GIARDIA INTESTINALIS

THE ORGANISM/TOXIN

- *Giardia* is a flagellated, unicellular protozoan parasite that inhabits the intestinal tract of vertebrate hosts, causing watery diarrhoea in humans and mammals (1).
- *Giardia intestinalis* (*G. intestinalis*) is synonymous with *G. duodenalis* and *G. lamblia* (2).
- Eight major genetic groups (known as assemblages) of *G. intestinalis* have been identified. Two of which (A and B) are found in both humans and animals, having zoonotic potential for causing human infection (3, 4).
- There are two stages in the lifecycle of *G. intestinalis*: a reproductive, vegetative stage (trophozoite), which colonises the small intestinal epithelium causing disease, and an infective, environmentally-hardy stage (cyst), responsible for transmission (1, 4).
- Human giardiasis is distributed worldwide and is estimated to cause >280 million diarrhoea infections annually. Many developing countries are considered endemic regions (5, 6).
- The organism does not produce toxins in food (7).

GROWTH AND ITS CONTROL

Growth:

- The organism does not grow outside of the animal or human host reservoir.
- Suitable environmental conditions within the host (increased bile salt concentration and cholesterol deprivation) are required for trophozoites to transform into infectious cysts (1).

Survival:

Temperature	• Cysts, but not trophozoites, can survive, and remain infectious, for up to several months in cool, damp environments including soil, water and cattle faeces (7, 8). • Cyst survival in water is better at lower temperatures. For example, cysts can survive, and remain viable, for 2 to 3 months at < 10°C, for almost 1 month at 21ºC and for only 4 days at 37°C (7). • Cysts can survive on fresh lettuce leaves, for up to 2 weeks, when kept moist and refrigerated (9).

Inactivation:

Thermal inactivation:	
Temperature	• *Giardia* cysts can be reduced by more than 2 $\log_{10}$ following heating to 56-70°C for 10 minutes or by heating water to a rolling boil for 1 minute (10). • Cysts are sensitive to standard pasteurisation techniques. *Giardia* poses no problem in heat-processed food or tap water that has undergone appropriate treatment (7).
	• Cysts are killed at -20°C after 1 hour (11).
Drying	• Cysts are susceptible to desiccation and direct sunlight and are destroyed more quickly under hot, dry conditions (7).
Non-thermal inactivation:	
Sanitisers /disinfectants	• Disinfectants used to inactivate *Giardia* include chlorine, chloramine and chlorine dioxide (12). • Chlorination at levels required to inactivate *E. coli* is not sufficient to inactivate *Giardia* cysts (13). • Commercial phenol-based disinfectants are effective at inactivating the organism however, it is unknown if alcohol-based sanitisers effectively kill *Giardia* (14).
Radiation	• Cysts killed by UV radiation at 10 mJ/cm^2 however trophozoites and encysting parasites can recover from UV treatment at 100 mJ/cm^2 and 50 mJ/cm^2, respectively (20 second treatment with 3 hours allowed for recovery) (15).
Preservatives and other non-thermal processing technologies	• Ozone is a potent chemical against *G. intestinalis* although the effectiveness is reduced at lower temperatures and the contact time values are high (16). • Physical removal of cysts by passing water through a filter with an absolute pore size of 1 micron or less (tested and certified filters NSF 53 or NSF 58) (17)

THE ILLNESS

Incubation: 6-15 days after ingestion. Average of 9 days (18).

Symptoms:

- Abdominal cramps, nausea, acute or chronic foul-smelling diarrhoea, low-grade fever, anorexia, bloating, weight loss, failure to thrive in children (18).
- Symptoms usually resolve within 7 to 10 days but re-infection is common in endemic areas and chronic infections, lasting several months, can occur if untreated (18, 19).

Condition: Giardiasis

At Risk Groups:

- Children in day care, their close contacts, homosexual men, people who participate in recreational water activities, travellers to disease-endemic areas, and people drinking untreated or treated, but unfiltered surface water and shallow well water (5).
- Illness is more serious in immunocompromised patients and those with cystic fibrosis (15).
- Infants and children (0 to 5 years) are more susceptible than adults (5).

Long-term effects:

- Complications including extreme weight loss and lactose intolerance in some people after symptoms have ceased (20).

- Children under five are at risk from malnutrition which can interfere with their physical and mental development (20).
- Chronic enteric disorders, ocular complications, urticaria, allergies, chronic fatigue and reactive arthritis (18).

Dose: Low infectious dose: 1-10 cysts for a symptomatic infection (12).

