DRAFT TECHNICAL REPORT FOR CONSULTATON

ECDC TECHNICAL REPORT

Prevention of norovirus infection in schools and childcare facilities

Guideline adaptation and review

This report was commissioned by the European Centre for Disease Prevention and Control (ECDC), coordinated by Dr. Andreas Janssen, and produced by Bazian Ltd.

THIS DRAFT TECHNICAL REPORT IS SUBJECT TO A PUBLIC CONSULTATION PROCESS. THE RESULT OF THAT PROCESS MAY LEAD TO CHANGES IN THE FINAL REPORT

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Contents

Abbreviations

BS	British Standard
BSI	British Standards Institute
CDC	United States Centers for Disease Control and Prevention
CDNA	Communicable Disease Network Australia
CE	Conformité Européenne
EFSA	European Food Safety Authority
ELISA	Enzyme-linked immunosorbent assay
EU	European Union
FBVE	Foodborne Viruses in Europe Network
FDA	United States Food and Drug Administration
FSA	Food Standards Agency
FCV	Feline calicivirus
HACCP	Hazard Analysis and Critical Control Point System
HPA	Health Protection Agency
HPS	Health Protection Scotland
MCA	Maritime and Coastguard Agency
NHMRC	Australian National Health and Medical Research Council
NHS	National Health Service
NICE	National Institute for Health and Clinical Excellence
NoV	Norovirus
PPE	Personal protective equipment
RCP	Royal College of Physicians
RCT	Randomised controlled trial
RNA	Ribonucleic acid
RT-PCR	Reverse transcription-polymerase chain reaction
SRSV	Small round structured virus
WHO	World Health Organization

Executive summary

Introduction

The objective of this project is to provide a technical report for use in the European Union (EU) that synthesises current international guideline recommendations using an ADAPTE[1] methodology, and reviews findings related to the prevention and control of gastroenteritis outbreaks in schools and child care facilities. The particular focus of the report is on norovirus, which is of major public health importance. It is one of the most common causes of childhood gastroenteritis and with epidemiological characteristics that promote a high rate of infectivity and transmission. The report also aims to contribute to identifying the key facts that can support message development for the implementation of health communication activities in child care settings.

The Health Protection Agency (HPA) report norovirus as the most common cause of infectious gastroenteritis (diarrhoea and vomiting) in England and Wales. Norovirus (NoV), previously referred to as Norwalk-like virus, or small round structured virus (SRSV), is a non-enveloped, single strand ribonucleic acid (RNA) virus of the family *Caliciviridae,* which includes three other genera: sapovirus, lagovirus and vesivirus [1,2]. There are at least five genogroups, with strains GI, GII and GIV being most commonly implicated in human infection. Outbreaks are common, particularly in semi-enclosed environments such as hospitals, residential homes, schools and cruise ships.

It was not possible to identify summary national or international data related to the frequency of closure of schools or other child care facilities due to suspected or confirmed norovirus outbreaks. A systematic review of nosocomial outbreaks filed in the international outbreak database up to 2005 found that 34 of 1 561 outbreaks were due to norovirus, and 15 of these (44%) were associated with closure of a ward/unit, making norovirus the pathogen associated with the highest closure rate of all bacterial and viral nosocomial outbreaks published [3]. The latest data from the HPA [4] reported 33 suspected hospital outbreaks of NoV over a one month period in England between May and June 2011, 12 of which were laboratory-confirmed, and 22 of which led to ward closures. In England over the season from week 27 in 2010 to week 24 in 2011, there were 1 123 hospital outbreaks (688 confirmed) and 14 reported prison outbreaks of NoV [4].

Eurosurveillance data report that of 13 countries participating in the foodborne viruses in Europe (FBVE) network, 9 of 11 who responded reported increased NoV outbreaks or case reports in October/November 2006, compared to the same period in 2004 and 2005 [5]. The majority of NoV isolates have belonged to the genotype GII.4, which has been predominant globally in recent years [1]; although, over longer periods of time there is expected to be variation in the predominant genotype.

Norovirus prevalence in the community

A 2008 systematic review by Patel et al.[6] reviewed all articles assessing the prevalence of NoV among sporadic cases of diarrhoea, with studies stratified according to location of care (community for mild-moderate diarrhoea and secondary care for severe presentations). In 13 community-based studies (eight studies in children aged 0–13 years), the overall proportion of cases with NoV or saporovirus infection (confirmed by reverse transcription-polymerase chain reaction, RT-PCR) was 12% (95% CI 9–15%). In 23 hospital-based studies (19 in children aged <5 years), the pooled prevalence was also 12% (95% CI 10-15%). Prevalence was comparable between industrialised and developing countries. The review estimated that NoV causes 900 000 primary care consultations in children aged <5 years, and 64 000 hospitalisations, making it the second most common cause of severe childhood gastroenteritis following rotavirus [6]. These are likely to be underestimates of the true cross-sectional prevalence of NoV infection in the community at any one time, due to the number of people who do not consult medical care.

The prevalence of NoV infection among asymptomatic individuals in the community is also relatively high. A 2010 study by Phillips et al.[7] used data from the 1993–96 Study of Infectious Intestinal Disease in England, which enrolled participants with no recent history of diarrhoea or vomiting. Stool samples from these participants were archived and subsequently re-tested using real-time RT-PCR which is currently the recommended diagnostic technique with the highest sensitivity for NoV detection. Of 2 205 participants, 361 had asymptomatic NoV infection (genogroup II in 78%). The age-adjusted prevalence of asymptomatic NoV infection in England, estimated by standardising against the mid-1992 population estimate, was calculated at 12% (95% CI 11 to 14), with the highest prevalence among those aged <5 years (roughly 20–35%). There was a peak prevalence of asymptomatic carriage of 20% during the winter season of November through to January [7].

