



## **NOROVIRUS INFECTION IN THE HOME AND THE ROLE OF HYGIENE**

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### **Introduction**

Indications are that noroviruses (NoV) are now the single most significant cause of infectious intestinal disease (IID) in the developed world. Indications are that the major route of transmission is from person to person, either directly via hands, surfaces or aerosols, or indirectly via food. Good hygiene involving the prevention of transmission via hands and via hand and food contact surfaces thus plays a key role in reducing the risks of transmission, particularly for sporadic and family related cases in the community. The available data on the transmission of infection in the home has been previously reviewed by IFH in 2002<sup>1</sup> and more recently in 2007<sup>2</sup>. In the following short review, published data specifically related to the occurrence and transmission of noroviruses in community and home settings is reviewed, together with data on the impact of hygiene in reducing risks of transmission. The data has been taken from recent reviews by de Wit 2003<sup>3</sup>, Lopman et al 2004<sup>4</sup>, Carter 2005<sup>5</sup> and Widdowson 2005<sup>6</sup>

### **Emergence and prevalence of norovirus infections in the community**

Widdowson<sup>6</sup> reports that noroviruses were first reported as the viruses definitively associated with acute gastroenteritis in 1972. During the subsequent two decades, mainly because methods to detect these viruses were unavailable, they were largely overlooked as agents of gastroenteritis, and attention was focussed on outbreaks of *Salmonella* Enteritidis, *Escherichia coli* etc. The development of RTP-PCR in the early 1990s provided the breakthrough needed to facilitate diagnosis of norovirus infection. Today, noroviruses are recognised as the most common cause of infectious gastroenteritis among persons of all ages<sup>7</sup>. Infections occur around the globe and throughout the year, but may be more common in winter giving rise to its former name 'winter vomiting disease'. Although it has achieved notoriety in public health terms because of the outbreaks which have occurred in hospitals, hotels and cruise ships, and the costs of these outbreaks to the health service and tour operators, indications are that norovirus infection is now commonly circulating in the home and community to an extent that economic costs to affected countries, in terms of work days lost, are significant. Since norovirus infections are largely self-limiting within a few days, sporadic infections are not usually reported, which means that only limited data is available on the prevalence of norovirus infections in the community and home as opposed to hospitals and public places. However two recently reported community-based studies give some idea of the extent of the problem:

- A UK community-based study reported in 1999 and involving some 460,000 participants indicated that as many as one in five people in the general UK population develop infectious intestinal disease each year, with an estimated 9.4 million cases occurring annually (Wheeler et al. 1999<sup>8</sup>, Tomkins et al.<sup>9</sup>, FSA 2000<sup>10</sup>). The study indicated that for

every 1 reported case of norovirus infection, about 1,500 cases respectively go unreported. From this Carter estimated that of the 9.4 million annual cases of IID, some 16% are caused by norovirus. Although it is not possible to obtain proof, since the sources of these cases was not directly investigated, the most obvious conclusion is that a very significant proportion of these infections relate to community settings including the home. Carter estimated that, assuming that all of these unreported outbreaks took place in a household of four persons and that all persons in each household were infected, this would correspond to a minimum of 380,000 infected households per years.

- From a community-based study carried out in the Netherlands in 1999,<sup>11, 12, 13</sup> de Wit and co-workers concluded that the overall incidence of gastroenteritis in the Netherlands was estimated at 283 per 1,000 persons per year. Noroviruses were detected in 11% of cases. The incidence at the general-practice level from 1996 to 1999 was estimated at 14 per 1,000 person-years; 5% was attributed to norovirus and 5% to rotavirus. By extrapolation de Wit et al<sup>3</sup> estimated that, relative to the population of the Netherlands (16 million), 650,000 norovirus gastroenteritis cases occur annually.
- In the US Widdowson estimates that noroviruses are responsible for 50% of all foodborne gastroenteritis outbreaks<sup>14</sup> and are a major contributor to illness in nursing homes<sup>15</sup> and hospitals.<sup>16</sup> There is however currently no data to indicate the extent of norovirus circulating in the community.

The application of national surveillance systems for monitoring norovirus infections in the past few years has established that norovirus strains periodically emerge either globally or nationally and displace other strains causing an increase in disease incidence. In 1996, 2002 and 2004, the appearance of new variants within genotype GII.4 coincided with high levels of outbreak reporting world-wide. In winter 2002, a new variant due to genotype G.II 4 (Bristol virus) caused a surge of norovirus outbreaks on cruise ships and in nursing homes in the United States and in healthcare facilities in Europe, and it has been the predominant genotype since this time. There is concern that these G.II 4 (Bristol virus) strains cause different or more severe symptoms than other noroviruses, are more transmissible or can better evade the host immune response<sup>4</sup>.

