

# WATER- AND FOODBORNE VIRUSES: CURRENT DEVELOPMENTS

*Water and food are still major sources of enteric viruses.*

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Despite the major advances made in preventive health care and food technology, water and foodborne transmission of human enteric viruses is a well-recognised widespread public health problem.<sup>1-3</sup> Factors such as changing lifestyles and demographics, faster and more frequent travel, decreasing water supplies and the globalisation of the food industry have contributed to the increase in water- and foodborne infections.<sup>4</sup> Water and food contaminated with viruses may conform to acceptable bacterial standards<sup>5</sup> and look, taste and smell normal.<sup>6</sup> Exposure to treated and untreated drinking water and recreational water sources can result in waterborne disease. 'Safe and sufficient drinking water is a fundamental human need and basic human right'<sup>7</sup> and yet drinking water is still considered to be the main source of pathogenic organisms in developing regions, although poor sanitation and food sources are integral to enteric pathogen exposure.<sup>8</sup> The World Health Organization has estimated that globally 1.1 billion people drink unsafe water<sup>8</sup> and that 1.7 million deaths are due to unsafe water and lack of adequate sanitation.<sup>3</sup> In South Africa approximately 12 million people are without potable water and 21 million people are without sanitation. Food sources can be contaminated through sewage-polluted irrigation water, environmental contamination, or during harvesting, processing, preparation or serving by infected food handlers. In the US approximately 67% of foodborne illnesses are due to viruses and the rest due to bacteria (30%) and parasites (3%). Fresh produce was responsible for the largest number of cases of illness although seafood was responsible for the highest number of outbreaks. Due to the prevalence of many asymptomatic or mild infections, underreporting and the fact that the health effects of water- and foodborne disease can be nonspecific, the true clinical and economic impact of water and foodborne enteric virus infections may be underestimated.<sup>9</sup> In addition, person-to-person and water- and foodborne routes of transmission may overlap (Fig. 1), which further impacts on the estimation of water- and foodborne illness.

**Water and food contaminated with viruses may conform to acceptable bacterial standards and look, taste and smell normal.**

More than 100 enteric viruses found in the human intestinal tract are potential pollutants and three disease categories are associated with water- and foodborne viral infections, namely:

- gastroenteritis: caused by human rotaviruses (HRV), human caliciviruses (HuCV), which include noroviruses (NoV) and sapoviruses (SaV), human astroviruses (HAstVs) and the enteric adenoviruses
- hepatitis: caused by the faecally transmitted hepatitis viruses, namely hepatitis A virus (HAV) and hepatitis E virus (HEV)
- other severe illnesses such as myocarditis: caused by enteroviruses, which include human enteroviruses A-D (coxsackie A, coxsackie B and echoviruses) and polioviruses.<sup>6</sup>

Although many enteric viruses from a number of viral families have been associated with water- and foodborne disease, HAV and NoVs are the leading causes of water- and foodborne illness (Table I) and most of the viruses associated with foodborne disease are of human origin. In South Africa (SA) recreational exposure to faecally contaminated water was identified as the route of transmission of HAV in canoeists<sup>10</sup> and NoVs were implicated in an outbreak of gastroenteritis associated with the consumption of salads.<sup>11</sup>

Infection via contaminated water or food depends on viral stability, amounts of virus shed by the infected person, method of processing of water or food, dose needed to produce infection, and susceptibility of the host.<sup>4</sup> Most of the water- and foodborne viruses are non-enveloped and are resistant to heat, disinfection and pH changes. Enteric viruses