[1] http://www.adapte.org

The asymptomatic prevalence in this study is higher than that identified in previous studies, which have used the less sensitive technique of gel-based RT-PCR. Real-time RT-PCR itself has a detection limit of roughly 10 [4] NoV particles per gram of stool, and therefore the true prevalence of asymptomatic carriage in the community is predicted to be higher than 12% [7]. The role of asymptomatic infection in the epidemiology of sporadic gastrointestinal illness and outbreaks is unknown.

Methods

The approach used for this technical report was a guideline adaptation using modified ADAPTE methodology, supplemented by rapid review of high quality primary research, with the aim of efficiently summarising the interventions that are considered effective at preventing childhood gastroenteritis, and controlling outbreaks that occur in child care and school settings. Norovirus was used as the indicative organism due to its ease of transmission and high infectivity; interventions that succeed in prevention and containment of norovirus are considered likely to be successful in other gastroenteritic disease outbreaks.

The focus of this document is norovirus. Quality international guidelines related to the prevention and control of norovirus are available, though none specifically focus upon child care settings. The need for an EU-wide technical document to support public health practice, and promote effective primary prevention and outbreak control interventions to protect children is clearly a priority.

The report aimed to address issues relevant to the infectivity and transmission of norovirus in child care settings, and appropriate interventions to prevent this. Questions were developed in relevant areas of interest:

Epidemiology:

- the background rate of asymptomatic and symptomatic norovirus infection in the community
- the routes of transmission and sources of recent outbreaks (e.g. person-to-person, foodborne)
- infectivity and period of viral shedding
- how long NoV persists in the environment
- symptoms
- declaration of an outbreak, including definitions and public health action
- primary and secondary attack rates
- specimen collection (i.e. stool) for investigation and confirmative diagnosis

Primary and secondary prevention and infection control:

- the most effective method of hand washing and drying
- the role of alcohol gels/hand sanitisers in child settings
- the use of gloves and personal protective equipment
- locations where hand hygiene facilities should be provided
- appropriate food hygiene and catering standards in child settings
- appropriate procedures for nappy changing and disposal, toilet training
- management of soiled clothing/linen
- appropriate cleaning schedule for the school/care centre environment (general and during an outbreak)
- management of spillages of body fluids
- efficacy of disinfectants against norovirus
- appropriate exclusion period for infected children/child care staff
- closure of school facilities
- appropriate notification of parents
- the focus of remediation planning: interventions with the strongest evidence of efficacy

The literature review for this report took place on 18 May 2011 and searched bibliographic databases (Medline, Medline Plus, MeSH, PubMed, EMBASE, Cochrane Library,York Centre for Reviews and Dissemination databases, TRIP database), guideline sites (including the National Institute for Health and Clinical Excellence, national health service evidence and national guidelines clearinghouse), and other related websites (including Noronet, European Food Safety Authority), for any articles related to norovirus or gastroenteritis. The search retrieved a total of 71 pieces of guidance, reviews, interventional and observational studies, which were reviewed in-depth.

Fifteen international guidelines (English language) were reviewed in full text following the exclusion of local/regional protocols and those concerned with therapeutic management, eight high quality guidelines (appraised using AGREE criteria,[2]) were identified as key documents that provided up-to-date recommendations on the prevention and control of gastroenteritis, and those that would be most appropriate to adapt in the technical report. Two of these guidelines were specifically addressing infection control and prevention of gastroenteritis in child care settings; three were specific to the prevention and control of norovirus (not specific to child care settings); and three related to specific aspects of infection control and prevention methods (one World Health Organization guideline on hand washing, and two related to prevention of foodborne infection):

1. Health Protection Scotland (HPS), 2011: Infection Prevention and Control in Childcare Settings (Day Care and Childminding Settings)
2. National Health and Medical Research Council (NHMRC), 2006: Staying Healthy in Child Care - preventing infectious diseases in child care
3. Communicable Disease Network Australia (CDNA), Australian Dept Health and Ageing, 2010: Gastroenteritis outbreaks due to norovirus or suspected viral agents in Australia
4. Health Protection Agency (HPA), Norovirus Working Group: Guidance for the management of norovirus infection on cruise ships
5. Centers for Disease Control and Prevention (CDC), 2011: Updated norovirus outbreak management and disease prevention guidelines.
6. World Health Organization (WHO), 2009: Guidelines on hand hygiene in health care
7. Royal College of Physicians (RCP), 2008: Infected food handlers: occupational aspects of management
8. World Health Organization, 2008: Foodborne disease outbreaks: Guidelines for investigation and control

The recommendations from these eight guidelines have been synthesised in the following report and form the basis for all suggested actions in the report. Even though these guidelines have been produced using a rigorous development process, most of the recommendations in the guidelines specific to norovirus control and prevention, and to infection control in child care settings, have been formed by expert consensus. Primary research on the efficacy of interventions for the prevention and control of NoV and other virological causes of gastroenteritis is limited. World Health Organization guidance provides strong evidence-based graded recommendations on the efficacy of hand washing technique.

Alongside guidelines, our initial search identified 56 additional articles, which included systematic reviews and interventional studies, though the majority were surveillance reports, case series, cohorts and cross-sectional analyses. Priority was placed upon systematic reviews relevant to either epidemiology of norovirus or the efficacy of infection control interventions; and to randomised controlled trials investigating the efficacy of interventions for the prevention and control of gastroenteritis (norovirus or otherwise). Secondarily, observational studies and experimental studies were selected if they contained information relevant to the epidemiological and infection control areas of interest (e.g. quantifying carriage rates, transmission, infectivity). Searching of bibliographies of retrieved studies identified a further ten studies which were of possible relevance to these areas of interest.

