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Escherichia coli O157:H7 and Its Effect on Human Health

Mojtaba Mohseni, Benyamin Djawadi and Noushin Khazaei

Abstract

Escherichia coli (*E. coli*) has many serotypes. The O157:H7 *E. coli* serotype is the most prominent serotype of enterohemorrhagic *E. coli*. It produces the Shiga toxin, which is one of the most important virulent factors discovered till today and has different subtypes with different antigenic and molecular traits. Consumption of contaminated water, milk or even eating an uncooked raw meat can cause bloody diarrhea that can end up in a life-threatening disease, such as hemolytic uremic syndrome (HUS). This is a condition that affects endothelial cells in the blood vessels and leads to thrombocytopenic purpura (TTP) that can cause blood clots formation in small blood vessels. The *E. coli* O157:H7 can be isolated from patient's stool and be identified by serological tests such as enzyme-linked immunosorbent assay (ELISA) and immunoblotting methods. This special strain of *E. coli* can be used as a biological weapon, as it can be so dangerous and has the ability to spread easily from person to person.

Keywords: *E. coli* O157:H7, Stx, STEC, HUS, foodborne illness

1. Introduction

For the first time in the 1970s early work showed that special *E. coli* strains could produce a certain type of a toxin called verotoxin and was named after that because of its effect on Vero cells they can be classified according to virulence factors such as toxins into different groups [1].

These toxins were also called Shiga toxins (Stx) because of their relation to the toxin produced by *Shigella dysenteriae* type 1. The group of *E. coli* strains producing these toxins is referred to as Shiga-toxin producing *E. coli* (STEC), or verocytotoxin producing *E. coli* (VTEC). The genes encoding Stx can be often carried by bacteriophages and plasmids [2].

E. coli O157:H7 is the most common strain of STEC, but there are many other strains of STEC as well. Anyone can get STEC infection and the whole processes begins when a person eat or drink any contaminated product, particularly raw or under-cooked meat. The term enterohemorrhagic *E. coli* (EHEC) is used to designate a subset of STEC that cause severe diseases in humans, including hemorrhagic colitis (HC) (bloody diarrhea) and the hemolytic uremic syndrome (HUS).

2. History

Since the beginning of August 1982 specimens obtained from four patients located in the United States of America, who were suffering from an unusual bloody

diarrheal illness started suddenly with abdominal pain within 24 hours followed by watery diarrhea, led to identification of *Escherichia coli* serotype O157:H7. All patients recovered within 7 days.

By further examination of stool samples from different cases of this type of diarrheal illness which nowadays designated as “hemorrhagic colitis,” for the first time CDC associated the 1993 large outbreak with undercooked hamburgers served at fast-food chain restaurants in Oregon and Michigan. Hemorrhagic colitis is characterized by severe abdominal pain, grossly bloody diarrhea, and even fever [3].

E. coli O157:H7 is the most commonly identified member of STEC and is becoming as a best-known emerging pathogen in the United States causing foodborne diseases [4, 5].

However, experiences have established a diversity of sources for *E. coli* O157:H7, including apple juice and cider, vegetables such as lettuce, raw milk, and processed foods such as salami [6].

3. Virulence factor

As already we know, STEC is a zoonotic pathogen that is responsible for severe outbreaks worldwide. The main virulence factor of STEC is the production of Shiga toxins 1 and 2. There are additional factors like plasmid-encoded enterohemolysin (EhxA), an autoagglutinating adhesin (Saa), a catalase-peroxidase (KatP), an extra-cellular serine protease (EspP) that can damage the intestinal tissue or even some factors related to the adhesion to bovine colon like intimin which can induce a characteristic histopathological lesion defined as “attaching and effacing” (A/E) [7–9].

Shiga toxins are encoded by *stx1* and *stx2* genes which are carried by lysogenic phages. They belong to the family of AB5 protein, contains active A subunit and 5 B subunits responsible for binding to cellular receptor available in organs as kidney, brain, liver, and pancreas [10].

These toxins that are produced in colon besides causing local damage can travel via bloodstream to its target organs such as kidney and play an important role in causing HC and HUS (Figure 1) [11].

The damaged caused by toxins is because of inhibition of protein synthesis which leads to apoptosis of endothelial cells [12].

Stx-phages are highly mobile genetic elements which can be transferred through horizontal gene transfer to other *Enterobacteriaceae* [13].

The expression of these genes (especially *stx2*) is affected by environmental conditions such as stress and temperature [14, 15].

The whole cluster of other virulence factors is encoded by chromosomal region called the locus of enterocyte effacement (LEE) presents in many STEC strains, which are responsible for the attaching and causing lesions. In a large proportion of STEC, a plasmid encoding several putative virulence factors like hemolysin can also be found [16].