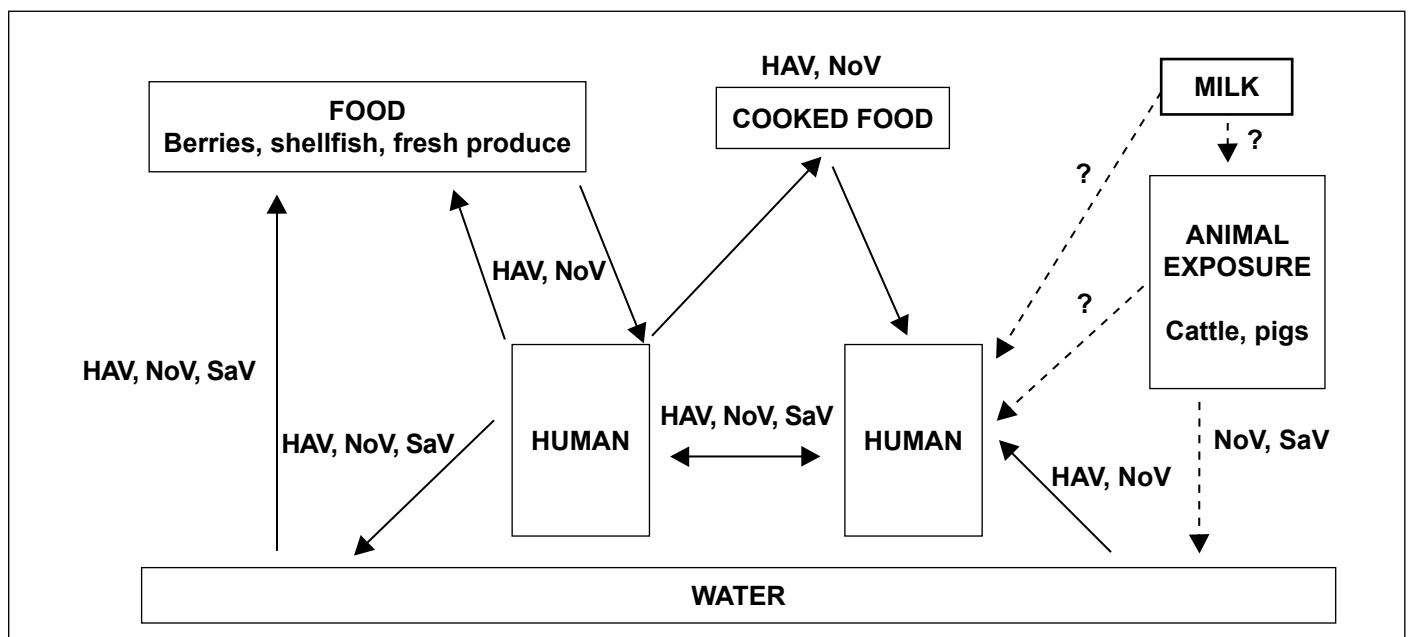


Fig. 1. Routes of transmission of hepatitis A virus (HAV), noroviruses (NoV) and sapoviruses (SaV).<sup>6</sup>

**Table I. Most important food- and waterborne viruses and the associated clinical syndrome<sup>6</sup>**

Likelihood of water- and food-borne transmission	Gastroenteritis	Hepatitis	Other
Common	Norovirus	Hepatitis A virus	
Uncommon	Enteric adenovirus Rotavirus Sapovirus Astrovirus Coronavirus Aichivirus	Hepatitis E virus	Enterovirus

are extremely infectious, with the infectious dose for HAV and NoVs estimated to be around 10 - 100 infectious viral particles.<sup>12</sup> As these viruses are shed in large numbers in the acute phase of disease the risk of faecal contamination of water and food sources is increased.

***In SA, HAV is endemic in the lower socio-economic communities, with mostly asymptomatic infection in children while sporadic symptomatic infections are more common in the more affluent communities.***