Information from these systematic reviews, randomised controlled trials, and selected observational and experimental studies was used to supplement the recommendations made in the guidelines. The studies included in this report do not present an exhaustive review of the literature on all aspects related to the epidemiology and prevention of gastroenteritis, NoV or other microorganism; instead the focus was on studies with relevance to guiding appropriate public health practice for the primary prevention and control of outbreaks of gastroenteritis in schools and child care facilities in Europe. Some guidelines, notably those produced by the CDC, and the CDNA, are recently published. These include evidence tables, and are the product of collaboration by expert working groups in NoV; and were assessed as the most appropriate findings, recommendations, and guidelines to adapt to form this technical report.

The following report is divided into sections, outlining initially primary prevention measures to be taken to prevent gastroenteritis outbreaks in school and child care settings; secondly action to be taken upon an outbreak of gastroenteritis (norovirus or otherwise); thirdly key infection control measures to be taken during an outbreak; and finally action at the conclusion of an outbreak, including training and remediation planning.

Validation has been by internal review, external (peer) review, and an expert panel meeting held in Stockholm in December 2011. Following consultation, any additional documents or information, including regional protocols, that were referred to us during the peer review process, were reviewed to ensure that the information contained within this report was broadly consistent with that of other sources.

[2] http://www.agreetrust.org/

Key findings: summary of recommendations

The following summarises, by section, the key findings of the report. The main recommendations have been given an evidence grading. These gradings are primarily based on the strength of the underlying evidence used to form these recommendations in the adapted guidelines; and as such they reflect the methodological processes and evidence evaluation of the original guidelines. However, with the exception of the WHO guideline on hand hygiene, and the RCP guideline, Infected Food Handlers, the individual guidelines have not provided evidence-based graded recommendations. Therefore, for the majority of these summarised recommendations, the grade given follows our evaluation of the referencing and textual context of the individual guidelines.

The below grading recommendations have been developed for the purposes of this technical report. It has been developed from the grading systems used in guideline development, with (A) corresponding to a higher level of evidence in which the reader can have more confidence than lower levels. These grades need to be interpreted with caution as a full guideline development process has not been undertaken for this report.

Levels of evidence (in decreasing order)	
A	Recommendation given by adapted guidance and supported by systematic review of high quality randomised controlled trials (RCTs) or several RCTs without bias
B	Recommendation given by adapted guidance and supported by consistent results from observational, non-randomised or laboratory studies. Studies may have a moderate risk of bias, use indirect outcomes (e.g. NoV surrogates) or have taken harms into consideration. The category is for less robust body of evidence compared to (A) level evidence.
C	Recommendation given by adapted guidance and required by legislation/national standard
D	Recommendation given by adapted guidance and supported by expert opinion or isolated studies and accepted as good practice, but without the consistent evidence base required for (A) or (B) level evidence

Note: These levels relate to the quality of the underlying evidence base and do not necessarily reflect the importance of a recommendation.

Primary prevention of gastroenteritis in child care facilities

1. Hand hygiene

a) Hand washing facilities should be available in appropriate locations (e.g. toilets, kitchen areas, activity areas). (D)
b) Sinks should be supplied with liquid soap and disposable hand towels. (B)
c) Hands should be washed according to the WHO protocol: wet hands with warm water; apply soap to all hand surfaces; rinse and dry thoroughly with paper towel; use towel to close tap (the entire process to take between 20 and 60 seconds). (B)
d) Children and staff should be advised on appropriate times to wash their hands; e.g. after toileting, before and after preparing/handling/eating food, after play, after contact with potentially contaminated surfaces/items, after nose-blowing, coughing or sneezing, and before and after putting on personal protective equipment. (D)
e) Pre-school children (under four years of age) should be supervised to wash their hands. (D)
f) Alcohol gels should only be used when hand washing facilities are not available, and are not effective if hands are visibly soiled. (B)
   - if used, ≥70% ethanol applied to cover all hand surfaces and rubbed in for a contact time of 30 seconds. (B)
   - any hand sanitiser is required to reduce the viral titre by log 2 (99%). (C)

2. Environmental cleaning

a) A cleaning schedule should list, for each area, the items to be cleaned, frequency of cleaning and who is responsible, and a signed and dated cleaning record kept. (D)
b) Toilets, bathroom fittings, and other frequently contacted surfaces (including tables, toys) are advised to be cleaned daily; more frequently if visibly soiled. (D)
c) Potties/potty chairs, if used, should be cleaned with detergent and water after each use and stored dry and un-stacked. (D)
d) Detergent and warm water alone are considered sufficient for environmental cleaning outside of the outbreak situation. (D)
e) Separate cleaning cloths/sponges should be used for each area (e.g. colour coded) and stored dry between use; all other cleaning equipment regularly checked and maintained. (D)
f) Lined pedal bins should be placed in specific areas (e.g. kitchens, bathrooms); the disposable bin-liner sealed and discarded at least daily. (D)

3. Catering standards

a) All food handlers should be trained in food hygiene and safety according to the Hazard Analysis and Critical Control Point System (HACCP). (C)
b) Access to food preparation areas should be restricted to catering or kitchen staff. (D)
c) Catering or kitchen staff should not be involved in toileting children/nappy changing. (D)

Identification of an outbreak of gastroenteritis

4. Public health officials or environmental health authorities should be notified if there are two or more cases of diarrhoea and/or vomiting in a 24 hour period that are connected in time, place and person. (C)

5. Public health officials or the outbreak management team are required to assess and investigate the situation, provide advice on infection control, and convene with other health organisations to coordinate specimen collection and diagnostic testing. (C)

6. Diagnostic confirmation:
a) faecal samples rather than vomit are most suitable for diagnostic testing. (B)
b) 10–15 ml faecal specimens should be collected from at least five individuals during the acute phase of illness (within 48–72 hours of symptom onset). (B)
c) real-time RT-PCR with full rapid sequencing is the diagnostic technique currently preferred. (B)