Figure 1.
The effects of Stx in STEC-HUS caused by enterohemorrhagic *E. coli*. GIS, gastrointestinal system; Gb3, globotriaosylceramide; Stx, Shiga-toxin.

4. Infection source and colonization management

E. coli O157:H7 can cycle through the environment and food chain via water, soil, and insect. But cattle and *Salmonella enterica* serovar Typhimurium are considered to be the main reservoir for STEC [17–19]. In the United States, between 1998 and 2005, a majority of the STEC outbreaks were related to contaminated food and occurred in the period from May to October [20].

Considerable effort has been done to inhibit or facilitate infection of animals with STEC O157:H7, because of the readily transmission of pathogen strains such as EHEC in the farm environment and animals can even represent as vectors [21, 22].

However, illnesses caused by contaminated meat product still occur. But great effort has recently been placed on developing new strategies to control the widespread of distribution of EHEC serotypes, O157 and even non-O157 in cattle population to maintain their healthy condition and finally to decrease such illnesses in human [23].

Another practice for controlling is, by the use of beneficial bacteria often referred to as probiotics. Probiotics can interfere with pathogenic strains by producing metabolites that are inhibitory to STEC O157:H [24].

Some strains of *E. coli* strains can produce colicins that are inhibitory to STEC O157:H7 [25].

5. Detection of *E. coli* O157:H7

5.1 Cultured-based detection

O157 STEC can usually be differentiated from most commensal *E. coli* by their ability to ferment sorbitol when plated on a sorbitol-containing agar.

For isolation this strain, samples are plated onto a selective and differential media, such as sorbitol-MacConkey agar (SMAC), cefixime tellurite-sorbitol MacConkey agar (CT-SMAC), CHROMagar O157, or Rainbow agar. After incubation for 16–24 hours at 37°C, the plate is being examined for possible O157 colonies, which are colorless on SMAC or CT-SMAC and are mauve or pink on CHROMagar O157 [26].

Non-motile flagella-less (H-) sorbitol-fermenting STEC O157 might not grow on CT-SMAC agar because of their susceptibility to tellurite [27].

In the laboratory, culture and biochemical analysis is considered as the “gold standard” for the identification of STEC. Selective media, such as SMAC and CT-SMAC can be used to identified O157:H7 STEC because of the ability to ferment sorbitol within 24 hours [28].

Guidance for public health laboratories on the isolation and characterization of Shiga toxin-producing *Escherichia coli* (STEC) from clinical specimens are given in Table 1 [29].

5.2 Nucleic-acid-based detection

Recently, PCR methods (like real-time PCR and conventional PCR) have been developed to test the samples for the presence of Stx genes [30].

This method is inexpensive and easy to perform. During the protocol multiple primer sets in a single PCR reaction in order to detect different types and subtypes of Stx genes in a certain sample. But we have to keep in mind, the detection of Stx mRNA is not possible because they have not been expressed yet and there's a possibility of having a false negative test. Also analysts must be aware of the presence of cryptic bacteriophages which are prophages that have become trapped within a bacterial genome [31].

Medium	Characteristics	Properties	Morphology
Cefixime-tellurite sorbitol MacConkey agar (CT-SMAC)	Selective and differential distinguishes O157 from other fecal <i>E. coli</i>	Inhibits <i>Proteus mirabilis</i> , non-O157 STEC, and other sorbitol non-fermenting strains	O157 STEC appear clear, non-O157 STEC appear pink, and other normal enteric bacteria appear pink
CHROMagar™ O157	Selective and differential distinguishes O157 from other fecal <i>E. coli</i>	The chromogen mixture consists of artificial substrates	O157 STEC appear mauve, non-O157 STEC appear steel blue or blue green, and other enteric bacteria appear colorless
Rainbow® agar	Selective and differential distinguishes O157 from other fecal <i>E. coli</i>	Tellurite and novobiocin reduce the number of bacteria other than <i>E. coli</i> O157:H7 that will grow	O157 STEC appear black/gray, non-O157 STEC appear purple or violet, and other enteric bacteria appear pink
Sorbitol MacConkey agar (SMAC)	Modified MacConkey agar distinguishes O157 from other fecal <i>E. coli</i>	Primary carbon source sorbitol supports growth of non-O157 STEC	O157 STEC appear clear, non-O157 STEC appear pink, and other enteric bacteria appear pink

Table 1.
Guidance for public health laboratories on the isolation and characterization of Shiga toxin-producing Escherichia coli (STEC) from clinical specimens [29].

5.3 Detection by monoclonal antibodies

Detection of Shiga-toxin in clinical samples has been approved by the FDA [27]. These kits can detect Shiga-toxin in the enrichment samples, although none of them can distinguish the seven subtypes of Stx2 or the three subtypes of Stx. In 2015, researchers designed sandwich ELISAs capable of detecting and distinguishing between stx2 subtypes a, c, and d [32]. These antibodies provide a significant way to test the samples as fast as possible, even including samples from beef and pure culture [33].