### Noroviruses

Noroviruses are a major cause of sporadic and epidemic gastroenteritis in all age groups. Noroviruses, previously called 'small round structured viruses (SRSVs)' or Norwalk-like viruses, are classified in the genus *Norovirus* of the family *Caliciviridae*. Based on sequence analysis of the capsid gene, five genogroups (GI - GV) of NoVs have been identified and human infection has been associated with NoV GI, GII and GIV.<sup>13</sup> Noroviruses from genogroups III and V infect cows and mice and strains from genogroup II can infect pigs and from genogroup V, cats and dogs. Noroviruses are species specific and, to date, no human infection attributable to animal strains has been reported.<sup>14</sup> Genotype I strains are more frequently associated with shellfish-associated outbreaks while GII.<sup>4</sup> strains appear to be more commonly associated with person-to-person transmission. Noroviruses are transmitted predominantly via the faecal-oral route, directly from person-to-person or indirectly through contaminated water and food. Secondary transmission is common, often via aerosols of vomitus, leading to extensive outbreaks in closed settings such as hospitals, hotels, cruise ships and child-care centres.<sup>15</sup> Except for temperate climates where winter seasonality has been reported, NoV infections occur throughout the year. Clinical NoV infection was previously referred to as 'winter vomiting disease'.<sup>15</sup> The incubation period for NoV infection is usually 24 - 48 hours (range 10 - 51 h) and NoV-associated gastroenteritis is characterised by the sudden

onset of nausea, vomiting, abdominal cramps, malaise and myalgia and non-bloody watery diarrhoea.<sup>14,15</sup> Vomiting is more common in individuals >1 year of age and watery diarrhoea in children <1 year of age,<sup>15</sup> and subclinical infection is common.<sup>14</sup> The infection is self-limiting and usually resolves after 2 - 3 days although symptoms can persist >4 days in the young and the elderly.<sup>14</sup> Chronic diarrhoea has been documented in immunocompromised individuals.<sup>14</sup> After rotaviruses, NoVs are the second most important viral agent causing gastroenteritis in children <5 years of age<sup>15,16</sup> with NoV-associated diarrhoea being as severe as rotavirus-associated diarrhoea in hospitalised children.<sup>15</sup> Diagnostic tests are not widely available for NoVs, and diagnosis is usually based on epidemiological features. Commercial enzyme immunoassays (EIAs) and immunochromatographic assays are available for NoV antigen detection in stool specimens, but due to the NoV antigenic variation they have a poor sensitivity. Molecular-based assays, such as real-time reverse transcriptase polymerase chain (RT-PCR), which target a conserved region of the genome, are preferable for diagnostic and epidemiological investigations. Treatment of NoV infection is usually supportive with oral rehydration if necessary, but no antibiotic therapy is required.<sup>14,15</sup>

### Hepatitis A virus

Hepatitis A is the most common form of hepatitis worldwide and its distribution is linked to the socio-economic development of the geographic area.<sup>17,18</sup> Hepatitis A virus belongs to the genus *Hepatovirus* within the family *Picornaviridae*. Six genotypes (I-VI) of HAV have been recognised and genotypes I, II and III are of human origin. Clusters of related strains predominate in certain geographic regions<sup>19</sup> and subgenotype IB has been found to predominate in SA.<sup>20</sup> Despite the nucleotide variability HAV is antigenically stable, with only one serotype, resulting in lifelong immunity after natural infection or immunisation with the highly efficacious vaccine.<sup>17</sup> Hepatitis A virus is transmitted via the faecal-oral route, most commonly through close contact with an infected person in a closed setting. Ingestion of contaminated water and food has led to outbreaks of hepatitis A, especially in areas or communities with low endemicity.<sup>18,19</sup> In SA, HAV is endemic in the lower socio-economic communities, with