7. Child care facilities should document infection control procedures and advice given by public health officials, document outbreak characteristics (including symptoms and the numbers of children and staff affected: date of first symptoms/last attendance/when parents contacted to collect child), and retain food samples as requested. (C)

Infection control measures during an outbreak

8. Exclusion of infected individuals

a) Any child or staff member who has diarrhoea and/or vomiting, stomach pain, or otherwise feels unwell or appears to be unwell, should be isolated and sent home. (D)
b) Any child or staff member with diarrhoea and/or vomiting should be excluded until symptom-free for 48 hours. (D)
c) The exclusion policy of the child care facility should be effectively communicated to parents, preferably via a clearly stated written policy. (D)

9. Hand hygiene

a) Hands should be washed according to the WHO protocol: wet hands with warm water; apply soap to all hand surfaces; rinse and dry thoroughly with paper towel; use towel to close tap (the entire process to take between 20 and 60 seconds). (B)
b) Alcohol gels should only be used when hand washing facilities are not available, and are not effective if hands are visibly soiled. (B)
- if used, ≥70% ethanol applied to cover all hand surfaces and rubbed in for a contact time of 30 seconds. (B)
- any hand sanitiser is required to reduce the viral titre by log 2 (99%). (C)

c) Staff should use personal protective equipment (e.g. disposable gloves and disposable apron) as an adjunct to hand washing when coming into contact with body fluids (e.g. cleaning spillages or nappy changing). (B)

10. Environmental cleaning

a) Sodium hypochlorite at a concentration of 1000 parts per million (1:50 dilution 5.25% bleach) is the standard required for disinfection of norovirus. (B)
b) Cleaning with detergent and water prior to use of bleach is required to remove all organic matter. (B)
c) Any disinfectant is required to reduce the viral titre by log 4 (99.99%). (C)
d) Any frequently contacted surfaces should be cleaned twice daily, and after high usage times; this includes toilet seats, flush handles, taps, tables and door handles. (D)
e) Any textiles not suitable for chemical disinfection should be laundered preferably at a temperature of at least 70C (minimum temperature of 60C). (C)
f) Terminal cleaning of the entire affected facility should be carried out 72 hours after resolution of symptoms in the last case. (D)

Post-event review and remediation planning

11. The outbreak management team should declare the end of the outbreak; there is no consistent recommendation about when this should be. (D)

12. A public health report summarising the outbreak (including laboratory results, minutes of meetings, other communication, etc.) should be kept and forwarded to appropriate stakeholders. (D)

13. Debriefing between public health officials and all other individuals involved in the outbreak is recommended to review and consider how future situations may be better managed. (D)

14. All child care facilities should provide a programme of education and training for staff that cover the key methods of outbreak management, and a run-through of these procedures performed at least annually. (D)

Conclusion

The evidence base surrounding infection control interventions to prevent and control outbreaks of gastroenteritis, in particular norovirus, in child care facilities is fairly limited. No systematic reviews or randomised controlled trials that provide firm evidence to support the effectiveness of any infection control measures, including exclusion strategies, hand hygiene or surface disinfection were identified. This may reflect the difficulties in ethical approval for such studies, in addition to the relative cost. There are several observational and experimental studies that support the value of hand hygiene methods in preventing the carriage and transfer of infective organisms (washing with soap and water and drying thoroughly); and that ≥70% ethanol hand sanitiser and 1000–5000ppm sodium hypochlorite surface disinfectant are most effective in inactivating norovirus. However, experimental testing has been limited to norovirus surrogates (predominantly feline calcivirus), and it is not known how truly representative these are of norovirus inactivation.

The majority of recommendations in current international guidelines for infection control in child care facilities, or control of NoV in non-child care settings, are therefore based on expert opinion, and wide acceptance as good practice due to knowledge of epidemiology of norovirus, including its high virulence and infectivity.

There are unresolved issues surrounding the infectivity of norovirus, principally the role of asymptomatic carriage and prolonged post-symptomatic shedding, which raise questions of whether the period of exclusion is sufficient, particularly for food handlers. Also, specific to child care settings, this report raises other research questions related to the planning and design of facilities for children:

- How effective are hands-free taps and soap dispensers in school toilets at minimising spread?
- What is the appropriate number of sinks and toilets to have in a child care facility, by size?
- What is the optimal duration of hand washing: 40–60 seconds, as in most health care guidance, or 15–20 seconds only?
- In child bathrooms, in order to avoid hot water exposure, should there be mixer taps or cold-water-only taps? Is cold water equivalent to warm water in preventing the spread of infection?
- How effective are interventions to educate children about correct hand washing procedure, hygiene and spread of infection, e.g. notices/posters in school toilets, educational sessions?
- How effective are health promotion interventions targeting children and parents?
- Does the removal of alcohol hand gel from schools reduce infection or transmission? Should it have restricted use only, e.g. when on recreational trips?
- Outside of the outbreak situation should any disinfectant (and at what strength) be used for environmental cleaning? That is, are consensus recommendations that detergent-and-water-only cleaning is sufficient correct? Or should disinfectant have restricted use, e.g. to toilets and visibly-soiled areas?
- What is the optimal frequency of cleaning toilets, kitchens and other frequently-contacted surfaces?

1. Primary prevention of gastroenteritis in child care facilities and schools

Two pieces of guidance were identified that related to standard infection control precautions in child-specific settings: the 2011 publication by Health Protection Scotland (HPS), *Infection Prevention and Control in Childcare settings (day care and childminding)* [8], and the 2005 publication by the Australian National Health and Medical Research Council (NHMRC), the 4th Edition to *Staying Healthy in Child Care, Preventing Infectious Diseases in Child Care* [9]. Both of these guidelines relate to care facilities for children of pre-school age; none were indentified that were specific to schools.

