



衛生防護中心
Centre for Health Protection

Scientific Committee on Enteric Infections and Foodborne Diseases

Epidemiology and Prevention of *Escherichia coli* O157:H7 Infection

Purpose

This paper provides an overview of *Escherichia coli* O157:H7 (*E. coli* O157:H7) infection, the global and local epidemiology, current health protection measures in Hong Kong, and recommendations for further prevention and control of the disease.

The Pathogen and the Disease

The bacteria

2. *Escherichia coli* presents a large array of genetic subtypes defined by the somatic (O) and flagellar antigen (H). Most subtypes are harmless whilst some can cause severe diarrhoea (1). *E. coli* O157:H7 is an important subtype that causes many foodborne outbreaks worldwide in the past decades (2). Other serotypes such as *E. coli* O26:H11, O111:H8, O103:H2, O113:H21 and O104:H21 have also been implicated in causing foodborne outbreaks (3,4).

3. *E. coli* O157:H7 can also be classified according to the pathogenic factor, under the group of enterohaemorrhagic *E. coli* (EHEC) because it can cause haemorrhagic colitis through the production of cytotoxins (also called Shiga toxins) (1). *E. coli* O157:H7 is capable of producing Shiga toxin 1, Shiga toxin 2, or both. The cytotoxin(s) block protein synthesis and are associated with disease presentation. The subtypes of *E. coli* which are capable of producing



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Shiga toxins, including *E. coli* O157:H7, are named as Shiga toxin producing *E. coli* (STEC). Other non-O157 serogroups which can also produce Shiga toxins include *E. coli* O26, O111, and O103.

4. *E. coli* O157:H7 can grow in temperatures ranging from 7°C to 50°C, with an optimum temperature of 37°C (3). It is destroyed by thorough cooking of foods until all parts reach a temperature of 70°C or higher (3).

5. Healthy cattle are the major reservoir for *E. coli* O157:H7 (5). *E. coli* O157:H7 is commonly found in the intestines of cattle and cross contamination of other parts of the animal is possible when slaughtering is not properly done. The bacterium is also found naturally in the intestines of other animals like pigs, sheep, goats and deer (1,2,5).

Disease Transmission and Clinical Presentation

6. *E. coli* O157:H7 infection is transmitted by faecal-oral route through contaminated food or water. Shiga-toxin producing strains have a high potential for person-to-person transmission since a very low infective dose is required and ingestion of as few as 10 organisms may be sufficient to cause infection (6). The rate of secondary household transmission for sporadic Shiga-toxin producing strains has been estimated to range from about 4% to 15% (6). Institutional outbreaks due to person-to-person transmission have also been reported in nursing homes, schools and day care centres for children (7).

7. The incubation period is around 3 to 4 days but can range from one to ten days (8). The spectrum of infection with *E. coli* O157:H7 includes asymptomatic faecal shedding of the organism; non-bloody or bloody diarrhoea accompanied by abdominal cramps, vomiting and occasionally fever; post-diarrheal hemolytic uremic syndrome (HUS); and thrombotic thrombocytopenic purpura (TTP) (3,4,8).

8. Most patients recover within 10 days (3). About 8% to 10% of patients, especially young children under 5 years old and the elderly, may progress to HUS ~ a condition characterized by microangiopathic haemolytic anaemia, acute renal failure and thrombocytopenia (4). *E. coli* O157:H7 infection has been reported as the predominant cause of HUS, which is in turn the most common cause of acute renal failure in young children in many parts of the world (7,9). Neurological complications (such as seizure, stroke and coma) occur in around 25% of HUS patients and chronic renal sequelae are seen in around 50% of HUS survivors (3). The estimated case fatality rate of HUS ranges from 3 % to 5% (3).

9. Adults typically shed the bacteria for one week after infection while young children can excrete the bacteria for more than three weeks (10,11). However, asymptomatic prolonged carriage of *E. coli* O157:H7 is

unusual among young children (11).

Laboratory Diagnosis

10. A clinically suspicious case of *E. coli* O157:H7 infection can be confirmed by stool culture on sorbitol-MacConkey agar, followed by serological testing for O157:H7 antigen and Shiga-toxin assay. *E. coli* O157 can be differentiated biochemically from other enteric *E. coli* because they ferment sorbitol slowly, whereas other *E. coli* usually readily ferment sorbitol (1,9). Detection of H7 antigen may be more difficult. Testing of Shiga-toxin has led to the identification of non-O157:H7 STEC. Both serology test and Shiga-toxins assay are available in Public Health Laboratory Services Branch of the Centre for Health Protection (CHP).