mostly asymptomatic infection in children while sporadic symptomatic infections are more common in the more affluent communities. Hepatitis A virus has been detected in water sources in SA and the risk of infection has been quantified.<sup>21</sup> With the current trends in urbanisation, and as sanitary conditions improve, a change in the epidemic vulnerability of the SA population, with an increase in HAV outbreaks, can be expected. Hepatitis A virus persists for long periods on contaminated fomites such as sanitary tiles and latex gloves.<sup>17</sup> Hepatitis A virus can persist for up to 9 days on lettuce, 4 days on carrots and 7 days on fennel, and washing does not guarantee total removal of viral contamination. The average incubation period of hepatitis A is 28 days (range 2 - 7 weeks) and is dependent on the dose of virus ingested. The prodromal or pre-icteric phase of 4 - 6 days is characterised by nonspecific symptoms such as anorexia, nausea, malaise, abdominal pain, rash, fever and gastrointestinal symptoms. The icteric phase, of approximately 3 weeks, is marked by jaundice and begins with yellow discolouration of the mucous membranes, conjunctivae, sclera and skin, dark urine and pale stools. The convalescence phase ranges from 3 to 6 weeks but fatigue, right upper quadrant faecal virus shedding, can occur in 3 - 20% of cases and is usually less severe than the original episode. Hepatitis A is usually asymptomatic in children <5 years of age while symptomatic infection usually occurs in older children and adults. Maximal shedding of HAV in the faeces occurs late in the prodromal phase prior to the onset of symptoms, which provides an opportunity for person-to-person spread and environmental contamination. Diagnosis of acute hepatitis A infection is made by the demonstration of anti-HAV IgM antibodies in acute-phase serum.<sup>19</sup> There is no specific treatment for hepatitis A. Effective control measures to prevent HAV infection include improved personal hygiene, adequate disposal of human waste and preventing faecal contamination of food and water. Vaccination is recommended for

travellers, homosexual men and individuals at occupational risk.<sup>22</sup>

### Viral analysis of water and food

The analysis of water and food samples for viruses is a complex process and often not performed. Unlike bacteria, viruses which are present in low numbers in water and food cannot replicate in these matrices and the number of infectious particles therefore does not increase during packaging and processing. The analysis of water and food is a multistage process:

- sample preparation and recovery of the virus from the matrix
- virus detection
- virus characterisation or typing.

It is essential that sensitive and specific methods are applied to the viral analysis of food and water to exclude false negative and false positive results.<sup>12,23</sup> The most common water- and foodborne viruses, namely HAV and NoV, are difficult to isolate in conventional cell culture or cannot be isolated at all, therefore their infectivity status is uncertain. The development and

introduction of molecular techniques have increased the knowledge base of water- and foodborne viruses but there is still the debate as to whether or not viruses detected by RT-PCR or real-time RT-PCR pose a public health risk. Epidemiological data from many countries, however, indicate that water- and foodborne viruses contribute significantly

to the economic burden of gastrointestinal disease due to staff illness, disruption of services and absence from work.

References available at [www.cmej.org.za](http://www.cmej.org.za)

## IN A NUTSHELL

- Water- and foodborne viral disease is a major public health problem.
- Water and food which conforms to bacterial standards may still be contaminated with viruses.
- Drinking water is considered to be the main source of pathogenic organisms in developing regions.
- Viruses are responsible for the majority of foodborne infections.
- Clinical and economic impact of water- and foodborne disease is underestimated.
- Most of the water- and foodborne viruses are non-enveloped and are resistant to heat, disinfection and pH changes.
- Hepatitis A virus and noroviruses are the leading viral causes of water- and foodborne disease.
- The infectious dose for HAV and NoVs is estimated to be around 10 - 100 infectious viral particles.
- An effective vaccine is available for the prevention of hepatitis A.
- The analysis of water and food samples for viruses is a complex process and is often not performed.

## SINGLE SUTURE

### *A real pain for astronauts*

When astronauts reach for a painkiller in space they might not get the relief they expect. A NASA-funded investigation has found that medicines can be compromised by conditions in space. This could be a big problem on longer space flights, such as a trip to Mars.

If stored correctly most drugs have a shelf life of between one and two years, during which time they should retain most of their potency. To investigate how space travel might affect drug potency Brian Du, at the Wyle Engineering Group, and colleagues, sent four medical kits containing 35 medicines commonly used by astronauts into space, while four identical kits were stored in a controlled environment back on Earth. The kits were sent back at intervals over 28 months.

At the end of the study less than a third of the solid formulations kept in space met US requirements for levels of active ingredients. The longer the kits were in space, the fewer formulations came up to scratch.

Pharmaceuticals are packed in compact flight kits during missions, not in the manufacturer's packaging. This, along with higher levels of ionising radiation in space, seems to be responsible for the degradation says Lakshmi Putcha, a NASA researcher who co-authored the study.

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