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Infection control for norovirus

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Abstract

Norovirus infections are notoriously difficult to prevent and control, owing to their low infectious dose, high shedding titre, and environmental stability. The virus can spread through multiple transmission routes, of which person-to-person and foodborne are the most important. Recent advances in molecular diagnostics have helped to establish norovirus as the most common cause of sporadic gastroenteritis and the most common cause of outbreaks of acute gastroenteritis across all ages. In this article, we review the epidemiology and virology of noroviruses, and prevention and control guidelines, with a focus on the principles of disinfection and decontamination. Outbreak management relies on sound infection control principles, including hand hygiene, limiting exposure to infectious individuals, and thorough environmental decontamination. Ideally, all infection control recommendations would rely on empirical evidence, but a number of challenges, including the inability to culture noroviruses in the laboratory and the challenges of outbreak management in complex environments, has made it difficult to garner clear evidence of efficacy in certain areas of infection control. New experimental data on cultivable surrogates for human norovirus and on environmental survivability and relative resistance to commonly used disinfectants are providing new insights for further refinining disinfection practices. Finally, clinical trials are underway to evaluate the efficacy of vaccines, which may shift the current infection control principles to more targeted interventions.

Keywords: Disinfection, epidemiology, infection control, norovirus, nosocomial
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Introduction

Norovirus is a leading cause of acute gastroenteritis in people of all ages and settings. Approximately 19–21 million norovirus illnesses occur each year in the USA [1]. A high titre of shedding by infected persons, a low infectious dose and environmental stability are some of the attributes that facilitate effective norovirus transmission through a variety of modes (person-to-person, food, water, and environment) [2–5]. These attributes present an array of challenges for prevention and control, in particular in institutional settings [4,6]. Specialists involved with infection and environmental control use a range of strategies aimed at preventing and controlling norovirus outbreaks [7–9]. However, some of these measures, such as ward/unit closures in hospitals, can place a substantial burden on institutions and personnel; a UK study estimated a loss of *c.* $1 million for every 1000 beds [10–12]. Ideally, outbreak management guidelines would be supported by high-quality empirical evidence. However, generating high-quality evidence for efficacy is difficult, as the evidence for outbreak management is largely empirical, and there are challenges associated with a non-cultivable virus. Here, we review the current knowledge of norovirus outbreak epidemiology and virology, and infection control guidelines, with a focus on disinfection and decontamination, and highlight areas for future research.

Norovirus Outbreaks

Settings

Outbreaks provide an opportunity to study norovirus epidemiology, including how these viruses spread and what control measures are effective. Outbreaks occur in the diverse range of settings where humans congregate. In the USA, outbreaks in

restaurants and on cruise ships are frequently picked up by the media. However, one would have a skewed sense of the distribution of norovirus outbreak patterns from media reports alone. Data from broad-based surveillance in high-income countries show that the majority of outbreaks occur in healthcare facilities; however, the specific types of facility reporting outbreaks can differ between countries. In the USA, >60% of all norovirus outbreaks occur in long-term-care facilities [13,14]. This contrasts with the settings reported in Europe, Japan, and other high-income settings, where outbreaks in acute-care hospitals are common and roughly equal in number to outbreaks in long-term-care facilities (Fig. 1) [15]. In the USA, acute-care outbreaks are relatively uncommon, constituting *c.* 5% of norovirus outbreaks [13,16]. Whether the lower frequency of outbreaks reported from US hospitals represents a real difference in epidemiology or infection control, or an artefact of reporting bias, is not well understood.