Patient Management and Infection Control

11. Patients diagnosed to have O157:H7 infection should be preferably managed in an in-patient setting with provision of supportive management such as intravenous fluid. Boluses of normal saline may protect against the development of HUS. Treatment with antibiotics, antimotility agents, narcotic opioids and non-steroidal anti-inflammatory drugs are not recommended due to possible adverse effects and absence of strong evidence to support their efficacy (9).

12. Adequate infection control measure should be implemented to prevent secondary spread of the disease via the faecal oral route. For patients with diarrhoea, especially those who are incontinent or diapered, contact precautions should be applied in addition to standard precautions. Ideally patients with diarrhoea should be placed in a single room with its own toilet facilities. If a commode is used, it should be reserved to the patient's sole use and cleaned thoroughly with disinfectant before being returned to general services. All staff should wear disposable gloves and a gown when providing care to infected patients and personal protective equipment (PPE) should be removed before leaving the room. Hand hygiene should be observed all the times, especially before and after patient contact, removal of PPE and before leaving patient's room. Environmental decontamination should be enforced.

13. The patient should only be discharged from hospital when symptom-free. Depending on the risk of secondary transmission at home (home environmental condition, presence of young children or immunocompromised persons at home), two successive negative stool cultures taken not less than 48 hours apart may be needed before discharge. If cases are discharged before the availability of the stool result, they should be advised to stay at home and avoid going to places with recreational facilities such as a swimming pool or ball pool. Children should be excluded from school or play-group until free from symptoms for at least 48 hours and two successive negative stool cultures taken

not less than 48 hours apart, after recovery. Implementing infection control in residential care homes for the elderly is also crucial in view of the outbreak potential and the higher risk of complications among the elderly (4,12). If a laboratory confirmed case is a food handler, he/she would be advised to be suspended from food handling duties until symptom free for at least 48 hours with two negative stool samples taken 48 hours apart, in order to prevent spreading the infection (4).

Global Situation

14. *E. coli* O157:H7 was first isolated in 1975 from a woman with bloody diarrhoea but was not considered a significant human pathogen until 1982 when two foodborne outbreaks in the USA were traced to the ingestion of contaminated hamburger meat (13,14). Since then, over 200 outbreaks of *E. coli* O157:H7 have been reported from over 30 countries worldwide (2,3,5). According to a review done by Doyle et al in 2006, most outbreaks occurred in developed countries, in particular, the United States, the United Kingdom and Canada (2). However, it was noted that paucity of sophisticated diagnostic laboratories in developing countries may limit the number of infections being reported. Table 1 summarizes the key findings of the large outbreaks (affecting more than 200 persons) reported. The largest *E. coli* O157:H7 outbreak took place in Sakai City of Japan in 1996 in which the radish sprouts in school lunches were contaminated, causing a total of 9451 cases with 12 deaths (15).

Table 1. Large *E. coli* O157:H7 outbreaks (affecting over 200 persons) worldwide (1982 – 2006)(2)

Reported year	Country	No. of persons affected (death)	Vehicle
1990	US	243 (4)	Well water
1991	Canada	521 (2)	Minced beef and caribou
1992-93	US	>700 (3)	Hamburger
1995	UK (Scotland)	633 (0)	Sewage contaminated drinking water
1996	Japan (Sakai)	9451 (12)	Radish sprouts
1996	UK (Scotland)	503 (20)	Lunch foods
1996-7	UK (Scotland)	512 (17)	Meat from a shop
1997	UK	332 (0)	Restaurant food
1999	US	>1,000 (2)	Well water
1999	US	329	Beef
2000	Canada	2,300 (7)	Drinking water
2000	US	788 (1)	Raw beef, cross contamination of other foods
2006	US (26 states) and Canada	204 (3)	Spinach

15. In Asia, other than Japan, relatively few outbreaks of *E. coli* O157:H7 have been reported. In Mainland China, *E. coli* O157:H7 was first identified from patients suffering from haemorrhagic colitis in Jiangsu Province in 1986 (16). No major outbreaks of *E. coli* O157:H7 have been reported except for one in Jiangsu Province in 1999, which involved 95 *E. coli* O157:H7 infected patients developing acute renal failure with a case fatality rate of 87% (17). In Taiwan, EHEC is a notifiable disease but as of August 2009, only one confirmed case had been recorded in 2001 (18).

16. Most foodborne outbreaks have been traced to foods derived from cattle, especially ground beef and raw milk (1,2,5). In the 1980s, most outbreaks were associated with inadequately cooked hamburgers and unpasteurized milk (2). Later, outbreaks were traced to other dairy products such as yogurt and cheese (2). Besides, fruits and vegetables such as lettuce, apple cider, unpasteurized apple juice and alfalfa sprouts have been implicated in *E. coli* O157:H7 outbreaks (1,5). These outbreaks may be due to contact with animal faeces at some stage during cultivation or handling (3). Over the years, contaminated water has been reported increasingly as a source of human infection, including drinking water contaminated with animal faeces and swimming in lake and pool water (2). Apart from contaminated food and water, person-to-person transmission spread by the faecal oral route was also documented in many outbreaks (2).

