The Where is Norovirus Control Lost (WINCL) Study: an enhanced surveillance project to identify norovirus index cases in care settings in the UK and Ireland

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Abstract

Background: Norovirus outbreaks have a significant impact on all care settings; little is known about the index cases from whom these outbreaks initiate.

Aim: To identify and categorise norovirus outbreak index cases in care settings.

Methods: A mixed-methods, multi-centre, prospective, enhanced surveillance study identified and categorised index cases in acute and non-acute care settings.

Results: From 54 participating centres, 537 outbreaks were reported (November 2013 to April 2014): 383 (71.3%) in acute care facilities (ACF); 115 (21.4%) in residential or care homes (RCH) and 39 (7.3%) in other care settings (OCS). Index cases were identified in 424 (79%) outbreaks. Of the 245 index cases who were asymptomatic on admission and not transferred within/into the care setting, 123 (50%) had been an inpatient/resident for 4 days. Four themes emerged: missing the diagnosis, care service under pressure, delay in outbreak control measures and patient/resident location and proximity.

Conclusion: The true index case is commonly not identified as the cause of a norovirus outbreak with at least 50% of index cases being misclassified. Unrecognised norovirus cross-transmission occurs frequently suggesting that either Standard Infection Control Precautions (SICPs) are being insufficiently well applied, and or SICPs are themselves are insufficient to prevent outbreaks.

Keywords

Norovirus, outbreaks, index case, care setting

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Introduction

Noroviruses frequently cause outbreaks in health and social care settings across the world (Iturriza-Gomara and Lopman, 2014). These outbreaks have significant impact on the people who acquire the infection and on the operational management of the affected care settings (Lopman et al., 2004; Danial et al., 2011). Guidelines are available that recommend key measures to manage outbreaks (Centres for Disease Control and Prevention, 2011; Health Protection Agency et al., 2012).

Previous research has focused largely on transmission within the care setting and on the viruses themselves. There

are a number of studies which have identified and documented transmission from the index case (IC) in a single outbreak (Khanna et al., 2003; Sala et al., 2005; Schmid

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et al., 2005) and a single study investigating the effect of ICs on outbreak severity (Mattner et al., 2005). However, little is known about the ICs that trigger outbreaks. This study aimed to identify the ICs in care setting outbreaks and understand the factors contributing to spread in order to develop improved strategies to minimise the frequency and size of future outbreaks.

Methods

A mixed methods multi-centre, prospective, enhanced surveillance study was designed to identify and categorise the norovirus ICs over a single norovirus season in the UK and Ireland. Data were captured between 4 November 2013 and 28 April 2014; an analysis of point prevalence surveys in Scotland indicated that 80% of norovirus outbreaks in hospitals occurred during this period (unpublished data). Participants also provided qualitative accounts of the factors contributed to delayed outbreak identification or transmission.

Participants

Infection prevention and control teams (IPC) and health protection nurses/teams (HPT) were recruited from the UK and Ireland using a range of channels, including advertising through the Infection Prevention Society (IPS) networks, the *Journal of Infection Prevention* and by direct contact with Health Protection Teams by email. Teams were recruited from acute care facilities (ACF), residential or care homes (RCH) and other care settings (OCS) (these included psychiatric hospitals, hospices and other non-acute community hospitals).

Data collection

Following the referral/notification of a possible or confirmed norovirus outbreak to a member of the IPC/HPT that occurred during the study period, data were collected locally using a standard outbreak template. Shortly thereafter (while the outbreak was still ongoing) the data were entered into a study database at the Robertson Centre for Biostatistics (University of Glasgow). If further information came to light after the outbreak was logged this was locally updated. This system was tested internally and with sample users to ensure fitness for purpose. The outbreak data collection template was piloted in three different settings during 16 outbreaks.

Outbreaks of norovirus that were associated with a food-borne source were excluded. Outbreaks were defined as follows:

Possible Outbreak - two or more possible norovirus cases in a single care unit.