These guidelines provide key primary prevention measures. The World Health Organization provides guidance on the recommended procedure for hand washing, [10] and this is endorsed by these two child care guidelines.

Hand hygiene for staff and children

Infection spreads through the environment via respiratory droplets, faecal-oral route, contact with skin and mucous membranes, or in some cases, saliva and urine. Thorough hand washing and drying is the key measure for both primary and secondary prevention.

Hands of both adults and children should be washed according to WHO protocol, which is summarised below: [8-10]

- running water (not hot) used to wet hands
- liquid soap applied from dispenser, sufficient to cover all hand surfaces
- thorough rub over entire hand surface(palms, backs of hands, between fingers and thumbs, nails)
- rinse
- disposable paper towel used to dry hands
- elbow or paper towel to close tap

Child care guidelines recommend that the entire process should take 10–15 seconds [8,9]; guidelines from the CDC recommend at least 20 seconds [2]; and WHO recommend that hand washing should take 40–60 seconds (though this guidance is relevant to healthcare settings) [10].

It is advised that pre-school children (under four) are supervised to wash and dry their hands in the same way as adults, and that babies' hands are washed at the sink by an adult, or cleaned using wet towlettes/cloths and dried with paper towel [9].

Water temperature has not been demonstrated to be an important factor in microbial removal, but hot water significantly increases risk of skin damage and dermatitis [10]. Additionally rubbing hands dry increases risk of cracking and irritation, and patting dry with paper towel is preferable to rubbing dry [10]. For people with irritation/dermatitis/eczema, NHMRC recommend that sorbolene may be used alternatively to soap, and barrier cream is advised if skin will be wet for long periods [9]. Cuts and abrasions should be treated and covered [8,9]. If protective gloves are used, these do not replace the need for hand washing and drying, as skin may become contaminated through tears, or when removing gloves [8,9].

When planning facilities, basins should be located in required areas such as, toilets, nappy changing areas, kitchens/food preparation areas and relevant outdoor areas. Hands-free taps and soap dispensers are further considered to reduce risk of contamination [9]. The World Health Organization recommend that empty or partially empty soap dispensers should not be refilled with soap without appropriate cleaning of the dispenser [10].

In child facilities, the following are **not recommended**, or have **cautioned** use:

- Water rinsing alone:
  - detergent is required to remove fats and oils present on soiled hands [10]
- Solid bars of soap:
  - child care guidance advises against use as there is higher risk of contamination and risk of the soap not being used [8,9]
  - in non-specific settings, WHO advise that bar soap may be used, provided the bar is small and stored in a rack that facilitates drainage and allows the soap to dry between uses (there is some evidence that the actual hazard of transmitting microorganisms through washing with previously used soap bars is minimal) [10]

- Antibacterial liquid soaps:
  - child care guidance advises they are unnecessary and may increase the risk of bacterial resistance [8,9]
- Alcohol-based gels:
  - child care guidance advises they only have a role only when hand washing facilities are not available (e.g. excursions) [9]
  - they do not replace washing with soap and water, and hand washing is always the required method if hands are visibly soiled [10]
  - if alcohol-based gel is used it should not be used concomitantly with soap [10]
  - if used the following principles are summarised below [10]:
  - a 'palmful' should be applied (though the specific volume required is unknown, 1ml has been demonstrated to be significantly less effective than 3ml [10])
    - hands should be rubbed together covering all surfaces (as for hand washing), until completely dry
    - the entire process is recommended to last for 20–30 seconds
- Cloth towels/multiple-use towels:
  - not recommended due to increased risk of re-contamination and cross infection [9,10]
  - Health Protection Scotland advise if non-disposable hand towels are used they should be identified as only for drying hands and washed at least daily [8]
- Warm air dryers:
  - not recommended in child care and WHO guidance mainly on the basis of poor compliance and inadequate drying: access at the dryer is restricted to one person at a time, and the time taken to dry hands is longer than that needed with paper towels [9,10]
  - if air driers are used they should dry hands as effectively and quickly as paper towels, and should have been proven not to be associated with the aerosolisation of pathogens (a concern raised by one study)[10]

Health Protection Scotland and NHMRC recommend that hands (child and adult) are washed:[8,9]

- before and after eating or handling food and drink
- after using the toilet, potty or nappy changing
- after nose-blowing, coughing or sneezing
- after touching animals/animal waste
- after contact with contaminated surfaces such as rubbish bins, cleaning cloths
- before putting on and after removing protective gloves
- after children come in from outdoors (NHMRC recommendation)
- when arriving at the centre and before they leave to go home

A 2009 Cochrane review by Ejemot et al.[11] concluded the effectiveness of interventions to promote hand washing on reducing diarrheal episodes in children and adults. Fourteen RCTs were included, and considering only trial results that adjusted for cluster randomisation, interventions promoting hand washing resulted in a 39% reduction in diarrhoea episodes in children in institutions in high-income countries (incidence rate ratio 0.61, 95% CI 0.40 to 0.92; 2 trials), and a 32% reduction in diarrhoea episodes in children living in communities in low- or middle-income countries (IRR 0.68, 95% CI 0.52 to 0.90; 4 trials) [11].

Toilet hygiene and nappy care

Child care guidance advises that all toilets and toilet seats should be visibly clean, with sufficient toilet roll and nearby hand washing facilities; and that facilities should be inspected at regular times during the day (the guidelines do not specify a frequency) [8].

The Australian National Health and Medical Research Council advise that younger children should be assisted in using the toilet and washing their hands [9]. It is advised against rinsing any soiled clothes in the centre, and these should be placed in a tied plastic bag to be sent home with the parent [9].