In Europe, new variants of genotype GII.4 2006 appeared during the 2005/2006 season and have been circulating widely since the spring of 2006, causing at least 45 outbreaks of norovirus illness on cruise ships sailing around Europe. It is believed that the emergence of these 2006 variants, and the increase in outbreaks on cruise ships may be the forewarning of a very active norovirus season across Europe over the 2006/2007 winter. This conclusion comes partly from a survey of countries across Europe by the Foodborne Viruses in Europe network (FBVE) reported in the December 2006<sup>17</sup>. Nine of the eleven country authorities which replied to the survey indicated an increase in norovirus activity (outbreaks and/or case reports) in October and/or November 2006 compared with the same period in 2004 and 2005 (see Table 1). In two countries (France and Spain), no increase in norovirus activity was found. Already in summer 2006, an unusually high norovirus activity was reported by the Hungarian authorities (thought to be due to a drinking-water related outbreak) as well as the Netherlands, Denmark, Ireland, Finland and Norway. The highest increases were reported in Norway, Hungary and in England and Wales. For England and Wales the number of outbreaks reported was 768, compared with 374 outbreaks in the previous period of peak activity in 2004.

**Table 1.** Reports of norovirus cases and outbreaks across Europe, as provided by an email survey. Numbers of reports in the email survey were partly estimates.

	<b>Increasing norovirus activity in</b>	<b>Numbers of outbreaks/ cases in Oct and Nov reported after email request for data</b>	<b>Basis of information</b>
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	October and/or November	2006	2005	2004	Lab database national	Surveill. database national
<b>Germany</b>	Yes	604 outbreaks	184 outbreaks	514 outbreaks	No	Yes
<b>Denmark</b>	Yes	249 lab samples	38 lab samples	222 lab samples	Yes	No
<b>Spain<sup>2</sup></b>	No	2 outbreaks	6 outbreaks	12 outbreaks		
<b>Finland</b>	Yes	~ 120 cases	~ 10 cases	~ 10 cases	Yes	No
<b>France</b>	No	3 outbreaks	1 outbreak	2 outbreaks	Yes	No
<b>England and Wales<sup>3</sup></b>	Yes	768 outbreaks and round 756 lab samples	83 outbreaks and 281 lab samples	374 outbreaks and 682 lab samples	Yes	Yes
<b>Hungary</b>	Yes	81 outbreaks	17 outbreaks	24 outbreaks	Yes	
<b>Ireland</b>	Yes	7 outbreaks	0 outbreaks	22 outbreaks	No	Yes
<b>Italy</b>	Unknown					
<b>The Netherlands</b>	Yes	36 outbreaks	5 outbreaks	68 outbreaks	Yes	
<b>Norway</b>	Yes	~ 160 cases	~ 65 cases	~ 35 cases	Yes	No
<b>Sweden</b>	Yes	~ 400 cases	~ 50 cases	~ 350 cases	Yes	No
<b>Slovenia</b>	Yes	7 outbreaks	6 outbreaks	5 outbreaks	Yes	No

<sup>2</sup>Data from Valencia and Catalonia

<sup>3</sup>Outbreaks reported from virus reference laboratory only. Laboratory data are from England and Wales, these data will include outbreaks and sporadic cases.

In January 2007 norovirus-related gastroenteritis reached a record high level in Japan, according to the Japanese National Institute of Infectious Diseases<sup>18,19,20</sup>. Some 3,000 medical institutions across Japan reported that they treated 65,638 infected patients between November 27<sup>th</sup> and December 3<sup>rd</sup>, a record-high average of 21.8 per institution, compared with 19.8 logged in the preceding week, also a record since the survey began in 1981. Experts warn that gastroenteritis normally peaks from late-December and fear the worst of the outbreak may be yet to come. Since late October 2006, gastroenteritis cases have been double those of regular years. Gastroenteritis symptoms normally disappear after a couple of days, but it has led to some fatalities among the elderly. Previously, the highly contagious virus has typically been transmitted by eating raw oysters and clams but this season's epidemic comes mostly from human-to-human infections. Experts suggest the current trend can best be explained by a possible outbreak of a new virus variant in Japan. The virus' DNA structure has been identified to a certain degree and it is currently categorised into genogroup I (GI), containing 15 genotypes, and genogroup II (GII), containing 18 genotypes. GI.4 viruses are now sweeping across the globe, including Japan, although it is not clear whether the outbreak in Japan is linked to outbreaks in Europe.