Confirmed Outbreak - one or more confirmed norovirus cases in a single care unit.

An IC was defined as the first identified symptomatic person (patient / resident, care worker or visitor) who had norovirus symptoms between 12 and 48 h before symptoms developed in other people in the same care area.

The following data were captured for each outbreak: type of care setting and clinical specialty, date first case symptomatic, dates the outbreak was reported (to IPC/HPT) and when control measures commenced; if an IC was identified, their origin, admission and symptom history was recorded. Additional information was collected about the context and circumstances that may have contributed to the outbreak, e.g. sequence of events, organisational factors and actions taken to limit spread. The number of cases identified when outbreak control measures were initiated was also recorded.

Data entry was direct to a study database at the Robertson Centre for Biostatistics (RCB) with appropriate security and access controls in place. All participants were pre-registered and required to have an approved access confirmation. Study participants had access to their own data and all data changes were stored with an audit trail available. No personal identifying information was obtained about any patients or staff. The West of Scotland Research Ethics Service reviewed the proposal and recommended that as a surveillance study the project did not require formal ethical review.

Statistical analyses

Data are presented as mean, standard deviation (SD), median, interquartile range (IQR), or number and percentage (%), as appropriate. Associations were tested using linear or logistic regressions and Fisher's tests. Similarities in outcomes across facility types between Wales and the rest of the UK were tested using the interaction between outcome and country (Wales/Others) in general linear models with the facility type. All statistical analysis was carried out using SAS v9.3®. *P* values of 0.05 or less were considered to be statistically significant, and all tests were two-tailed.

Qualitative methods and analyses

Qualitative data comprised written observations made by the (IPC/HPT) related to each outbreak event. The observations were written on the data entry form and focused on the factors that practitioners considered contributory to early detection or delays in identifying an outbreak and also provided insights into what other actions could have been taken. Documented observations were analysed by two researchers using a six-step thematic analysis process (Braun and Clarke, 2006). The familiarisation stage involved reading and re-reading the data over several days and was followed by noting insights and reflections on data chunks. The data were manually coded using an inductive, bottom-up, data-driven approach that avoids fitting the data to existing frameworks or preconceived categories. Saturation was reached when no further meanings or perceptions could be found within the data set. Themes were reviewed by two researchers and definitions and names agreed.

Results

Seventy-five centres were recruited to participate in the study. Of these, 54 participated and reported 550 outbreaks during the study period. Insufficient data were entered in 13 reports and the remaining 537 reports were included in the analyses (Table 1); 383 (71.3%) were from ACF, 115 from (21.4%) RCH and 39 from (7.3%) OCS. Five centres had no outbreaks during the study period; the remaining 49 (90.7%) reported one or more norovirus outbreak. The median number of outbreaks in the 49 centres reporting outbreaks was 7 (IQR 2:16). An IC was identified in 424 (79%) of outbreaks. The median duration of stay before symptoms commenced was 8 days in 245 of the outbreaks where the reported IC was a patient/resident who was not symptomatic on admission or transfer. A total of 122 of the ICs (49.8%) became symptomatic within 4 days of their admission, 78 (31.8%) between 4 and 29 days after admission, and 45 (18.4%) had been an inpatient/resident for 30 days or longer. In 50% of the outbreaks the identified ICs had been an inpatient/resident for longer than the norovirus incubation period (Table 1, Figure 1).

The ranking order for locations where the outbreaks occurred was as follows: medical wards 196 (36.5%), care for the elderly (included RCH) 165 (30.7%), surgical wards 60 (11.2%), medical receiving or admission wards 30 (5.6%) and 86 (16%) in all remaining care settings including mental health. ACF accounted for 383 (71.3%) of all reported outbreaks, RCF 115 (21.4%) and OCS 39 (7.3%). The proportion where an IC was identified varied significantly between care settings (ACF 72.8%; RCH 94.8% and OCS 92.3%; $P < 0.0001$). The mean number of cases at the time the outbreak was significantly higher in RCH (7.78) compared to ACF (3.74; $P < 0.0001$) (Figure 2); ICs were more likely to be symptomatic on admission in ACF (17.6%) than RCH (1%) or OCS (3.3%) ($P < 0.0001$). These ACF ICs were also more likely to have been recently transferred within the care setting (Table 1). Outbreaks took significantly longer to be reported in RCH (mean 3.41 days) compared to ACF (2.35 days; $P < 0.0001$).