Local Situation

Characteristics of Human Cases Reported

17. *E. coli* O157:H7 infection became a statutory notifiable disease in July 2008. Prior to this only nine sporadic cases had been reported to the Department of Health from 1998 to June 2008. From July 2008 to 2009, three cases were reported.

18. Table 2 summarizes the major characteristics of these twelve cases. Three had spent the entire incubation period outside Hong Kong and were classified as imported cases. The other nine acquired the infection locally. Seasonality was difficult to delineate given the small number. There were ten boys and two girls and all were under 5 years of age. Most presented with watery diarrhoea, vomiting and fever, with only one case having bloody diarrhoea complicated by haemolytic uraemic syndrome (HUS) which developed around 8 days after onset of symptoms and required peritoneal dialysis. The other eleven cases did not have complications and there was no fatal case reported. There was no epidemiological linkage among these twelve cases. The exact source of infection of most of these cases could not be ascertained despite intensive epidemiological and environmental investigations. Two cases (Cases 1 and 2) had a history of consumption of high risk food items

such as unpasteurized milk in an overseas farm and undercooked beef. The family members of three cases (Cases 3, 7 and 12) were found to have asymptomatic infection which suggested possible person-to-person transmission among family or close contacts.

Table 2: Reported *E. coli* O157:H7 infections in Hong Kong, 1998- 2009

Case no.	Month-Year	Sex	Age	Importation status	Complicated by HUS	Fatal
1	Aug-98	M	4 years	Imported from UK	Yes	No
2	Jul-00	M	8 months	Local case	No	No
3	Feb-01	M	17 months	Local case	No	No
4	Jun-01	M	8 months	Imported from mainland	No	No
5	Aug-01	M	16 months	Local case	No	No
6	Dec-03	M	11 months	Local case	No	No
7	Dec-06	M	16 months	Local case	No	No
8	Nov-07	F	12 months	Imported from Mainland	No	No
9	May-08	M	18 months	Local case	No	No
10	Jul-08	F	10 months	Local case	No	No
11	Sep-09	M	10 months	Local case	No	No
12	Dec-09	M	12 months	Local case	No	No

Laboratory Surveillance

19. The Public Health Laboratory Services Branch (PHLSB) of CHP has been undertaking surveillance on STEC from all diarrhoeal stool specimens collected by the general out-patient clinics since November 2009. From November 2009 to June 2010, 1,340 stool specimens have been tested and only one yielded an STEC (*E. coli* O146:H10).

Prevalence of *E. coli* O157:H7 among Local Animals

20. In a local study on the prevalence of STEC in cattle and pigs in an abattoir conducted between August 1996 and December 1998, *E. coli* O157:H7 was detected in 0.9% (9/986) of the faecal samples from cattle and 0% (0/487) of the faecal samples from the pigs (19). It was suggested that local dietary preference for pork or chicken rather than beef could explain the low prevalence of Shiga-toxin producing *E. coli* O157:H7 infection in our locality (19).

Prevention and Control Measures

21. Currently, measures to prevent *E. coli* O157:H7 infection are mainly incorporated into other joint activities of CHP and Centre for Food Safety (CFS), Food and Environmental Health Department (FEHD) to control foodborne diseases. These activities focus on three main aspects, namely disease surveillance and public health response, food surveillance and control, and health promotion to the public and trade. In the following, we examine these current measures and discuss areas for potential enhancement.

Disease Surveillance and Public Health Response

22. Food poisoning is a statutory notifiable disease in Hong Kong. Foodborne outbreaks associated with *E. coli* O157:H7 are monitored under this reporting system. Since April 2001 physicians were encouraged to report *E. coli* O157:H7 infections to Department of Health on a voluntary basis (20). The investigation carried out after notification would examine the epidemiological details and implement control measures such as identifying the source of infection, active case finding and medical surveillance of close contacts. If food premises are suspected to be the source of infection, the case is referred to FEHD for further investigation. FEHD collects food and environmental specimens for laboratory analysis, provides specific advice on food hygiene, conduct source tracing and takes action against any irregularities identified during the investigation. Sale and distribution of incriminated food may be suspended as appropriate. A closure order can be issued to close food premises which are considered to pose an immediate health hazard.