Modes of transmission

Although noroviruses have been detected in bovines, mice, and canines, these virus strains appear to be highly species-specific, and zoonotic transmission does not seem be common. In humans, the virus typically spreads directly via person-to-person transmission (faecal–oral and vomit–oral) or indirectly through foodborne, waterborne and environmental transmission. Direct person-to-person transmission is reported in >90% of the norovirus outbreaks in healthcare facilities [6,13,17]. Foodborne, waterborne and environmental transmission have some features in common, in the sense that a food product, water source or fomite may become contaminated by an infected person, and another individual then ingests virus after coming into contact with that object. In the USA, norovirus is estimated to be the most common aetiological cause of foodborne illness, which accounts for 7–24% of norovirus outbreaks worldwide [13,14,18–20]. Although food may become contaminated at any point in the 'farm to fork continuum', the majority of foodborne norovirus illness is a result of contamination by infected food-handlers during preparation [21]. Ready-to-eat foods (such as leafy greens) and foods handled after cooking are the most frequently identified products associated with outbreaks [21]. Each of these transmission modes presents specific challenges in terms of infection prevention and control, as discussed below.

The high levels of virus shed in faeces and vomit [2], the low infectious dose [3] and the environmental stability of the virus [4] all contribute to the ability of noroviruses to utilize various modes of transmission (Table 1). Furthermore, transmission has been reported to occur before the onset of symptoms [22], in the post-symptomatic period, and during subclinical

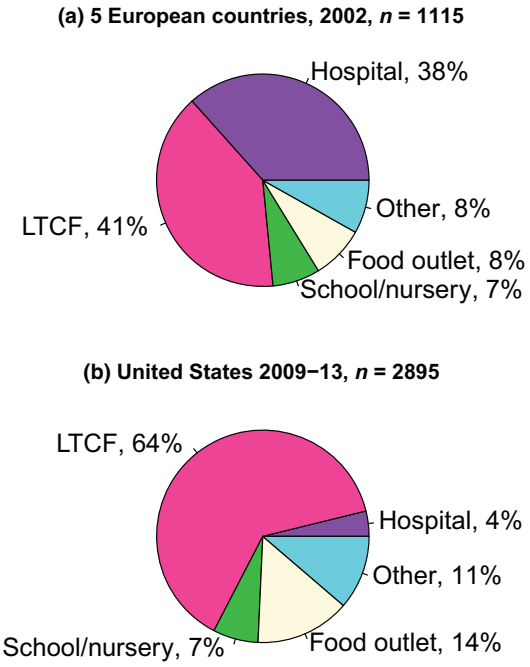

FIG. 1. Setting of (a) norovirus outbreaks reported in five European countries with broad-based surveillance, 2002, *n* = 1115, and (b) the USA, 2009–2013, *n* = 2895. Long Term Care Facility (LTCF). Adapted from Lopman *et al.* [15] and Vega *et al.* [13].

TABLE 1. Characteristics that facilitate norovirus transmission

Characteristics	Description
Low infectious dose	Estimates of the infectious dose ranges from 18 to 10^3 virus particles [3]
High shedding titre	Peak shedding ranges from 10^5 to 10^9 particles/g of stool [2]
Prolonged shedding	Virus can be detected up to 8 weeks after symptom onset, with a median of 4 weeks; even longer durations of shedding may be detected in immunocompromised individuals [2,107]
Genetic diversity	Over 30 genotypes (nine GI and 22 GII) infect humans [5]. No long-lasting immunity [25,108]. Different genotypes can infect humans over their lifetime [25]
Environmental stability	Norovirus particles may be infectious for 2 weeks on environmental surfaces and for >2 months in water [67,109]
Resistant to common disinfectants	Surrogates used to determine the efficacy of EPA-registered disinfectant products have different physiochemical properties; therefore, different disinfection profiles exist, and overestimate the efficacy of disinfectant products [29,87]
Vomiting	Vomiting appears to be a particularly effective route of norovirus spread. Vomiting events may occur and lead to direct transmission (when in public) as well as environmental contamination from vomit droplets [59,110]
Transmission through multiple routes	Noroviruses are transmitted via the faecal–oral route and vomit–oral route, and through a number of specific modes, including foodborne, waterborne, environmental and direct person-to-person spread [6,13,21,57,64]

Adapted from [4].