There were 28 HCW ICs identified; of these, five were known to be symptomatic before coming to work. Of the 13 visitor index cases, nine (69.2%) were symptomatic before their visit (Table 1).

In Wales, nine centres participated, reflecting all acute and public healthcare in the country. In the general linear model all interaction P values were >0.05 , suggesting that there was no difference in results between Wales and other centres.

Qualitative data were captured for 170 of 550 (30.9%) reported outbreaks. These data indicated that there were often multiple factors contributing to outbreak measures being delayed or not activated. Four key themes were identified: missing the diagnosis, care services under pressure, delay in outbreak measures, and patient/resident location and proximity.

Missing the diagnosis: Teams reported that diarrhoea and vomiting were either considered to be a result of other

healthcare interventions, e.g. antimicrobial agents, nasogastric feeds or laxative use, or co-morbidities, e.g. renal failure or Crohn's disease. If there was no reported evidence of contact with someone who had symptoms in the previous 48 h or other cases of norovirus on the ward, then norovirus was not considered as a possible diagnosis in a patient who had been in hospital for a prolonged period. Poor history taking was also a factor where a bowel history or high-risk exposure was not recognised.

Care service under pressure: Pressure from 'front door' admissions, high patient turnover and lack of isolation facilities were identified as contributory factors. These pressures contributed to failures in effective decontamination of the patient environment, e.g. not changing curtains or failing to carry out terminal cleaning of bed spaces. Staff shortages due to sickness also featured and resulted in patients not being nurse cohorted and staff returning to work before they had been symptom free for 48 h.

Delay in outbreak measures: Reported delays in the notification of IPC team meant that their advice was not sought for a number of days and other delays in control measures occurred for the reasons identified above. Lack of IPC advice being available over Christmas, other leave periods or weekends was also highlighted as an issue in some reports particularly during out of hours (weekends), or when team members were on leave. Despite being given IPC advice some clinical areas failed to act promptly to isolate patients or close bay/wards.

Patient / resident location and proximity: This theme related to factors associated with the location of ICs when signs of norovirus emerged. Instances were reported where patients vomited in communal patient areas, e.g. dining rooms or resident lounges, or where patients 'wandered' around bays/wards where cases were cohorted. Failures to restrict the transfer of known norovirus patients were also identified as a potential contributory factor.

Discussion

This study set out to identify and categorise the ICs that triggered norovirus outbreaks within care settings. The study took place during a quiet norovirus season (2013–2014) (HPS, 2014; Public Health England, 2014) and our findings may not reflect a high-incidence season. Although ICs were identified for a high proportion of the reported outbreaks, there was a significant difference between the care settings, with more being identified in RCHs than ACFs. This may be explained by the rapid turnover of patients within ACFs making retrospective identification of IC more difficult. ACFs tend to be larger than both RCHs and OCS; it has been recognised that larger care units with higher throughput have been found to have increased rates of gastroenteritis outbreaks (Lopman et al., 2005).

The difficulty in identifying ICs was illustrated in a recent systematic review and meta-analysis of observational studies of norovirus introduced into nursing homes, which

Table 1. Main WINCL study results by care setting.