5.4 O- and H-antigen determination

The most common method used in clinical laboratories when samples suspected to O157:H7 are being tested, is the O-antigen determination which is run by latex agglutination. These latex particles are coated with antibodies against the O157 antigen and when they are mixed with bacterial growth, O157 STEC bacteria will bind to the latex particle to produce visible agglutination which means positive reaction [34]. H7-specific antisera for latex agglutination are available for O157 but unlike the previous method, detection of flagellar antigens may be difficult and usually it is being done for non-O157 outbreaks [34].

6. Epidemiology and outbreaks

STEC infection causes a wide spectrum of illnesses, such as non-bloody diarrhea, hemolytic uremic syndrome (HUS), and hemorrhagic colitis (HC) [35]. Many non-O157:H7 STEC strains may also cause HUS but the majority of diarrhea-associated HUS cases in the US are caused by infection with O157:H7 STEC [36].

STEC are found in the intestines of healthy animals and are easily transmitted to humans by consumption of contaminated food or water, or even through direct contact with infected animals or persons [37].

Undercooked beef especially ground beef plays an important role in many O157:H7 STEC outbreaks, although other foods including unpasteurized juice, raw milk, and raw produces (e.g., lettuce) have been implicated in outbreaks too [38–40].

For the years 1998 and 1999 data about in implicated vehicles in outbreaks of *E. coli* O157:H7 exist and are given in **Table 2**.

CDC officials in several states, and the U.S. Food and Drug Administration (FDA) have collected data to investigate a multistate outbreak of *E. coli* infections linked to cake mix. As of July 27, 2021, 16 people infected with the outbreak strain of *E. coli* O121 have been reported from 12 states. Illnesses started on dates ranging from February 26, 2021 to June 21, 2021 and this outbreak is over right now [41].

In December 22, 2020 the FDA and CDC investigated a multistate outbreak of *E. coli* O157:H7 infection linked to leafy greens, a total of 40 people infected with the outbreak strain of *E. coli* O157:H7 were reported from 19 states. Illness started on dates ranging from August 10, 2020 to October 31, 2020. Ill people ranged in age from 1 to 85 years [42].

Outbreaks of *E. coli* infection linked to leafy greens (which often eaten raw with no cooking) including various types of lettuce such as romaine or iceberg lettuce, spinach, and mesclun mix in Canada and United States, are known as critical issues since 2008 [43].

Of the 57 *E. coli* infection outbreaks identified, 48 were attributed to *E. coli* O157 and the most of the causative agents (45 of the 48 outbreaks) were identified as *E. coli* O157:H7 and the other nine outbreaks were attributed to non-O157 *E. coli* [44].

Vehicle	1998	1999	Total
Ground beef/hamburger	10	9	19
Roast beef	0	2	2
Lettuce	1	3	4
Coleslaw	2	1	3
Salad	1	1	2
Milk	2	0	2
Tacos	0	1	1
Apple cider	0	1	1
Game meat	0	1	1
Cake	1	0	1
Cheese curd	1	0	1
Fruit salad	1	0	1
Macaroni salad	1	0	1
Multiple	1	0	1
Unknown	0	2	2
Total	21	21	42

Sources: ([38]; [39]).

Table 2.
Food vehicles implicated in outbreaks of E. coli O157:H7, United States, 1998–1999.

In the United States since 2008, 37 outbreaks of *E. coli* O157:H7 infection linked to leafy greens were identified: 5 linked to iceberg (13.5%), 11 linked to romaine lettuce (29.7%), and 21 linked to other or unspecified types of leafy greens (56.8%). These 37 outbreaks resulted in 1070 illness cases: 491 linked romaine lettuce (45.9%), 144 linked to iceberg lettuce (13.5%), and 435 linked to other or unspecified types of leafy greens (40.7%) [45].

Information on which month the outbreaks occurred is available for 17 of the 18 outbreaks linked to romaine lettuce in Canada and the United States from 2008 to 2018. The majority of these outbreaks happened during two seasons: eight occurred in the spring (March to June) and eight occurred in the fall (September to December) [46].

A possible theory for the distribution of *E. coli* O157:H7 illness cases observed in Canada could be related to the commercial distribution of lettuce. Lettuce imported from U. S. lettuce-growing regions can travel long distances to reach Canada and even distances farther than the eastern part of the country [47].