Potties and potty chairs are considered to carry higher risk of infection spread and using a toilet is preferable [9]. If potties are used it is advised the contents are washed down the toilet, the potty washed with water and detergent (in a separate sink to that used for hand washing), dried with paper towel and stored un-stacked in a clean, dry area [8].

Nappy care

Key guidance points given by the HPS and NHMRC when changing nappies in day care centres [8,9]:

- having a dedicated area with all supplies ready to hand
- a clean waterproof changing mat cleaned with detergent and warm water after every use and dried (if disposable paper is used to cover the mat it does not remove need for cleaning [9])
- always using gloves and washing hands (wash before putting on gloves as first task; remove gloves and wash hands after cleaning the child but before re-dressing them; wash again after cleaning the mat); HPS also recommend a disposable apron [8]
- nappies disposed of in a tied plastic bag and placed in a lined and lidded bin, which is separate from food and play areas (disposable nappies are preferable to reusable, which if used should not be washed at the centre, but sealed in a bag and sent home with the parent [9])
- warm water and detergent or disposable wipes used to clean the child, and the child dried thoroughly
- not sharing tubs of barrier cream between children

Environmental cleaning by staff and cleaners

Health Protection Scotland recommend that a schedule is in place listing each area and items to be cleaned, how often they are to be cleaned and who is responsible, and that a record of cleaning is kept signed and dated [8]. Health Protection Scotland advise that staff and parents are encouraged to raise concerns about level of cleanliness [8].

Health Protection Scotland and NHMRC recommend that neutral, all-purpose detergent and warm water is sufficient for general environmental cleaning [8,9]. They state that outside of an outbreak situation, the emphasis should be upon washing with detergent, rinsing and drying, and consider that disinfectants are unnecessary for environmental cleaning as most microbes do not survive when exposed to air and light on clean surfaces [9]. (Though during an outbreak situation, norovirus surrogates have been demonstrated to survive on environmental surfaces for up to three days [12]).

It is recommended that household gloves are worn and specific cleaning sponges/equipment used for each area (e.g. colour coded); all items of which are advised to be stored dry between uses. It is recommended that all cleaning equipment (e.g. vacuum cleaner filters) is regularly checked and well maintained [8,9].

The National Health and Medical Research Council advise that all bathroom fittings including toilet handles, taps and door handles are cleaned daily, more if visibly soiled. In addition they recommend that toys and objects put in the mouth, and other surfaces that children frequently contact, e.g. floors bench tops, cots and tables, are washed daily. Specific cleaning advice by item is given by HPS [8]. Toys should be well maintained and carry a British Standard (BS), British Standards Institute (BSI) or Conformité Européenne (CE) mark [8].

Waste disposal and laundry management

It is advised that lined pedal bins are positioned in specified areas, e.g. nappy changing or kitchen areas. Health Protection Scotland recommends that bins are emptied and cleaned according to schedule, when no more than three-quarters full and at least at the end of every day. The main waste bin should be in a secure area away from play areas and where it cannot be accessed by animals [8].

Health Protection Scotland recommend that if the centre uses bed linen this should be allocated to each child, kept in a named bag or drawer when not in use and washed every week or when visibly dirty at the hottest temperature specified by the manufacturer [8]. (However, laundering should be acceptable from an infection control perspective: linen that is contaminated with body fluids is required to be laundered at a minimum temperature of 60C, as covered in the below section on infection control). Soiled or wet clothing should not be rinsed by hand but put in a sealed plastic bag for the parent to collect [8].

Food hygiene/catering standards

The Royal College of Physicians' guideline, *Infected Food Handlers: occupational aspects of management*, reports norovirus and salmonella (*enteritidis* and *typhimurium*) as the pathogens associated with the majority of the outbreaks of food poisoning [13]. Though there are cases of food items contaminated by NoV at source (notably filter-feeding shellfish), most foodborne outbreaks of NoV are related to preparation and service of cooked and uncooked items by infected food handlers [14].

The RCP recommend that a standardised hand washing procedure should be included as part of the induction programme for all those involved in food handling and preparation [13]. Hand washing using soap and water, followed by thorough drying with paper towels or a hot air dryer, is the most effective method for preventing the spread of infection from food handlers to food and then transferring this to others [13]. This is essential as the role of asymptomatic carriage of pathogens is unknown, and those involved in food preparation may transmit pathogens to others via the food that they handle [13]. There is insufficient literature to estimate how common asymptomatic carriage among food handlers is, or how frequently they cause outbreaks of foodborne infections. The RCP state that it is not currently possible to recommend routine microbial testing as a means of detecting asymptomatic viral carriage by food handlers [13]. Food handlers who have been ill with gastroenteritis should be excluded from duty until they have been symptom-free for 48 hours [13] (as covered below).

From 1992–2005 the HPA centre for infection recorded 47 NoV outbreaks associated with infected food handlers (21.7% of all outbreaks), with an average number of 50 affected cases per outbreak [13]. Of the 47 NoV outbreaks, 15 were related to food handlers who worked while sick; one returned to work four hours after symptoms ceased; two prepared food within 24 hours of the onset of diarrhoea and vomiting; and 14 were related to asymptomatic food handlers. From 1992–2005 four gastroenteritis outbreaks traced to infected food handlers (all pathogens) were reported to have occurred in schools, and four in university/college [13]. In published literature over the same time period, the number of food-handler-borne NoV outbreaks was 14 (35.8% of all published). Of these 14 published outbreaks, nine were caused when food handlers worked while symptomatic with gastroenteritis, but four were reportedly related to asymptomatic individuals (there was no information on the health status of one food handler). In food-handler-borne NoV outbreaks, both recorded by the HPA and in the published literature, the main vehicles of infection were raw foods or those not requiring further heating [13].