	ACF		RCH		OCS		Total		
	n	%	n	%	n	%	n	%	
Care setting type	383	71.3%	115	21.4%	39	7.3%	537	100.0%	
Lab confirmed	251	65.5%	24	20.9%	23	59.0%	291	52.4%	
Cases on reporting: Mean (SD)	3.74	(2.72)	7.78	(6.42)	6.05	(5.43)	4.77	(4.35)	$P < 0.0001$
Median (IQR)	3.00	(2.11–5.00)	6.00	(4.00–9.00)	4.00	(2.00–8.00)	4.00	(2.00–6.00)	
Min Max	1.00	18.00	1.00	46.00	1.00	25.00	1.00	46.00	
Identified IC	279	72.8%	109	94.8%	36	92.3%	424	79.0%	$P < 0.0001$
IC designation: Patient/resident	256	91.8%	97	89.0%	30	83.3%	383	90.3%	
Visitor	8	2.9%	0	0.0%	5	13.9%	13	3.1%	
HCW or CW	15	5.4%	12	11.0%	1	2.8%	28	6.6%	$P = 0.001$
IC transferred from another care setting in previous 4 days	13/256	5.1%	9/97	9.3%	7/30	23.3%	29/383	7.6%	$P < 0.0001$
IC transferred within care setting in previous 4 days	53/256	20.7%	2/97	2.1%	1/30	3.3%	56/383	14.6%	$P < 0.0001$
IC symptomatic on admission	45/256	17.6%	1/97	1.1%	1/30	3.3%	47/383	12.3%	$P < 0.0001$
Isolated on admission for symptomatic IC	11/45	24.4%	1/1	100	0/1	0%	12/47	25.5%	
HCW IC: symptomatic before coming on duty	2/15	13.3%	3/12	25.0%	0/1	0%	5/28	17.9%	
Visitor IC : symptomatic pre visit	5/8	62.5%	0		4/5	80%	9/13	69.2%	
Days until reporting: Mean (SD)	2.35	(2.36)	3.41	(2.21)	2.56	(2.16)	2.59	(2.35)	
Median (IQR)	2.00	(1.00–3.00)	3.00	(2.00–4.00)	2.00	(1.00–3.00)	2.00	(1.00–3.00)	$P < 0.0001$
Min Max	1.00	33.00	1.00	16.00	1.00	11.00	1.00	33.00	
Duration of stay pre symptoms (nontransferred ICs) (n = 245) <4 days	80	53.7%	35	44.7%	7	33.3%	122	49.8%	
4–29 days	66	44.3%	2	2.7%	10	47.6%	78	31.8%	
≥30 days	3	2.0%	38	50.7%	4	4.2%	45	18.4	

Figure 1. Outbreak reports, index cases and duration of stay pre symptoms.

suggested that in 20% of outbreaks an IC was not identified (Petrignani et al., 2015). In our study, although an IC was identified for a high proportion of outbreaks, 50% of the identified ICs had been admitted to the care setting for 4

days; much longer than mean incubation period found in another systematic review of 1.2 days (Lee et al., 2013). This suggests that other cases of norovirus had occurred previously but not been recognised and the point when the outbreak was detected did not reflect its initiation, i.e. the reported IC had been misclassified. Other studies, using molecular epidemiology, have also shown that normal IPC/HPT epidemiology misses both individual cases and some clusters (Sukhrie et al., 2011; Beersma et al., 2012). Missed cases may have been asymptomatic but it has been shown that most norovirus transmission arises from people who are symptomatic and even HCWs who report no symptoms may actually have had them (Sukhrie et al., 2012). Our study has provided some insight into factors that might contribute to these cases being missed, in particular ascribing symptoms of infection to other underlying conditions or treatments. This problem is exacerbated by most outbreaks affecting services that care for the elderly where such symptoms and/or treatments are common and may therefore be readily discounted as being due to factors other than norovirus.

In this study, ICs were most likely to be to patients/residents rather than visitors or staff. The majority of staff ICs reported being asymptomatic while on duty, which is consistent with the recognised abrupt onset of norovirus symptoms (Atmar and Estes, 2006). Staff returning to work after norovirus and visitors attending their relatives while potentially still symptomatic was identified as a small but important problem in the qualitative reports.

Figure 2. Box and whisker plot of the number of cases at time outbreak was reported to IPC/HPT by centre type. Key: Diamond = Mean; Middle line = Median; Box top and bottom = inter-quartile range; Whiskers = non-outlier range; Circles = outliers.

