections are self-limiting in most cases. Antimicrobial therapy is ordinarily indicated only for severe gastrointestinal and systemic disease.
- Inactive strains of *Escherichia coli* can be difficult to distinguish from *Shigella* strains, using multiple laboratory methods.
- Molecular methods such as polymerase chain reaction and mass spectrometry are being used more routinely for identification of these organisms, but both methods have limitations.
- There is active investigation in the areas of vaccine development and characterization of virulence mechanisms.

INTRODUCTION

In this review, the authors discuss 3 enteric pathogens: *Salmonella*, *Shigella*, and *Yersinia*. These important members of *Enterobacteriaceae* are responsible for significant morbidity and mortality, causing diarrhea and a spectrum of associated symptoms from mild to severe in most parts of the world. In this review, the authors cover infection and epidemiology; taxonomic classification; collection, transport, and storage of specimens; culture techniques; molecular detection methods; susceptibility testing; and treatment. Discussions that pertain to individual organisms are organized into individual sections starting with *Salmonella*, followed by *Shigella* and then *Yersinia*.

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Topics common to all 3 (such as collection, transport and storage of specimens, and molecular multiplex methods of detection) are discussed as they first occur, denoted as such in paragraph headings. Throughout, priority of discussion is placed on newer techniques and data, with less emphasis on details of classic methods available in reference textbooks.

***Salmonella* Introduction**

Members of the genus *Salmonella* cause a well-characterized spectrum of disease in humans, ranging from asymptomatic carriage to fatal typhoidal fever. In the developed world, food-borne acute gastroenteritis and enterocolitis are the most common forms of *Salmonella* infection, with an estimated 1.2 million annual cases of nontyphoidal *Salmonellosis* occurring in the United States.¹⁻³ Although relatively uncommon in the United States, typhoid, paratyphoid, and enteric fever constitute a very serious global public health problem, with 25 million new infections and greater than 200,000 deaths occurring annually.^{4,5}

Salmonella is a member of the *Enterobacteriaceae*, originally characterized by the ability to metabolize citrate as a sole carbon source and lysine as a nitrogen source as well as the ability to produce hydrogen sulfide.⁶ However, classic biochemical testing alone does not unambiguously distinguish key pathogenic members of this genus, and modern classification relies instead on serology and increasingly on molecular methods.

***Salmonella* Disease Manifestations**

Infection with *Salmonella* typically follows 2 very different disease courses, depending on whether the infecting *Salmonella* strain is a typhoidal or nontyphoidal serovar. Infection with nontyphoidal serovars ordinarily presents as diarrhea associated with fever and abdominal cramping 12 to 72 hours after infection.⁷ In most cases in healthy individuals, this infection runs a self-limited course over 4 to 7 days; but, in susceptible hosts, certain nontyphoidal strains of *Salmonella* may spread systemically to other sites in the body. Although this is more common in those with compromised immune systems or underlying medical conditions (eg, sickle cell anemia), systemic spread of nontyphoidal *Salmonella* strains may also be seen in otherwise healthy individuals.

In contrast to infection with nontyphoidal *Salmonella*, infection with typhoidal strains (primarily serovars Typhi and Paratyphi) presents as a systemic, often serious, disease. After invading through intestinal mucosa, typhoidal strains disseminate through a transient primary bacteremia that may occur without diarrhea.⁵ Following hematogenous dissemination, some individuals will develop typhoid fever, which involves high temperature (>39°C), vomiting, and headache, sometimes with complications that include neurologic involvement, intestinal perforation, and death.⁵

***Salmonella* Taxonomic Classification**

The classification of the salmonellae has a complicated history, resulting in part from multiple independent investigators using phenotypic, serologic, and genotypic methods to characterize phylogenetic relationships within the genus and in part from disagreements on nomenclature. The most recent consensus defines a classification scheme that recognizes 2 principal species of *Salmonella*: *S enterica* and *S bongori* (Fig. 1). In this scheme, *S enterica* is further classified into 6 subspecies: subspecies I or *S enterica* subsp *enterica*; subspecies II or *S enterica* subsp *salamae*; subspecies IIIa or *S enterica* subsp *arizonae*; subspecies IIIb or *S enterica* subsp *diarizonae*; subspecies IV or *S enterica* subsp *houtenae*; and subspecies VI or *S enterica* subsp *indica*.⁸⁻¹⁰ Recent sequence analysis has shed light on the genetic

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