Norovirus Surveillance: An Epidemiological Perspective

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Surveillance for norovirus is challenging because the nature of illness due to norovirus is such that the majority of people who are infected will not have any contact with medical services and are highly unlikely to have a sample collected for diagnosis. Public health advice urges people to not visit hospitals or their family physicians, to prevent the risk further spread. The recognition of the importance of this pathogen was quickly established following the introduction of surveillance of outbreaks of gastrointestinal infection in England and Wales in 1992. This period saw >1800 outbreaks of norovirus infection reported in hospitals in England, affecting >45 000 patients and staff. A new system for reporting outbreaks of norovirus infection in hospitals, the Hospital Norovirus outbreak Reporting Scheme (HNORS), began in January 2009. Summary information on outbreaks is provided by infection control staff at hospitals and includes questions on the date the first and last person in the outbreak became symptomatic and whether closure of a bay or ward was needed. In the first 3 years (2009–2011) of the HNORS surveillance scheme, 4000 outbreaks were reported, affecting 40 000 patients and 10 000 staff. Over the last 3 years, these outbreaks have been associated with an average of 13 000 patients and 3400 staff becoming ill, with 15 000 lost bed-days annually. With the possible introduction of a vaccine on the horizon, targeted research with a more integrated approach to laboratory testing and outbreak reporting is essential to a greater understanding of the epidemiology of norovirus.

Keywords. norovirus; epidemiology; surveillance; diarrheal disease outbreaks.

Surveillance for norovirus is challenging; illness from norovirus is characterized by a sudden onset of symptoms, mostly vomiting and diarrhea, and recovery is equally rapid, with most patients recovering within 1 or 2 days [1]. Public Health England has been gathering laboratory reports of a range of pathogens for many years, since the inception of the Emergency Public Health Laboratory Service in the late 1930s [2, 3]. However, norovirus detection in the laboratory was not possible until technological developments facilitating detection occurred in early the 1970s [4]. Despite developments since then and the advent of more-sensitive techniques, laboratory reports remain a significant underestimate of the number of cases of norovirus infection [5]. The nature of the illness means that the majority of people who are infected will not have any contact with medical services and are highly unlikely to have a sample collected for diagnostic analysis [5]. This situation is further exacerbated because the public health advice issued to individuals with norovirus-associated illness is to remain at home and not visit hospitals or general practitioners, for fear that they risk further spread. In the community, outbreaks of norovirus infection are difficult to ascertain, particularly if the individuals involved are from a widely disseminated area, yet despite this norovirus is recognized as the leading cause of gastrointestinal (GI) disease in the United Kingdom [5] and many other countries around the world [1, 6–8].

The recognition of the importance of this pathogen as a cause of outbreaks in England was quickly established following the introduction of surveillance of GI disease outbreaks in England and Wales in 1992 [7]. The surveillance of GI disease at this time relied upon the sending and receiving of paper questionnaires. The data from these questionnaires were then entered into a database for analysis later. Analysis of these data showed that >25% of outbreaks reported from 1992 to 2008 were in hospitals and that around 80% of the outbreaks were either suspected or confirmed to be due to norovirus [7]. This period saw >1800 outbreaks of norovirus infection reported in hospitals in England, affecting >45 000 patients and staff [7]. The seasonality of norovirus infection outbreaks was also clearly demonstrated, with increasing activity occurring in the winter months. Furthermore, differences were observed showing that some winter seasons had considerably more outbreak reports than others, particularly in 2002, when the emergence of the new GI.4 strain of norovirus was detected in Europe [9]. The importance of the impact of norovirus on organizations was demonstrated in 2003 [10]. A prospective study was published showing that outbreaks cost the National Health Service £635 000 ($1.01 million) in one region because of ward closures and staff sickness. Extrapolation of this figure estimated the cost to the NHS in England as around £115 million ($184 million).

Organizational changes and recognition by the United Kingdom Department of Health for the need to collect data on norovirus infection outbreaks in a more detailed and systematic way led to changes in the way surveillance of GI disease was
carried out in England and Wales. Ultimately this led to the setting up of a new system for reporting outbreaks of norovirus infection in hospitals, the Hospital Norovirus outbreak Reporting Scheme (HNORS), beginning in January 2009 [7]. Development of HNORS took advantage of the increasing use of electronic methods of data gathering.

**METHODS**

Data on outbreaks in hospitals are now gathered via a web-based system, described in detail elsewhere [7]. Briefly, users are provided with log-in information to access the system. Information about outbreaks is provided by infection control staff at hospitals and includes summary details, such as the dates the first and last people involved in the outbreak became symptomatic, whether closure of a bay or ward was needed (and, if so, the dates of the closure), whether the outbreak was confirmed by the laboratory as due to norovirus, the number of staff and patients affected, and the ward type. Users are asked to report outbreaks at the ward level (ie, to treat each outbreak on a ward as distinct). For the benefit of capturing the entire winter seasonal activity of norovirus, the annual surveillance period begins on 1 July and ends on 30 June the following year.

**RESULTS**

In the 7 years since the reporting scheme began, 7613 outbreaks have been reported to HNORS, and, of these, 68% (5160) have been confirmed by the laboratory to involve norovirus. These outbreaks have affected 73 129 patients and 18 685 staff, involved 52 343 days, and led to 45 034 ward/bay closures.

In the first 3 years (2009–2011) of the HNORS surveillance scheme, 4000 outbreaks were reported, affecting 40 000 patients and 10 000 staff. On average, these outbreaks were associated with 13 000 patients and 3400 staff becoming ill and 15 000 lost bed-days each year. Over 80% of outbreaks reported led to some form of ward or bay closures. Further analysis of HNORS data, using Poisson regression analysis to assess the effect of ward closure on length of closure, suggests that acting quickly, by closing wards within 3 days of the outbreak start, is associated with a shorter outbreak duration [11].