Incidence:
- New Zealand incidence rate of 34.5/100,000 (2016) (21). Since 2008 the rates have remained relatively stable between 45.4/100,000 and 32.9/100,000. Updates can be found on the ESR website *https://surv.esr.cri.nz/surveillance/annual_surveillance.php*
- New Zealand incidence rates are higher than the EU (5.4/100,000 (2015)) (22), and the USA (5.8/100,000 (2012)) (23). Giardiasis is not notifiable in Australia.
- In 2016, New Zealand children aged 1–4 years (110.9 per 100,000), adults aged 30–39 years (55.4 per 100,000) and infants aged less than 1 year (43.9 per 100,000) had the highest notification rates in 2016 (21).

Treatment:
- Treatment rarely required as most cases are self-limiting. Supportive therapy (maintenance of hydration and electrolyte balance) may be given if required (19).
- When necessary, the drugs of choice include the anthelmintic Quinacrine and the antibiotics Metronidazole, Tinidazole, Nitazoxanide, Furazolidone, and Paromomycin (19, 18).

SOURCES

Human:
- Infected persons (stools) (24).
- Asymptomatic individuals often become chronic carriers and may excrete the organism for years (25).
- Only assemblages A and B, and their respective subtypes, cause human infection. The relative proportion of infection from these assemblages varies temporally and spatially. Globally a higher number of human isolates type as assemblage A however there is a predilection for more assemblage B infections in endemic settings (3, 26).

Animal:
- Domesticated or wild animals including birds, fish and reptiles can harbour *G. intestinalis* however, isolates from these sources are not necessarily pathogenic to humans as both zoonotic (assemblages A and B) and host-specific assemblages can be found (4, 26).
- Assemblages A and B have been identified from both calves and humans in New Zealand with assemblage A being more prevalent in both mammalian species (4, 26). This information conflicts with another study that found no attribution of human giardiasis with farming or farm contact in New Zealand (27).

Food:
- Usually associated with food products that are eaten raw or that are inadequately cooked (2, 24).
- Agricultural products that have been subjected to faecal contamination. For example, via contaminated water used for crop irrigation, run-off water, wash or waste water used in packing houses (24).
- Faecal and slurry discharges can play a role in cyst contamination of shellfish in fresh water, marine and coastal environments (24).

Environment/Water:
- Infected human, livestock and feral hosts as well as transport hosts, including birds and insects, can contaminate the environment (24).
- Oocysts shed in faeces can contaminate soil, pasture and water acting as a source of infection for humans and other animals (16, 24).
- Contaminated drinking or recreational water is an important source of human outbreaks and cases (16).
- In addition to direct animal to human contact, transmission of zoonotic assemblages is also likely to occur through the ingestion of contaminated water (4, 24).

Transmission Routes:
- Consumption of faecally-contaminated food or water (20).
- Person-to-person via faecal-oral route (or to a lesser extent animal-to-person) transmission (4, 20).

OUTBREAKS AND INCIDENTS

Outbreaks:

New Zealand
- Since 2007, the number of outbreaks of giardiasis has ranged from 21 to 97 (average 57). The number of associated cases has ranged from 111 to 378 (average 229). The number of outbreaks associated with food and water has remained stable at 10 or less and 29 or less respectively since 2007 (28).
- The remainder of the annual outbreaks each year can be attributed to multiple sources including other environmental, person-to-person, travel and zoonotic. The majority of foodborne outbreaks of *Giardia* have no identifiable source (28).

New Zealand

Notable foodborne outbreaks in recent years are included below (28).

Year	Foodborne outbreaks (cases)	Suspected foods (outbreaks)
2007	1 (6)	No identifiable source
2008	0 (0)	No foodborne outbreaks
2009	0 (0)	No foodborne outbreaks
2010	4 (13)	Poultry (1) and dairy (1)
2011	6 (24)	No identifiable source
2012	6 (17)	No identifiable source
2013	10 (36)	Dairy (2)
2014	6 (27)	Eggs (1)
2015	2 (30)	No identifiable source
2016	4 (11)	Raw milk (2) (suspected, but weak evidence)

NB: Approximately 25% of outbreaks have a source confirmed by laboratory methods. Implicated foods are mostly associations which can be spurious as they have not taken into account the prevalence of commonly consumed foods in the general population (28).

Worldwide

Notable food and waterborne outbreaks are included below.

Year	Cases	Suspected foods	Country	Control measure failure
1990	18	Raw, sliced vegetables	USA	Food prepared by an infected food handler (29).
2004/2005	1300	Water	Norway	Municipal water supply contamination (30).
2007	31	Water	USA	Contamination of groundwater well supplying a community drinking water system (31).
2010	7	Water	Korea	Contaminated drinking water supply (32).

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