SUPPLEMENT

Introduction to the Food Safety Concerns of Verotoxin-Producing *Escherichia coli*

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Verotoxin-producing *Escherichia coli* (VTEC) have emerged in the past two decades as food-borne pathogens that can cause major outbreaks of human illnesses worldwide. The number of outbreaks has increased in recent years due to changes in food production and processing systems, eating habits, microbial adaptation, and methods of VTEC transmission. The human illnesses range from mild diarrhea to hemolytic uremic syndrome (HUS) that can lead to death. The VTEC outbreaks have been attributed to O157:H7 and non-O157:H7 serotypes of *E. coli*. These *E. coli* serotypes include motile (e.g., O26:H11 and O104:H21) and nonmotile (e.g., O111:H$^-$, O145:H$^-$, and O157:H$^-$) strains. In the United States, *E. coli* O157:H7 has been the major cause of VTEC outbreaks. Worldwide, however, non-O157:H7 VTEC (e.g., members of the O26, O103, O111, O118, O145, and O166 serogroups) have caused approximately 30% of the HUS cases in the past decade. Because large numbers of the VTEC outbreaks have been attributed to consumption of ruminant products (e.g., ground beef), cattle and sheep are considered reservoirs of these food-borne pathogens. Because of the food safety concern of VTEC, a global perspective on this problem is addressed (Exp Biol Med Vol. 228, No. 4). The first objective was to evaluate the known non-O157:H7 VTEC strains and the limitations associated with their detection and characterization. The second objective was to identify the VTEC serotypes associated with outbreaks of human illnesses and to provide critical evaluation of their virulence. The third objective was to determine the rumen effect on survival of *E. coli* O157:H7 as a VTEC model. The fourth objective was to explore the role of intimins in promoting attaching and effacing lesions in humans. Finally, the ability of VTEC to cause persistent infections in cattle was evaluated. Exp Biol Med 228:331–332, 2003

Key words: *Escherichia coli*; cattle; sheep; verotoxins; food-borne pathogens

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1535-3702/03/2284-0331$15.00

Verotoxin-producing *Escherichia coli* (VTEC), including O157:H7, are members of the *Enterobacteriaceae* family found in the intestines and feces of animals and humans. These bacteria are short, straight, and gram-negative bacilli. The designation of a specific serotype as an "O-" and/or "H-type" bacterium as the case in O157:H7 is a nomenclature based on serological identification of specific antigens produced by the bacterium as structural components. The O-type antigens are somatic lipopolysaccharides, whereas the H-type antigens are components of the bacterial flagellae.

The importance of VTEC as a food safety concern has increased dramatically in recent years because of the reported outbreaks of human illnesses associated with their infections. Unfortunately, the numbers of such outbreaks are on the rise due to changes in food production systems, food processing methods, globalization of food supply, new food packaging technologies, and changing eating habits. Other promoting factors include microbial adaptation, methods of transmission, and both human demographics such as aging, and behavior such as increased food consumption at fast food restaurants. In the past 20 years, it has become evident that VTEC can cause a variety of illnesses ranging from mild diarrhea to severe hemorrhagic colitis that is characterized by bloody diarrhea, abdominal cramps, fever, and vomiting. Approximately 10% of younger patients, especially children, with VTEC infection develop hemolytic uremic syndrome (HUS). This is a life-threatening illness characterized by anemia, acute renal failure, and central nervous system abnormalities. Although most patients recover, some die and some may develop strokes or chronic renal failure.

In the United States, most human VTEC outbreaks have been associated with *E. coli* O157:H7 (1). The significance of such pathogen had been documented in a 6-month study (2) at Mayo Clinic (Rochester, MN). The examination

of 2164 stool samples from patients admitted during the study period revealed that *E. coli* O157:H7 was the fourth most common bacterial pathogen. *E. coli* O157:H7 also was found to cause 85%–95% of the HUS cases in North America (3). However, in other countries, *E. coli* O157:H7 was not the predominant food-borne pathogen, and other VTEC serotypes were responsible for the outbreaks of human illnesses. Examples of these non-O157:H7 VTEC included the serotypes O26:H11 and O104:H21 as well as nonmotile (H^-) isolates such as O111:H^-, O145:H^-, and O157:H^-. The first reported United States outbreak of non-O157:H7 VTEC infection occurred in Helena (MT) in 1994 and was attributed to *E. coli* O104:H21 (4). After this outbreak, several researchers (5, 6) expressed concerns that such pathogens may pose an underestimated threat to public health in the United States. Earlier estimates indicated that non-O157:H7 VTEC were responsible for 5%–15% of HUS cases (3). Since the end of the 1980s, non-O157:H7 VTEC such as members of the O26, O103, O111, O118, O145, and O166 serogroups have caused as many as 10%–30% of the sporadic HUS cases in Germany (7–9), Italy (10), the United Kingdom (11), France (12), and Japan (13). It is worth noting that large numbers of human illness outbreaks of O157:H7 and non-O157:H7 VTEC infections have been attributed to consumption of ruminant products, especially undercooked ground beef. This is why ruminants, especially cattle (14) and sheep (15), are considered reservoirs of these food-borne pathogens. Although sheep products have not been linked to reported human illnesses due to VTEC infection, their role as a food safety risk factor should not be ignored.

Because of the increasing public fear of VTEC contamination of foods, especially beef and its products, this special issue (Exp Biol Med Vol. 228, No. 4) is intended to provide a global perspective of the VTEC problem. The first objective was to evaluate the non-O157:H7 VTEC strains isolated so far and to explain the problems associated with their identification and characterization. The second objective was to identify those VTEC serotypes commonly associated with major outbreaks of human illnesses, evaluate their prevalence rates, and explain the unique toxin genotype and phenotype characteristics that may promote their virulence. The third objective was to examine the role of the rumen environment in survival and proliferation of *E. coli* O157:H7 as a VTEC model. The fourth objective was to explore the role of other known and novel intimins in promoting attaching and effacing lesions in humans. The vero-toxin-induced immunomodulation and its implication in the ability of VTEC to cause persistent infections in cattle was also evaluated.

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