Key: Diamond = Mean; Middle line = Median; Box top and bottom = inter-quartile range; Whiskers = non-outlier range; Circles = outliers

Despite annual publicity about the dangers of norovirus outbreaks in healthcare settings delays in reporting and acting on outbreaks were still being identified as important factors related to norovirus outbreak incidence and outbreak size. This is perhaps strongly linked with the highlighted problem of accurately identifying patients as cases of norovirus; the lack of prompt implementation of expert IPC advice was also a factor reported to be related to outbreak size.

IPC/HPTs must deliver a service that is available outside 'office' hours and have a role in countering the service pressures identified as contributing to spread in outbreaks situations. This study suggests that current availability may not be sufficient during the norovirus season. Efforts to provide the most optimal IPC service to reduce the incidence and severity of norovirus outbreaks are important as in elderly care settings norovirus symptoms are more likely to be prolonged and outcomes more likely to be severe (Lopman et al., 2004; Trivedi et al., 2012).

The study also points to the particular challenge of identifying and managing norovirus in RCH. In 50% of RCH outbreaks where an IC was identified, they had been a resident for at least 30 days (Table 1). In RCH both the time to instituting control measures and the number of cases that had occurred by the time of reporting were significantly more than in ACF. This is not surprising given the lack of onsite HPT services and expert IPC knowledge of staff in RCH; additionally, the qualitative finding of the importance of the location and proximity of the IC when symptoms began, e.g. residents in care homes may be more likely to use communal areas like dining rooms. Under these circumstances cross-infection may be more likely to involve higher numbers of co-residents/patients. A failure of vomitus and/or stool decontamination in these areas could provide ongoing transmission risk as long as viable norovirus remains. This work does suggest that enhanced education of RCH staff in detecting and managing potential cases of norovirus may be beneficial in reducing spread in these settings. Large numbers of cases on outbreak reporting has been recognised in care home settings (Carpentier et al., 2011). More importantly there is evidence to suggest that outbreaks reported early are of a shorter duration (Davis et al., 2011, 2014).

Of the 45 ICs who were admitted to ACFs when symptomatic, only 11/45 (24%) were isolated on admission (Table 1). In addition, ICs in ACFs were also significantly more likely to have been transferred within their care setting (Table 1); this of course increases cross-infection exposures in both the number of persons and the numbers of clinical areas that could be affected.

Norovirus is recognised to be readily transmissible either through direct person-to-person contact or contamination of surfaces. Extensive contamination of the environment as a consequent of vomiting or diarrhoea has been implicated as a route of transmission in outbreaks (Wu

et al., 2005; Siebenga et al., 2008; Sukhrie et al., 2010, 2011; Nenonen et al., 2014); norovirus may survive for long enough to be transferred to other people if not removed by cleaning, although the inability to culture the virus makes this difficult to prove (Lopman et al., 2012). The precise route of transmission in outbreaks is often difficult to identify (Greig and Lee, 2012).

Adherence to standard infection control precautions (SICP) is key to preventing transmission of norovirus regardless of whether the patient/resident is known to have the virus. This study suggests that SCIPs may not be rigorously applied and evidence from both studies of hand hygiene and the use of clinical gloves indicates this is a common problem (Prieto and Macleod-Smith, 2005; Wilson et al., 2015).

The findings of this WINCL study demonstrate examples of the challenges in the detection and management of patients with norovirus and the prevention of outbreaks. The results indicate that the true index case is commonly not identified as the cause of a norovirus outbreak with at least 50% of index cases therefore misclassified. The evidence found of ongoing unrecognised transmission may indicate that either SICPs are being inadequately performed, or SICPs themselves are inadequate to prevent norovirus transmission. More effort needs to be directed towards educating staff about the importance of early detection, management and reporting of norovirus, encouraging a higher index of suspicion for a potential infectious cause of gastrointestinal symptoms, and the importance of adherence to SCIPs in both acute and non-acute healthcare settings.