A 2002 survey by the Food Standards Agency (FSA) (n=1000) reported that 53% of food workers and managers did not wash their hands before preparing food; reasons given for low compliance included [13]:

- skin irritation from frequent washing
- inaccessibility of hand washing facilities
- that they instead relied upon gloves
- too busy to wash hands
- forgetting to follow procedures
- lack of training and supervision

Within the United Kingdom and elsewhere in Europe, all food handlers are required to be supervised and instructed/trained in food hygiene matters to enable them to handle food safely. All training is required to follow the Hazard Analysis and Critical Control Point System (HACCP), which is an internationally recognised approach to food safety management that focuses on identifying the critical points in the food-handling process where hazards may arise, and putting in place measures to prevent them [13].

Besides effective hand hygiene, specific measures advised by the HPS and NHMRC to promote food safety in child care facilities include [8,9]:

- staff member who prepares food should not be involved with toileting/nappy changing
- raw and cooked foods kept separately (cooked stored above raw in fridge) and prepared with separate utensils
- hot food heated to a minimum of 60C, and preferably above 70C
- cold food stored below 5C
- previously heated or refrigerated food, no longer <5C or >60C:
  - safe for use if within 2 hours
  - between 2 and 4 hours – either consumed immediately or discarded
  - four hours or longer – discarded

Specific to the care of babies they advise that breast milk or formula milk provided by parent should be:

- labelled with name and preparation date [8]
- breast milk may be stored in the fridge (not door) for up to 48 hours [8]
- formula should be made with boiled water and preferably made up for immediate use; if made in advance, used that day [8] (only following recommended storage conditions)
- bottles not warmed in microwave which distributes heat unevenly [9]
- unused milk discarded and all bottles, teats, and utensils washed with detergent and water and then disinfected as appropriate [8]

As a catering standard, access to food preparation areas should be restricted to catering or kitchen staff; and this is of particular importance during an outbreak [1]. (If this is feasible; it is understood that separate allocation of care may not be possible in some small, pre-school care facilities).

2. Identification of an outbreak of gastroenteritis

Identification of a case of gastroenteritis

Diarrhoea and vomiting (gastroenteritis) may be caused by viruses (e.g. NoV, rotavirus), bacteria (e.g. campylobacter, salmonella), bacterial toxins, parasites (e.g. cryptosporidium), chemicals and certain drugs. The usual incubation period for bacterial and viral infections is between one and three days [9]. The definite cause can only be diagnosed through laboratory testing of faecal specimens, though clinical features may suggest a cause.

A 2009 study by Lyman et al.[15] investigated the aetiology of 29 outbreaks of acute gastroenteritis at child care centres in North Carolina, USA, occurring between October 2005 and March 2007. Twenty-three occurred between October and May of the first NoV season, and six between November and March of the second season. Sixty percent of children assessed were aged between one and three years. Acute gastroenteritis was defined as a child who had ≥2 episodes of diarrhoea in a 24 hour period, and an outbreak was defined as ≥2 children with diarrhoea in the same classroom on the same day. Aetiology was confirmed by two faecal specimens positive for the same virus (by real time RT-PCR) or, if there were multiple viruses, as two environmental samples positive for a faecal-detected virus. An average 2.7 faecal samples were collected per outbreak (range 2–6). Thirteen of the 29 outbreaks (45%) were caused by a single virus: rotavirus in five, NoV in three, astrovirus in three and sapovirus in two [15].

All four of these viruses are commonly associated with gastroenteritis outbreaks in schools and child care centres due to the lack of immunity to these viruses among children [2].

Suspected case of norovirus infection

The prominent symptom of NoV infection among children is vomiting (often acute, profuse and projectile), while a greater proportion of adults experience diarrhoea [1]. Additional symptoms include stomach cramps, fever, headache and muscle aches. The incubation period is usually in the range 12–48 hours (median 32 hours). The illness is self-limiting and symptom resolution among healthy people will usually be within 12–72 hours (usual period 24–48 hours), though a prolonged course of illness can occur in children, adults and the immunocompromised [1,2].

The Communicable Disease Network Australia define a suspected case of NoV as a person in a population of risk (e.g. institutionalised), and with characteristic clinical symptoms within a defined time period, either [1]:

- three or more loose stools or bowel movements in a 24 hour period that are different from normal; and/or
- two or more episodes of vomiting in a 24 hour period

The above suspected-case criteria are only defined once an outbreak of gastroenteritis has been confirmed by public health officials.

The Communicable Disease Network Australia state that for the purpose of control in the early part of an outbreak, suspected cases of NoV are regarded as potentially infectious until an alternative pathogen is demonstrated to be the cause of the illness; or until 48 hours has elapsed after resolution of symptoms [1].

Notification and assessment of a suspected outbreak of gastroenteritis

Individual (sporadic) cases of suspected NoV gastroenteritis are not notifiable [2]. An outbreak is generally considered to be two or more cases connected in place and time. Reporting to public health officials or environmental health authorities is indicated when an outbreak of gastroenteritis is assumed to be caused by person-to-person transmission; 'two or more associated cases of diarrhoea and/or vomiting in a 24 hour period, excluding cases which have a known cause, e.g. bowel disease, alcohol, or pregnancy'; or caused by foodborne or waterborne transmission - 'two or more associated cases of diarrhoea and/or vomiting caused by the consumption of common source of food or water within a specified time frame' [1].

Often in the initial stages of an outbreak in a child care or school facility the cause and mode of transmission will be unknown, and it is simply required that the local health protection team/public health authority are contacted if there are two or more associated cases of the same infection (or a single case of a what the HPS define as a 'serious' disease [presumably notifiable]) [8]. The health protection team will then assess the situation, provide advice on infection control precautions, and contact other organisations such as Environmental Health and primary care to coordinate specimen collection [8,9]. The health protection agency also advise that an outbreak in a child care facility in the United Kingdom requires contact of the Care Commission [8].