In the spring 2018 outbreaks in U.S., trace back investigation identified 36 growing fields on 23 farms in the Yuma, AZ, growing region as potential sources of contaminated lettuce. Growers reported the following common elements: romaine lettuce was grown under conventional agricultural practices; Colorado River water via an open irrigation canal was used to irrigate the romaine lettuce and to dilute agricultural chemicals; and overhead sprinkler irrigation was used during the germination of romaine lettuce followed in most fields by furrow irrigation [48].

In November 5, 2019 to November 16, 2019, CDC and FDA investigated a multistate outbreak of Shiga toxin-producing *E. coli* O157:H7 infection started in Georgia, Illinois, Minnesota, North Dakota, and Wisconsin. A total of 10 people ranged from 21 to 91, with a median age of 33, infected with the outbreak strain of *E. coli* O157:H7 were reported and 60% were female. Four of 10 ill people were hospitalized, including one person who developed hemolytic uremic syndrome. No deaths were reported. Information collected during the investigation showed that Fresh Express Sunflower Crisp chopped salad kits were the likely source of this outbreak. Of the 10 ill people with information available, all 10 reported eating any leafy greens in the week before their illness started. Eight ill people specifically reported eating a Fresh Express Sunflower Crisp chopped salad kit.

As of January 15, 2020, this outbreak appears to be over [49].

In December 2020, CDC, U.S. Food and Drug Administration, and public health regulatory officials reported an outbreak of *E. coli* O157:H7 in several states.

Public health investigators used the national PulseNet system to identify illness that may have been included in this outbreak. PulseNet system is the subtyping network of public health and food regulatory agency laboratories conducted by CDC, and with the help of the whole genome sequencing (WGS) method, analyzing the DNA fingerprinting is being done by official investigators. Molecular Investigations showed that people in this outbreak were more likely to share a common source of infection. As of December 16, 2020, a total of 32 people infected with the outbreak strain of *E. coli* O15:H7 were reported from 12 states. Illnesses started on dates ranging from June 6, 2020 to October 25, 2020. Ill people ranged in age from 2 to 75 years, with a median age of 27 years, and 72% were female. Of 29 ill people with information available, 15 were hospitalized and one developed hemolytic uremic syndrome (HUS). One death was reported from Michigan.

The officials interviewed ill people to determine what they ate, they reported variety of food items. Several ill people also reported eating at the same restaurant with common foods. As of December 18, 2020, this outbreak is over and that ended unknown, before enough information was available for investigators [50].

In November, 2021 CDC and FDA collected data to investigate a multistate outbreak of *E. coli* O157:H7 infections. Epidemiologic and laboratory data show that Josie's Organics prepackaged baby spinach may be contaminated with *E. coli* and may be making people sick. As of the November 15, a total of 10 people infected with the outbreak strain of *E. coli* O157:H7 have been reported from seven states. Illnesses started on dates ranging from October 15 to October 27, 2021. Sick people range in age from 2 to 71 years, with a median age of 26, and 70% are female. Of eight people with information available, two have been hospitalized and no deaths have been reported.

Public health investigators are using the PulseNet system and WGS method to identify illnesses that could be part of the outbreak, which showed that bacteria from sick people samples are closely related genetically, that suggests that people in the outbreak got sick from the same food. This outbreak is not over yet and CDC is advising people not to eat, sell or serve Josie's Organics prepackaged with best by date of October 23, 2021 [51].

On December 11, 2017 the Public Health Agency of Canada (PHAC) announced an outbreak of 21 STEC O157:H7 infections in three provinces linked to romaine lettuce.

This outbreak appears to be over as of January 25, 2018, and 25 people infected with the outbreak strain of STEC O157:H7 were reported [52].

On January 4, 2017 to April 18, 2018 *E. coli* O157:H7 infections linked to I.M. Healthy Brand SoyNut Butter was started and there were 32 people infected in Arizona, California, Florida, Illinois, Oregon, and Virginia and 9 people developed HUS. The source of the infection was a nut-free substitute for peanut butter and this outbreak seems to be over [53].

On June 27, 2016 to September 10, 2016, there were 11 reports based on *E. coli* O157:H7 infections in Connecticut, West Virginia, Pennsylvania, and Massachusetts. Epidemiologic and laboratory evidence indicated that beef products produced by Adams Farm Slaughterhouse in Athol, Massachusetts, were likely source of this outbreak and one ill person developed HUS. On October 19, 2016 officials declared this outbreak over [54].

On October 6, 2015 to November 3, 2015, there were a total of 19 people infected with the outbreak strain of Shiga toxin-producing STEC O157:H7 in Missouri, Colorado, Utah, Virginia, Washington, and Montana, ranged in age from 5 to 84 years, with a median age of 18. Two ill people developed HUS. The epidemiologic evidence collected during this investigation suggested that rotisserie chicken salad made and sold in Costco stores was the likely source of this outbreak. This outbreak seems to be over reported to CDC [55].