Norovirus is not an exclusively winter pathogen. Although the number of reported outbreaks and laboratory reports increases in the winter months, some occur during the summer, but at much lower frequency (Figure 1).

Norovirus activity varies from one winter season to the next, with some winters having a much greater number of outbreaks reported; the number of laboratory reports mirrors this pattern. There were 616 and 830 outbreaks during the 2013–2014 and 2014–2015 seasons, respectively. In these 2 seasons, 7249 and 11 978 patients were affected, respectively, with 3598 and 5232 days of ward/bay closure. The greatest number of outbreaks occurred during the 2009–2010 season, when 1884 outbreaks were reported, affecting 19 487 patients and 5229 staff and leading to 12 423 days of ward/bay closure. During the 2011–2012 season, norovirus activity began earlier than previously expected and was later associated with the emergence of a new strain (Sydney 2012) [12]. It was associated with the second highest seasonal activity since this scheme began, leading to 1653 outbreaks, affecting 15 633 patients and resulting in 8656 days of ward/bay closure.

Analysis of the effects of norovirus-associated outbreaks on patients, staff, length of outbreak, and duration of ward closure reveals that the epidemiologic characteristics of outbreaks have changed little over the years. The median number and distribution of patients, staff, length of outbreak, and length of ward closure has not changed, despite the changes in the level of norovirus activity (Figure 2). The average number of patients or staff affected has not significantly decreased over the years.
During the 2009–2010 season, the median number of patients affected was 9, and during the 2014–2015 season, the median number was 7. The median length of outbreak was 7 days in 2009–2010 and 2010–2011 and 6 days during the subsequent seasons. The variation in each of these characteristics has remained similar throughout the reporting period.

**DISCUSSION**

Despite the increased ability to detect norovirus infections, the challenges to surveillance of norovirus remain. Principally, this is a reflection that the reservoir for the virus is the human GI tract and that, unlike zoonotic bacterial foodborne infections, the focus of infection control is to prevent transmission from person to person. The public health advice to people with a sudden onset of diarrhea and vomiting is for them to remain home, which, while providing protection against further transmission and allaying the possibility of outbreaks in healthcare institutions, also prevents diagnosis.

The adoption of electronic means of reporting outbreaks has provided greater insights into the number of outbreaks occurring and the burden norovirus infection has on hospitals in England. In the first 3 years of reporting to HNORS, more outbreaks of norovirus were reported than in the entire previous system of reporting. This reflects the change to a system focused on gathering data on outbreaks in hospitals, where data can be entered online and directly, rather than on attempting to determine the contribution of different pathogens on the basis of a one-size-fits-all paper-based system [7].

The last 2 seasons have been relatively quiet in terms of the total number of outbreaks reported. Despite this, outbreaks of norovirus infection have had a considerable impact, affecting >12 000 patients and >3000 staff and resulting in >8500 days of ward/bay closure and >19 000 reported bed-days lost. Norovirus activity fluctuates from one year to the next [13], and various factors, including host, weather, and virological characteristics [9, 12–14], have been assessed as possible contributing causes. The changes observed in norovirus activity from outbreaks reported to HNORS are as likely to be affected by these factors as they are by any changes within the reporting scheme itself. The pattern of outbreaks is mirrored very closely by the pattern of laboratory reports of norovirus infections, suggesting that the low activity observed is real rather than an artifact. Furthermore, assessment of the coverage of HNORS suggests a high level of ascertainment of outbreak reporting [7].

Despite changes in the seasonal activity of norovirus, the epidemiologic characteristics of outbreaks appear to be stable. The median length of outbreak and closure has not shortened, neither has the number of patients or staff affected. In terms of infection control, ward or bay closure (perhaps more correctly described as restricted admission) is the mainstay of control of outbreaks of norovirus infection. Although this action has been questioned [15] and is disruptive, there is evidence from more-detailed analysis of HNORS data that such a policy is...
advantageous, particularly in the winter and for larger wards [11]. However, the benefits of this policy are not conclusive for smaller wards, and it remains challenging to assess the effect of ward closure in controlling outbreaks [11], largely because HNORS collects summary data on outbreaks. Data from another study also show that proximity is an important driver of outbreaks of norovirus infection [16], suggesting that when outbreaks are detected, prompt action in closing affected areas is crucial to prevent further exposures to this highly infectious pathogen.

Norovirus infection is often referred to as a mild self-limiting disease, but it has been shown that vulnerable people take longer to recover and that there is a demonstrable link to an increased risk of associated mortality, particularly in elderly individuals [17, 18]. Data from HNORS do not include enough details about the different genogroups/genotypes of norovirus. For example, did the Sydney 2012 strain lead to longer or more severe illness? We cannot answer these questions without linking outbreak data to findings of laboratory analysis of samples. Detailed analysis of samples from some past outbreaks has shed light on transmission events [19–21]. During the 2011–2012 season, modeling showed that the early increase was due to the introduction of a new strain but that this strain did not have the same impact as the new variant GII.4 strain that emerged in 2002 [9]. Other factors must also be explored, such as the role of asymptomatic carriage and how to interpret norovirus-positive stool specimens (eg, do positive test results indicate the presence of whole intact virus particles that can cause illness?). With the possibility of the introduction of a vaccine on the horizon [22], more-integrated approaches to laboratory testing and outbreak reporting is essential, and targeted research to answer these and other questions is essential to improve our understanding of the epidemiology of norovirus.

Note

Potential conflict of interest. Author certifies no potential conflicts of interest. The author has submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

References