23. To further enhance disease surveillance, *E. coli* O157:H7 was added to the list of statutory notifiable disease in July 2008. Given the large potential public health impact, doctors should continue to have a high index of suspicion if they encounter a patient presenting with compatible symptoms and history of taking possible contaminated food. Patients presented with acute diarrhea should be considered to test for *E. coli* O157:H7, especially those aged under five years old. Initial laboratory tests for *E. coli* O157, including growth of the bacterium on sorbitol-MacConkey agar and serological test for O157, are available in major public hospitals. Further testing on H7 antigen and Shiga toxin is available from Public Health Laboratory Services Branch of CHP. Besides, closer collaboration between CHP and FEHD should be maintained for the prompt investigation and control of *E. coli* O157:H7 related outbreaks.

Laboratory Testing

24. In countries with high incidence of the *E. coli* O157:H7 infection, laboratory testing guidelines for the bacteria are available. In the United States, the Centers for Disease Control and Prevention recommended that all stools submitted for testing from patients with acute community-acquired diarrhoea

should be cultured for STEC and tested for Shiga toxin (21). In the United Kingdom, the Subcommittee of the Public Health Laboratory Service Advisory Committee on Gastrointestinal Infections recommended that all diarrhoeal faecal specimens should be examined for the presence of *E. coli* O157 regardless of the age of the patient (22).

25. Incidence of *E. coli* O157:H7 infection in Hong Kong is considered to be low in the past decade. Even after it became a statutory notifiable disease in 2008, only two cases were reported each year in 2008 and 2009 respectively. Besides, recent study by PHLSB did not yield a single positive result for *E. coli* O157:H7 after testing over 1,300 specimens (paragraph 19). In view of the low prevalence of *E. coli* O157:H7 infection and the local study result, routine testing of all diarrhoeal stool specimens for *E. coli* O157:H7 may not be applicable to Hong Kong.

Food Surveillance and Control

26. Prior to March 2005 the *E. coli* O157:H7 surveillance programme in slaughterhouses required the regular collection of samples from the epidermis of cattle carcasses. Since March 2005 this has been replaced by the Generic *E. coli* monitoring programme in line with international trends e.g. USA, UK and Australia. The Generic *E. coli* programme is regarded as a more sensitive and effective faecal contaminant indicator to assess and monitor the hygienic practices and sanitation of slaughterhouses. In addition, overseas experience shows that *E. coli* O157:H7 surveillance programmes are not effective in enhancing hygiene standards of the slaughterhouse because of the low prevalence of *E. coli* O157:H7. Besides, faecal samples from live cattle have also been collected from slaughterhouse lairage for continuous monitoring of the prevalence of the bacterium since 2003.

27. Food surveillance for *E. coli* O157:H7 is conducted by CFS at the import, wholesale and retail levels. This surveillance is conducted on a risk-based approach. 247 and 238 food samples, including high risk “ready-to-eat” food such as *ready-to-eat minced beef and prepackaged vegetable for salad*, were collected in 2006 and 2007 respectively and all were negative for *E. coli* O157:H7.

28. It is recommended to maintain the surveillance programme of *E. coli* O157:H7 in local markets and the Generic *E. Coli* monitoring programme at the slaughterhouse. This is especially important for high risk foods imported from countries with previous reports on *E. coli* O157:H7 incidents or outbreaks. Besides, it is also important to establish collaboration of overseas public health authorities in exchange of information and alert the food trade promptly once there is incident of food contamination with *E. coli* O157:H7.

Health Promotion to Public and Trade

29. Both CHP and CFS have produced a variety of health education resources targeted at general public and the food trade to raise their awareness of this infection. Since *E. coli* O157:H7 is commonly found in the intestines of cattle and meat may be contaminated with *E. coli* O157:H7 on the surface from the slaughter process or subsequent handling, therefore, hygienic slaughtering process must be ensured. FEHD has worked with food trade to establish Hazard Analysis and Critical Control Points for identifying and controlling hazards and drawn up Working Guidelines governing the hygiene standards in cattle slaughtering. Designated health inspectors are stationed at slaughterhouses for supervising the enforcement process. Besides, seminars are arranged to educate staff of slaughterhouses about hygiene measures, especially precautions taken during the slaughtering process.

30. In view of current local situation, it was recommended to maintain the health education activities on prevention of *E. coli* O157:H7, including both food industry and members of the general public. Specific health advice could be fine-tuned based on scientific evidence and local diet pattern. For instance, all meat, in particular hamburgers, should be thoroughly cooked to reach a centre temperature of at least 70°C for two minutes in order to inactivate the bacteria (23). The public should be reminded to cook food thoroughly before consumption including ground beef served in hot congee. Vulnerable groups including young children, elderly people, pregnant women and immunocompromised persons should avoid eating raw or undercooked meat, especially minced meat and the products thereof.

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