On May 19, 2014, a total number of 12 persons were infected with the outbreak strains of Shiga toxin-producing *E. coli* O157:H7 were reported from Michigan, Missouri, Ohio, and Massachusetts. No ill people developed HUS. Federal officials indicated that contaminated ground beef produced by Wolverine Packing Company was the likely source of this outbreak of STEC O157:H7 infections. On June 20, 2014 this outbreak was over reported by CDC [56].

A total of 33 ill persons infected with the outbreak strain of STEC O157:H7 were reported from Arizona, California, Texas, and Washington, on November 10, 2013. Federal officials indicated that consumption of two ready-to-eat salads, Field Fresh Chopped Salad with Grilled Chicken and Mexicali Salad with Chili Lime Chicken, produced by Glass Onion Catering and sold at Trader Joe's grocery store locations, was the source of this outbreak of STEC O157:H7 infections and even two ill people developed HUS. This outbreak appears to be over [57].

From October 18, 2012 to November 12, 2012, a total of 33 people infected with the outbreak strain of STEC O157:H7 were reported from Connecticut, Massachusetts, New

York, Pennsylvania, and Virginia and two ill persons developed HUS. Epidemiologic investigation conducted by officials in local linked this outbreak to prepackaged leafy greens, produced by State Garden of Chelsea, Massachusetts. Testing conducted by the New York Department Health Wadsworth Center Laboratories isolated the outbreak strain of STEC O157:H7 from four leftover packages of Wegmans brand Organic Spinach and Spring Mix blend collected from four ill person's homes [58].

As of March 22, 2011, 14 persons infected with the outbreak strain of *E. coli* serotype O157:H7 have been reported from Maryland (three cases), New Jersey (two cases), North Carolina (one case), Ohio (two cases) and Pennsylvania (six cases) and none have reported HUS. Reported dates of illness onset range from January 10, 2011 to February 15, 2011. Collaborative investigative efforts of local, state, and federal officials have associated this outbreak with eating Lebanon bologna, produced by Palmyra Bologna Company, which is a fermented, semi-dry sausage. In an epidemiologic study conducted during March 15–18, a total of 13 ill persons reported about the common disease [59].

From October 16, 2010 through October 27, 2010, 38 persons infected with the outbreak strain of *E. coli* O157:H7 have been reported from New Mexico (3 cases), Arizona (19 cases), California (3 cases), Colorado (11 cases), and Nevada (2 cases) with one case of HUS. The officials linked this outbreak to Bravo Farms Dutch Style Gouda Cheese purchased from a Costco stores [60].

As of Tuesday, June 30, 2009, 72 persons infected with *E. coli* O157:H7 with a particular DNA fingerprint have been reported. The number of ill persons in each state is as follows: Arizona (2 cases), California (3 cases), Georgia (1 cases), Illinois (5 cases), Kentucky (2 cases), Montana (1 cases), Maine (3 cases), Maryland (2 cases), Nevada (2 cases), Ohio (3 cases), Oklahoma (1 cases), Utah (4 cases), Texas (3 cases), New Jersey (1 case), and Wisconsin (1 case). Ill persons range in age from 2 to 65 years, Thirty-four persons have been hospitalized and 10 people have developed HUS. The epidemiological study indicated a strong association with eating raw prepackaged cookie dough. Most patients reported eating refrigerated prepackaged Nestle Toll House cookie dough products raw. This outbreak is over [61].

As of July 17, 2008, 49 confirmed cases have been linked both epidemiologically and molecular fingerprinting to *E. coli* O157:H7. The number of cases in each state is as follows: Georgia (4 cases), Indiana (1 case), Kentucky (1 case), Michigan (20 cases), Ohio (21 cases), and Utah (1 case). Their illnesses began between May 27 and July 1, 2008. Twenty-seven persons have been hospitalized and one person developed HUS. The officials reported the ground beef sold at Kroger Co was the main source of the infection. This outbreak is over [62].

On December 14, 2006, 71 persons with illness associated with the Taco Bell restaurant outbreak have been reported to CDC from five states: New Jersey (33 cases), New York (22 cases), Pennsylvania (13 cases), Delaware (2 cases), and South Carolina (1 case). A total of 71 ill persons, 53 were hospitalized and 8 developed HUS. This outbreak has ended [63].

7. Hemolytic uremic syndrome

Hemolytic uremic syndrome (HUS) is complication of Shiga-toxin producing *E. coli* (STEC) infection. Prompted by the finding of an STEC in the stool of a patient who died from HUS Karmali et al. examined the samples of different cases of HUS and found evidence of STEC infection in 11–15 patients [64].

HUS actually develops 1 week or more after diarrhea begins. Due to the use of the immunomagnetic separation (IMS) the isolation of O157:H7 in the stools from patients with HUS has been increased dramatically [65].