Although surveillance data on norovirus outbreaks and cases is difficult to interpret, from the various data, expert opinion is that norovirus outbreaks are becoming more common<sup>4,6</sup>. In reaching this conclusion Widdowson and co-workers<sup>6</sup> suggest a number of reasons why this should be. First, it may relate to the fact that rates of bacterial foodborne illnesses are declining, in large part because of measures such as improved refrigeration and use of Hazard Analysis and Critical Control Point systems to reduce contamination of food of animal origin. Most of these measures, however, will be ineffective against noroviruses, which are resistant to chlorination and freezing, persist in the environment, and require only very low inocula to

infect. Thus, the relative contribution of noroviruses to foodborne disease is likely to increase. Second, modern lifestyles make us more vulnerable to norovirus infection than when these viruses were discovered. In most developing countries, more elderly people live in communal settings, with the number of beds in nursing homes increasing. In addition, we now eat more foods that have been handled by a variety of potentially infected people; 46% of household food expenditures is now spent on eating out, compared with 32% in 1972. We also eat more of the foods that are likely to be contaminated with norovirus; consumption of fresh vegetables and fruit has risen 20% in the last 30 years, and this produce is often grown in countries where crops are still irrigated with sewage-contaminated water. Finally, more people than ever are travelling and have an increased risk for norovirus infection through exposure to hotels, aeroplanes and cruise ships. From 1993 to 1998, for example, the number of cruise ship passengers in the United States increased by 50%.

### **Significance of norovirus and norovirus infections**

Because norovirus infections are generally self-limiting illnesses, lasting only up to 24–48 hours, and as a result, patients do not generally visit their GP, there is a tendency to dismiss these infections as trivial in public health terms. However, although norovirus infection is not regarded as severe in otherwise healthy adults, it is debilitating and very unpleasant and (although there are no estimates available) in badly affected countries such as the UK and Netherlands must result in significant numbers of work days lost. There is also evidence that, in vulnerable groups, such as the malnourished or elderly, it can be serious and may even precipitate death. Norovirus infection has put apparently healthy people in intensive care<sup>21</sup> and has been associated with chronic diarrhoea among transplant patients<sup>22</sup>.

Norovirus differs from other agents of gastroenteritis in a number of ways which can increase its significance in public health terms:

- it causes disease in adults (teenagers and above), thus norovirus is the most significant diarrhoeal virus in terms of work/education days lost.
- although there are probably multiple serotypes of norovirus, immunity to all seems to be short-lived. Thus individuals may be protected for only a few months following an infection before they become infectable once more by the same virus.
- Some people appear to have an inherent resistance to infection; community outbreaks that stemmed from communal exposure by swimming pool contamination showed familial clustering of symptomatic illness, and even in middle age population antibody levels are only 50%. Many of these seronegative individuals remain symptom-free and it is now thought likely that they lack the cell-surface receptor (a carbohydrate antigen) to which the virus must bind to initiate infection. Susceptible persons require several bouts of infection by the same virus before antibody levels are boosted sufficiently to afford some protection.
- Until now, norovirus has been seen as seasonal with most outbreaks occurring in the winter, although indications are that the season is now extending to cover the summer months. The reason for this seasonality is not well understood, but is probably due to a combination of climatic conditions that favour survival of the virus and social behaviours that increase the likelihood of person-to-person and foodborne transmission. Lopmans et al<sup>4</sup> postulate that the new variants may be more virulent or environmentally stable than previous genogroup 114 viruses.

### **Transmission of noroviruses in the home and the role of hygiene**

Developing hygiene policy and promoting effective hygiene practice to reduce the risks of transmission of norovirus in the home and community depends upon understanding the routes of transmission and the relative importance of different routes in this setting. Overall it is well established that foods can be contaminated with norovirus either at source or during

handling and preparation by infected food handlers (either prior to retail sale or by family members in the home). It is known that noroviruses can also spread by water, by direct person-to-person contact or via airborne droplets of vomitus, and can persist on environmental surfaces as a source of continuing infection. However the relative importance of these transmission routes in different settings is not well understood.