Limitations

There are several limitations to this study. It was largely based on IPC/HPT epidemiology findings and outbreaks were not required to be confirmed microbiologically. The participating organisations were volunteers and therefore the results may not be representative. However, since the results for Wales were found to not differ significantly from all other centres and countries it is likely that the results overall are generalisable. Finally the study took place during a quiet norovirus year and results may not be representative of busy years.

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References

- Atmar RL and Estes MK. (2006) The epidemiologic and clinical importance of norovirus infection. *Gastroenterology Clinics of North America* 35(2): 275–290.
- Beersma MF, Sukhrie FH, Bogerman J, Verhoef L, Mde MM, Vonk AG and Koopmans M. (2012) Unrecognized norovirus infections in health care institutions and their clinical impact. *Journal of Clinical Microbiology* 50(9): 3040–3045.
- Braun V and Clarke V. (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology* 3(2): 77–101.
- Carpentier M, Ollivro J, Baron R, Le GM, Fauchier C, Minoui-Tran A, Payan C, Lejeune B and Garlantezec R. (2011) Investigation and control of a nosocomial norovirus outbreak in a long-term care facility. *Infection Control and Hospital Epidemiology* 32(10): 1052–1055.
- Centres for Disease Control and Prevention. (2011) Guideline for the prevention and control of norovirus gastroenteritis outbreaks in health-care settings. Available at <http://www.cdc.gov/hicpac/pdf/norovirus/Norovirus-Guideline-2011.pdf> (accessed 6 February 2015).
- Danial J, Cepeda JA, Cameron F, Cloy K, Wishart D and Templeton KE. (2011) Epidemiology and costs associated with norovirus outbreaks in NHS Lothian, Scotland 2007–2009. *Journal of Hospital Infection* 79(4): 354–358.
- Davis C, Vally H, Bell R, Sheehan F and Beard F. (2014) Viral gastrointestinal outbreaks in residential care facilities: an examination of the value of public health unit involvement. *Australian and New Zealand Journal of Public Health* 38(2): 177–183.
- Davis CA, Vally H and Beard FH. (2011) Norovirus in residential care facilities: does prompt notification of outbreaks help? *Communicable Diseases Intelligence Quarterly Report* 35(2): 162–167.
- Greig JD and Lee MB. (2012) A review of nosocomial norovirus outbreaks: infection control interventions found effective. *Epidemiol and Infection* 140: 1151–1160.
- Health Protection Agency, British Infection Association, Healthcare Infection Society, Infection Prevention Society, National Concern for Healthcare Infections and NHS Confederation. (2012) Guidelines for the management of norovirus outbreaks in acute and community health and social care settings. Available at: http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1317131647275 (accessed 15 February 2012).
- HPS. (2014) Weekly Norovirus Report - 30 June 2014. 1–5. 30–6–2014. Health Protection Scotland Web Pages.
- Iturriza-Gomara M and Lopman B. (2014) Norovirus in healthcare settings. *Current Opinion in Infectious Diseases* 27(5): 437–443.
- Khanna N, Goldenberger D, Graber P, Battegay M and Widmer AF. (2003) Gastroenteritis outbreak with norovirus in a Swiss university hospital with a newly identified virus strain. *Journal of Hospital Infection* 55(2): 131–136.
- Lee RM, Lessler J, Lee RA, Rudolph KE, Reich NG, Perl TM and Cummings DA. (2013) Incubation periods of viral gastroenteritis: a systematic review. *BMC Infectious Diseases* 13: 446.
- Lopman B, Gastanaduy P, Park GW, Hall AJ, Parashar UD and Vinje J. (2012) Environmental transmission of norovirus gastroenteritis. *Current Opinion in Virology* 2(1): 96–102.