You can see the timeframe of the development and evolution of STEC-HUS (Figure 2).

The pathogenesis is related to the endothelial cell damage caused by Shiga-toxin which is produced in the gastrointestinal tract. These damaged cells become separated from the basement membranes of the glomeruli and in blood vessels to other organs. Clinically HUS from *E. coli* O157:H7 first appears similar to other common severe gastroenteritis, stools may be bloody, fever is absent, and thrombocytopenia as anemia is a hallmark. Edema is common in later stages and also blood loss via gastrointestinal tract and small blood vessels due to active hemolysis is common too. The *E. coli* O157:H7 can easily be cultured from feces. For more information please see (Table 3) which shows the distribution of children and adults in studies of STEC-HUS [67].

Figure 2.
Timeframe of the development and evolution of STEC-HUS. The timeframe and proportion represented are based on median values and are highly variable, depending on strain, epidemiological, and individual patient characteristics [66].

Year or time period and geographical region	STEC-HUS cases (children)	STEC-HUS cases (adult)
1979–1983 Washington and Baltimore	20	0
2000–2006 USA (8 states)	190	28
1992–2012 Norway	24	1
2017 Switzerland	4	3
1989–2006 Oklahoma	—	21
2009–2016 Alberta, Canada	33	6
2009–2013 England	66	20
2009–2017 France	—	96
2014 USA (10 states)	42	0

Table 3.
Distribution of children and adults in STEC-HUS cases [67].

Year	HUS cases	Incidence
2003	8	5.00
2004	3	1.88
2005	8	5.00
2006	11	6.88
2007	14	8.75
2008	7	4.38
2009	10	6.25
2010	15	9.38
2011	6	3.75
2012	19	11.88
Total	101	6.31

Table 4.
Annual HUS in U.S. incidence per 1,000,000 children [67].

HUS primarily affects the kidneys, however it can also lead to sepsis and neurological damages [66]. In (Table 4) there are some information based on Annual HUS incidence per 1,000,000 children in U.S. [67]. All the data based on HUS cases in last 10 years, are given in Section 6.

8. Prevention

As *E. coli* O157:H7 is an emerging cause of foodborne illness associated with undercooked all ground beef or hamburger, avoiding any undercooked hamburgers in the restaurant, practicing proper hygiene especially good handwashing, and consuming only pasteurized milk, can prevent *E. coli* O157:H7 infection [54].

9. Conclusion

Through decades several outbreaks related to *E. coli* O157:H7 have been occurred. According to *E. coli*'s genetic traits, the number of patients in outbreaks, *E. coli* O157:H7 may be considered a potentially deadly biological weapon agent, which anytime can be used for mass destruction.

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References

- [1] Karmali MA. Infection by verocytotoxin-producing *Escherichia coli*. Clinical Microbiology Reviews. 1989;2(1):15-38
- [2] Hayashi T, Makino M, Ohnishi K, Kurokawa K, Ishii K, Yokoyama C, Nakayama K. Complete genome sequence of enterohemorrhagic *Escherichia coli* O157:H7 and genomic comparison with a laboratory strain K-12. 2001
- [3] Fontaine R, Arnon S, Martin W. Raw hamburger: An interstate common source of human salmonellosis. 1978
- [4] Armstrong G, Hollingsworth J, Morris J. Emerging foodborne pathogens: *Escherichia coli* O157:H7 as a model of entry of a new pathogen into the food supply of the developed world. 1996
- [5] Ostroff S, Kobayashi J, Lewis J. Infections with *Escherichia coli* O157:H7 in Washington state: The first year of statewide disease surveillance. JAMA. 1989;262(3):355-359
- [6] Stephenson J. New approaches for detecting and curtailing foodborne microbial infections. 1997
- [7] Blanco M, Blanco J, Mora A, Dahbi G, Alonso M, González E. Serotypes, virulence genes, and intimin types of Shiga toxin (verotoxin)-producing *Escherichia coli* isolates from cattle in Spain and identification of a new intimin variant gene (eae-xi). 2004
- [8] Bustamante A, Sanso A, Lucchesi P, Parma A. Multiplex PCR assay for the detection of five putative virulence genes encoded in verotoxigenic *Escherichia coli* plasmids. 2011
- [9] Guth B, Prado V, Rivas M. Shiga toxin-producing *Escherichia coli*. In: Torres AG, editor. Pathogenic *Escherichia coli* in Latin America. Galveston, TX, USA: Department of Microbiology and Immunology, Sealy Institute for Vaccine Sciences, University of Texas Medical Branch; 2010
- [10] Gyles C. Shiga toxin-producing *Escherichia coli*. An overview. Journal of Animal Science. 2007;85(13 Suppl):E45-E62
- [11] Kaper J, Mobley H, Nataro J. Pathogenic *Escherichia coli*. Nature Reviews. 2004;2(2):123-140
- [12] Paton JC. Pathogenesis and diagnosis of Shiga toxin-producing *Escherichia coli* infections. Clinical Microbiology Reviews. 1998;11(3):450-479
- [13] Schmidt H, Karch H, Herold S. Shiga toxin-encoding bacteriophages—Genomes. International Journal of Medical Microbiology. 2004
- [14] McIngvale SC. Optimization of reverse transcriptase PCR to detect viable Shiga-producing *Escherichia coli*. American Society Microbiology. 2002
- [15] Muhldorfer I. Pathogenicity islands of virulent bacteria: Structure, function and impact on microbial evolution. Wiley Online Library. 1997
- [16] Nataro J, Kaper J. Diarrheagenic *Escherichia coli*. Clinical Microbiology Reviews. 1998;11(1):142-201
- [17] Davis M, Carpenter J, Hovde C. *Escherichia coli* O157:H7 in environments of culture-positive cattle. 2005
- [18] Hancock D, Besser T, Herriott D, Rice D. Multiple sources of *Escherichia coli* O157 in feedlots and dairy farms in the Northwestern USA. 1998