In the home and community, the potential for person-to person transmission, either directly or via airborne particles, hands and surfaces is shown by the fact that most enteric viruses are highly contagious. For most, the infectious dose is believed to lie between 10 and 100 particles and for norovirus possibly lower. It is known that vomiting can generate up to 30 million virus particles<sup>23,24</sup> and it has been shown that proximity to vomit at the time of vomiting may be a significant factor. Particles can also survive on dry surfaces for significant periods of time<sup>1</sup>. Although, as stated by Carter<sup>5</sup>, indications are that aerosolization is a means of infection for those in the immediate vicinity, airborne transmission must be regarded as distinct from respiratory transmission, as the route of infection remains via the gut rather than the respiratory tract; infection may result from the trapping of aerosolised droplets containing the virus in the nasal passages and thus its subsequent swallowing. The airborne route for person-to-person transmission of norovirus infection is consistent with the observed ease of spread of infection in closed settings such as hotels and cruise ships.

Alternatively an aerosolised virus may settle on surfaces or uncovered food. Once a virus is present it can be very hard to eliminate. The evidence showing the extent to which noroviruses can survive, persist and spread via environmental surfaces was reviewed in more detail by IFH<sup>1,2</sup>. Some of the key evidence that transmission via hands and surfaces plays a significant role comes from observations on recurrent outbreaks of norovirus on cruise ships and hotels, where apparently thorough inspections and cleaning between cruises of cohorts of hotel guests were not sufficient to stop the outbreaks. These recurrent waves of infection occurring in successive cohorts of guests strongly suggests that although during each outbreak, aerosol transmission was the source of the rapid spread, transmission via environmental sites and surfaces was responsible for initiating each new outbreak.

Perhaps the most difficult aspect to estimate is the contribution of each transmission route to the total burden of infection in the community. Carter reports that studies in the UK, US and the Netherlands all suggest that contact with an infected person is the greatest single risk for infection by norovirus (Mead et al. 1999<sup>7</sup>; FSA 2000<sup>10</sup>; De Wit et al. 2003<sup>3</sup>). However this does not mean that all community spreads must be by the person-to-person route, because unlike other viruses (which may be maintained entirely by this route), enteric viruses can also spread through food or water. The report of the UK community-based<sup>9</sup> study attributes community cases (almost) entirely to person-to-person transmission but presents no data on this point.

In order to better identify modes of transmission and opportunities for prevention, a case-control study was carried out in 1999 in the Netherlands by De wit et al<sup>3</sup> in order to study risk factors for gastroenteritis attributable to norovirus, Sapporo-like virus and rotavirus. The study cohort consisted of an age stratified sample of persons registered at general practices in the study area. It was found that having a household member with gastroenteritis, contact with a person with gastroenteritis outside the household and poor food-handling hygiene were associated with illness (population attributable risk fractions [PAR] of 17%, 56%, and 47%, respectively), thus supporting the hypothesis that noroviruses are mainly transmitted from person-to-person. For the risk factor of household gastroenteritis contact, risk was slightly higher if the household member was a child rather than an adult. Risks were comparable if the household member had diarrhoea or vomiting. PAR for the two factors representing transmission in the household (hygiene and household gastroenteritis contact) combined was 56%. The high PARs indicate that most of these infections could be prevented by stopping the spread from symptomatic persons to others. In this study it was identified that contact of

cases with symptomatic persons outside the household took place in the house of friends or family (31%), a day-care centre (19%), school (18%), home (10%), or other places and work (22%). The association of attendance at day-care and primary school with norovirus gastroenteritis was no longer observed after correction for household gastroenteritis contact, especially if the sick household member was a child.

The association with food-handling hygiene in the household indicates that, in a household setting these viruses do not only transmit directly from one person to another but also by means of food. Hygienic food-handling procedures can therefore further prevent the infection spreading from one person to another. Although the impact of food-handling hygiene can be partly explained by food contamination that occurs when a sick household member prepares meals, food contaminated at an earlier step in the food chain may also be a source.

The conclusions of de Wit et al are supported by surveillance data from the US and Japan together with earlier data from the Netherlands, all of which suggest that person-to-person spread and foodborne spread are the most common transmission routes.<sup>25,26,27</sup> De Wit et al point out however that the data suggests that the relative importance of each route of transmission differs by country and is strongly influenced by the design of the surveillance system. The 2003 study of de Wit suggests that in sporadic cases, direct and indirect person-to-person transmission remains the most prominent mode of transmission, followed by food contaminated outside the household. The data suggests that, of the 650,000 norovirus cases that occur annually in the Netherlands, an estimated 80,000 cases are foodborne, which is more than the estimate for Salmonella (50,000 foodborne cases each year).