- Lopman BA, Andrews N, Sarangi J, Vipond IB, Brown DW and Reacher MH. (2005) Institutional risk factors for outbreaks of nosocomial gastroenteritis: survival analysis of a cohort of hospital units in South-west England, 2002–2003. *Journal of Hospital Infection* 60(2): 135–143.
- Lopman BA, Reacher MH, Vipond IB, Sarangi J and Brown DW. (2004) Clinical manifestation of norovirus gastroenteritis in health care settings. *Clinical Infectious Diseases* 39(3): 318–324.
- Mattner F, Mattner L, Borck HU and Gastmeier P. (2005) Evaluation of the impact of the source (patient versus staff) on nosocomial norovirus outbreak severity. *Infection Control and Hospital Epidemiology* 26(3): 268–272.
- Nenonen NP, Hannoun C, Svensson L, Toren K, Andersson LM, Westin J and Bergstrom T. (2014) Norovirus GII.4 detection in environmental samples from patient rooms during nosocomial outbreaks. *Journal of Clinical Microbiology* 52(7): 2352–2358.
- Petrignani M, van BJ, Borsboom G, Richardus JH and Koopmans M. (2015) Norovirus introduction routes into nursing homes and risk factors for spread: a systematic review and meta-analysis of observational studies. *Journal of Hospital Infection* 89(3): 163–178.
- Prieto J and Macleod-Smith J. (2005) Contact precautions for Clostridium difficile and Methicillin-resistant Staphylococcus aureus (MRSA). *Journal of Research in Nursing* 10(5): 511–526.
- Public Health England (2014) PHE Monthly National Norovirus Report Summary of surveillance of norovirus and rotavirus. *Public Health England Weeks 23–26 report* (6 February 2015).
- Sala MR, Cardenosa N, Arias C, Llovet T, Recasens A, Dominguez A, Buesa J and Salleras L. (2005) An outbreak of food poisoning due to a genogroup I norovirus. *Epidemiology and Infection* 133(1): 187–191.
- Schmid D, Lederer I, Pichler AM, Berghold C, Schreier E and Allerberger F. (2005) An outbreak of Norovirus infection affecting an Austrian nursing home and a hospital. *Wiener Klinische Wochenschrift* 117(23–24): 802–808.
- Siebenga JJ, Beersma MF, Vennema H, van BP, Hartwig NJ and Koopmans M. (2008) High prevalence of prolonged norovirus shedding and illness among hospitalized patients: a model for in vivo molecular evolution. *Journal of Infectious Diseases* 198(7): 994–1001.
- Sukhrie FH, Beersma MF, Wong A, van der Veer B, Vennema H, Bogerman J and Koopmans M. (2011) Using molecular epidemiology to trace transmission of nosocomial norovirus infection. *Journal of Clinical Microbiology* 49(2): 602–606.
- Sukhrie FH, Siebenga JJ, Beersma MF and Koopmans M. (2010) Chronic shedders as reservoir for nosocomial transmission of norovirus. *Journal of Clinical Microbiology* 48(11): 4303–4305.
- Sukhrie FH, Teunis P, Vennema H, Copra C, Thijs Beersma MF, Bogerman J and Koopmans M. (2012) Nosocomial transmission of norovirus is mainly caused by symptomatic cases. *Clinical Infectious Diseases* 54: 931–937.
- Trivedi TK, DeSalvo T, Lee L, Palumbo A, Moll M, Curns A, Hall AJ, Patel M, Parashar UD and Lopman BA. (2012) Hospitalizations and mortality associated with norovirus outbreaks in nursing homes, 2009–2010. *Journal of the American Medical Association* 308(16): 1668–1675.
- Wilson J, Prieto J, Singleton J, O'Connor V, Lynam S and Loveday H. (2015) The misuse and overuse of no-sterile gloves: application of an audit tool to define the problem. *Journal of Infection Prevention* 16(1): 24–31.
- Wu HM, Fornek M, Schwab KJ, Chapin AR, Gibson K, Schwab E, Spencer C and Henning K. (2005) A norovirus outbreak at a long-term-care facility: the role of environmental surface contamination. *Infection Control and Hospital Epidemiology* 26(10): 802–810.