- [19] Schets F, During M, Italiaander R, Heijnen L, Rutjes S, Van Der Zwaluw W. *Escherichia coli* O157:H7 in drinking water from private water supplies in the Netherlands. 2005
- [20] Lynch M, Nguyen T, Painter J. Outbreaks of Shiga toxin producing *Escherichia coli* (STEC) infections in the United States, 1998-2005: Trends in foodborne STEC outbreaks. 2006
- [21] Besser T, Richards B, Rice D, Hancock D. *Escherichia coli* O157:H7 infection of calves: Infectious dose and direct contact transmission. 2001
- [22] Hancock D, Besser T, Rice D. Ecology of *Escherichia coli* O157:H7 in cattle and impact of management practices. *Escherichia coli* O157:H7 and other Shiga toxin producing *Escherichia coli*. 1998
- [23] Callaway T, Anderson R, Edrington T, Genovese K, Bischoff K. What are we doing about *Escherichia coli* O157:H7 in cattle? 2004
- [24] Center for Veterinary Medicine. A proposed framework for evaluating and assuring the human safety of the microbial effects of antimicrobial new animal drugs intended for use in food-producing animals. n.d.
- [25] Klapproth J, Scaletsky I, McNamara B, Malstrom C. A large toxin from pathogenic *Escherichia coli* strains that inhibits lymphocyte activation. 2000
- [26] Church D, Emshey D, Semeniuk H, Lloyd T, Pitout J. Evaluation of BBL CHROMagar O157. 2007
- [27] Gould L, Bopp C, Strockbine N, Atkinson R, Baselski V. Recommendations for diagnosis of Shiga toxin-producing *Escherichia coli* infections by clinical laboratories. 2009
- [28] Thompson J, Hodge D, Borczyk A. Rapid biochemical test to identify verocytotoxin-positive strains of *Escherichia coli* serotype O157. 1990
- [29] Atkinson M. Tracking media reports on the Shiga toxin-producing *Escherichia coli* O104: H4 outbreak in Germany. 2012
- [30] Scheutz F, Teel L, Beutin L, Piérard D, Buvens G, Karch H. Multicenter evaluation of a sequence-based protocol for subtyping Shiga toxins and standardizing Stx nomenclature. 2012
- [31] Wang X, Kim Y, Hong S, Pokusaeva K, Sturino J, Wood T. Cryptic prophages help bacteria cope with adverse environments. 2010
- [32] Skinner C, Patfield S, Hernlem B. New Stx2e monoclonal antibodies for immunological detection and distinction of Stx2 subtypes. 2015
- [33] He X, Kong Q, Patfield S, Rasooly R. A new immunoassay for detecting all subtypes of Shiga toxins produced by Shiga toxin-producing *E. coli* in ground beef. 2016
- [34] Atkinson R, Besser J, Bopp C, Carlson C, Crandall C, George K, Gladbach S. Guidance for public health laboratories on the isolation and characterization of Shiga toxin-producing *Escherichia coli* (STEC) from clinical specimens. 2012
- [35] Mead P, Griffin P. *Escherichia coli* O157:H7. 1998
- [36] Banatvala N. The United States national prospective hemolytic uremic syndrome study: Microbiologic, serologic, clinical, and epidemiologic findings. 2001
- [37] Griffin P, Tauxe R. The epidemiology of infections caused by

Escherichia coli O157:H7, other enterohemorrhagic *E. coli*, and the associated hemolytic uremic syndrome. Epidemiologic Reviews. 1991;13: 60-98