Taken by age, the data of de Wit<sup>3</sup> suggests that, for family members >5 years, transmission from one ill household member to another occurs almost entirely through food. For children, only part of the transmission from one person to another in the household is through food-handling hygiene. Possibly, for young children, exposure is very common and better food-handling hygiene in the household only prevents a minority of exposure possibilities. Several foodborne outbreaks are reported in which the food handler who had most likely contaminated the food was not symptomatic.

### **Reducing the risks of transmission of norovirus in the home**

Based on the evidence outlined above, a number of hygiene measures are indicated in situations where someone in the house has a norovirus infection, in order to reduce the risks of spread to other family members. It must be borne in mind that norovirus may be shed by people who have no symptoms, both those who have apparently recovered and those who have not yet developed symptoms:

- Handwashing is the single most important hygiene measure because it is the last line of defence. This applies to both ill people and other family members.
- Special care should be taken in preparation of food in the kitchen to avoid spread of norovirus from or via hands, cleaning cloths and food preparation surfaces to food. Ill people should stay away from the kitchen and should not prepare food for others. People affected by norovirus should not prepare food for others for at least 48 hours after symptoms have ceased.
- Toilets (potties, commodes etc) should be disinfected regularly. If someone has diarrhoea (or vomits into the toilet), the toilet, toilet seat, lid and flush handle should be disinfected after each time they use it.
- Any spillages of contaminated material (e.g. faecal matter or vomit) should be cleaned up immediately and the surface disinfected.
- Surfaces, particularly hand contact surfaces and items in the bathroom/toilet, and places that an ill person may touch (e.g. bedside items, doorknobs, switches) should be disinfected.

- Cleaning cloths and sponges should be disinfected after use by boiling or soaking in disinfectant and thoroughly dried. A clean cloth should be used for each separate task to ensure that the virus is not spread around the home.
- An ill person should not share towels, face cloths etc with others. The ill person's laundry and bed linen should be kept and washed separately.
- Where possible, ill people should stay in their own room and use their own facilities, cutlery, crockery etc.
- Ill people should particularly avoid contact with those who may be more vulnerable to infection and their personal items.
- Where young children are ill, or at particular risk:
  - their handwashing, personal and toilet hygiene may need supervision
  - nappies should be disposed of safely, or cleaned, disinfected and washed.
 Contrary to popular perception, the faeces of babies can be highly infectious.

For decontamination (hygienic cleaning) of hands, this can be achieved by soap or detergent-based cleaning, provided this is accompanied by thorough rinsing to remove norovirus particles from the hands. In situations where access to soap and running water is not an option, an alcohol hand rub or sanitizer should be used<sup>2</sup>. In "high risk" situations where there is an outbreak of norovirus in the home, it is suggested that handwashing followed by use of an alcohol rub/sanitizer should be adopted. A number of studies have been carried out to evaluate the efficacy of alcohol against norovirus. Using feline calicivirus as a surrogate for norovirus, Gehrke et al<sup>28</sup> found that 1-propanol was more effective than 2-propanol and ethanol. It was also found that these alcohols were less effective at 80% than 50% and 70%. 1-propanol produced >4 log reduction in titre within 30 secs, whilst 50% ethanol produced log reductions of 2.19, 3.65 and > 4 log reduction in 0.5, 1 and 3 min respectively.

Hygiene cleaning of food utensils and environmental surfaces can also be achieved by detergent-based cleaning but again, this is only effective if the surface can be thoroughly rinsed under running water. For contact surfaces such as large food preparation surfaces, and for the toilet seat, toilet lid, flush handles, together with other hand contact surfaces such as door handles and tap handles, telephones, computer keyboards etc, a recent study by Barker et al<sup>29</sup> showed that cleaning with detergent and water using a cloth does not eliminate norovirus from these surfaces but spreads the viral agent onto the cloth, and then via the cloth, to the hands and other surfaces. This indicates that for environmental surfaces, hygienic cleaning using an effective disinfectant product (i.e. a product which is effective against norovirus such as hypochlorite<sup>29,30</sup>) is advisable.

For more details on hygiene measures to reduce risks of norovirus transmission in the home, IFH has produced a 'briefing document' entitled "Norovirus: infection and infection prevention through hygiene in the home" which can be downloaded from our website ([www.ifh-homehygiene.org](http://www.ifh-homehygiene.org)).

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