[38] Outbreak of *Escherichia coli* O157:H7 among attendees of the Washington Country Fair-New York. 1999. Retrieved from Centers for Disease Control and Prevention: <https://www.cdc.gov>

[39] Outbreak of *Escherichia coli* O157:H7 infections among patients. 2001. Retrieved from Centers for Disease Control and Prevention: <https://www.cdc.gov>

[40] Rangel J. Epidemiology of *Escherichia coli* O157:H7 outbreaks, United States. 1982-2002

[41] Hoff C, Higa J, Patel K. Notes from the field: An Outbreak of *Escherichia coli* O157:H7. Centers for Disease Control and Prevention. 2021

[42] Retrieved from Centers for Disease Control and Prevention. 2020

[43] Public Health Agency of Canada. Outbreak summaries. 2018

[44] Retrieved from Centers for Disease Control and Prevention. 2018

[45] Foodborne viral outbreaks associated with *Escherichia coli* reported by PAIFOD. 2018

[46] Catford A, Martinez A. Outbreaks of *Escherichia coli* O157:H7 infections linked to Romaine lettuce. 2020

[47] Global Food Safety Initiative. 2020

[48] FDA. 2020. Retrieved from FDA: www.fda.gov

[49] CDC. 2021. *E. coli* outbreaks. Retrieved from CDC.gov: <https://www.cdc.gov/ecoli/outbreaks.html>

[50] CDC. 2021. Outbreak of *E. coli* infections. Retrieved from CDC.gov: <https://www.cdc.gov/ecoli/2020/o157h7-10-20a/index.html>

[51] CDC. 2021. Outbreak of *E. coli* infections linked to Fresh Express Sunflower Crisp chopped salad kits. Retrieved from CDC.gov: <https://www.cdc.gov/ecoli/2019/o157h7-12-19/index.html>

[52] CDC. 2018. O157:H7 infections linked to leafy greens. Retrieved from CDC.gov: <https://www.cdc.gov/ecoli/2017/o157h7-12-17/index.html>

[53] CDC. 2017. *E. coli* infections linked to I.M. Healthy Brand SoyNut Butter. Retrieved from CDC.gov: <https://www.cdc.gov/ecoli/2017/o157h7-03-17/index.html>

[54] CDC. 2016. O157:H7 infections linked to beef products produced by Adams farm. Retrieved from CDC.gov: <https://www.cdc.gov/ecoli/2016/o157h7-09-16/index.html>

[55] CDC. 2015. O157:H7 infections linked to Costco rotisserie chicken salad. Retrieved from CDC.gov: <https://www.cdc.gov/ecoli/2015/o157h7-11-15/index.html>

[56] CDC. 2014. O157:H7 infections linked to ground beef. Retrieved from CDC.gov: <https://www.cdc.gov/ecoli/2014/O157H7-05-14/index.html>

[57] CDC. 2013. O157:H7 infections linked to ready-to-eat salads. Retrieved from CDC.gov: <https://www.cdc.gov/ecoli/2013/o157h7-11-13/index.html>

[58] CDC. 2012. O157:H7 infections linked to organic spinach and spring mix blend. Retrieved from CDC.gov: <https://www.cdc.gov/ecoli/2012/O157H7-11-12/index.html>

[59] CDC. 2011. O157:H7 infections linked to Lebanon bologna. Retrieved

from CDC.gov: <https://www.cdc.gov/ecoli/2011/lebanon-bologna-3-23-11.html>

[60] CDC. 2010. O157:H7 infections linked to bravo farms cheese. Retrieved from CDC.gov: <https://www.cdc.gov/ecoli/2010/bravo-farms-cheese-11-24-10.html>

[61] CDC. 2009. O157:H7 linked to prepackaged cookie dough. Retrieved from CDC.gov: <https://www.cdc.gov/ecoli/2009/cookie-dough-6-30-2009.html>

[62] CDC. 2008. O157:H7 infections linked to beef from Kroger. Retrieved from CDC.gov: <https://www.cdc.gov/ecoli/2008/ground-beef-kroger-7-18-2008.html>

[63] CDC. 2006. O157:H7 infections linked to Taco Bell. Retrieved from CDC.gov: <https://www.cdc.gov/ecoli/2006/taco-bell-12-2006.html>

[64] Karmali M. Sporadic cases of haemolytic-uraemic syndrome associated with faecal cytotoxin-producing *Escherichia coli* in stools. 1983

[65] Karmali M. The association between idiopathic hemolytic uremic syndrome and infection by verotoxin-producing *Escherichia coli*. 1985

[66] Roberts J. HUS and TTP associated with *Escherichia coli* O157:H7. Emergency Medicine News. 2004

[67] Ardissino G. Early volume expansion and outcomes of hemolytic uremic syndrome. 2016