The Communicable Disease Network Australia and WHO describe that initial assessment and investigation by public health officials may include assessment of [1,14]:

- the outbreak setting
- when the outbreak began
- symptoms and duration of illness, and whether all cases have the same illness
- the total numbers affected and unaffected (attack rate)
- any common factors to cases/key exposures related to illness (e.g. food)
- arranging for laboratory tests: clinical specimens from cases or food specimens if indicated
- forming preliminary hypotheses
- initiate infection control measures
- consider need for further investigation
- consider need to convene an Outbreak Control Team

An outbreak control or outbreak management team may involve a public health practitioner or epidemiologist, food safety control officer, microbiologist/toxicologist, and secretarial/logistic support [14].

In cases of suspected person-to-person transmission, particularly in suspected NoV outbreaks which have high infectivity, public health authorities are likely to focus upon advising infection control measures rather than investigating [1]. Factors likely to prompt investigation are suspected foodborne transmission, setting, high case severity and morbidity, and high attack rates [1].

The Communicable Disease Network Australia provide a flow chart of procedures summarising the investigation and management of gastroenteritis outbreaks [1].

Suspected outbreak of norovirus

An outbreak is suggested by the clustering of cases in time, person and place [1]. The Communicable Disease Network Australia describe a *case definition* as a set of criteria for determining who should be classified as a case, which is formed by the outbreak management team once an outbreak has been declared.

The case definition is described to include the four components of [1]:

- well-defined clinical symptoms (with or without laboratory confirmation)
- information relating to timing of onset of symptoms
- persons affected
- the place or location where the outbreak has or is occurring

In the 1980s, Kaplan defined clinical and epidemiological criteria that form the case definition for suspecting that an outbreak of gastroenteritis is due to norovirus [1]:

- vomiting in >50% of affected persons
- mean (or median) incubation period of 24–48 hours
- mean (or median) duration of illness of 12–60 hours
- no bacterial pathogen isolated in stool specimens (only later confirmed once fecal specimens have been collected)

Diagnostic confirmation

Specimen collection

Faecal samples are most suitable for collection, as the sensitivity of molecular assays for vomit samples is limited [1,2]. For outbreaks in institutionalised settings, faecal samples may be submitted via the general practitioner, liaising with the public health authority to determine the laboratory testing required [1]. The Centers for Disease Control and Prevention advise that whole stool specimens are obtained during the acute phase of illness (within 48–72 hours after symptom onset), while the stools are still liquid or semisolid and viral excretion is at its peak [2,16]. Public health officials will advise the number of specimens required, but it is generally recommended that whole stool specimens are taken from at least five people, more if specimens are taken after the acute phase of illness, or if the outbreak is large or protracted, or if ELISA is used rather than RT-PCR [1,2].

The Centers for Disease Control and Prevention advise samples of 10–15mls placed in a stool cup or urine container and refrigerated at 4C, under which conditions the sample would remain suitable for diagnostic testing for 2–3 weeks. If frozen at -20C, NoV has been detected up to five years after storage [2]. For transportation, the sample should be placed in a sealed bag and kept on ice or frozen refrigerant packs in an insulated, waterproof container [2]. The same storage and transport guidance applies to vomit if sampled alternatively or supplementary.

If a foodborne/environmental source of infection is suspected, CDC state that in the US, elution and concentration techniques are currently only available to allow detection of NoV RNA in water (samples refrigerated at 4C) and shellfish (frozen at -20C) [2].

Laboratory-confirmed norovirus

A suspected case of NoV infection can only be confirmed by a positive laboratory diagnosis, which involves detection of human NoV either by antigen detection (ELISA) or nucleic acid assay (RT-PCR), or visualisation of NoV by electron microscopy [1].

Real-time reverse transcription-polymerase chain reaction (RT-qPCR) is currently the preferred diagnostic method, which has very high sensitivity allowing detection of very low viral titers that may be present in asymptomatic individuals. (Although as such, low titer results [high cyclic threshold values] should be interpreted with caution [2].) Full capsid sequencing is recommended to allow for genotyping of strains [2]. Enzyme-linked immunosorbent assay (ELISA) has lower sensitivity and specificity, and though the rapidity of the technique may still give it a role for the preliminary screening of multiple faecal specimens, negative findings will not preclude the need for RT-qPCR [2]. Electron microscopy was the original detection method although it is rarely used now as it has low sensitivity for detecting low viral levels, although it may still be used for specimens that are negative by both RT-qPCR and ELISA [1].

A 2010 publication by Philips et al. [17] demonstrates the high diagnostic sensitivity for RT-qPCR. They performed a re-estimation of the community incidence of NoV-associated gastrointestinal illness in England using frozen faecal samples that had originally been taken between 1993 and 1996 from people presenting to their general practitioner with 'infectious intestinal disease' (diarrhoea or significant vomiting lasting <2 weeks, with a prior symptom-free period of ≥3 weeks), and tested using electron microscopy. Due to the high level of asymptomatic carriage of NoV, Philips et al. in an earlier study had used receiver operating characteristics (ROC curves) to select a cut-off cyclic threshold value from RT-qPCR; i.e. the faecal viral load at which NoV illness could be considered to be the cause of illness [18]. This analysis had used cases with infectious intestinal disease from the same population group and compared them with healthy controls, finding 31 as the upper cyclic threshold limit at which NoV could be considered as the cause of gastroenteritis [18]. They employed these findings in their subsequent estimation of community incidence, and estimated that using RT-qPCR, the age-adjusted community incidence of NoV-associated gastrointestinal illness in England was 4.5 per 100 person years, equivalent to two million episodes per year. The community incidence among children aged <5 years was 21.4 per 100 person years [17]. Using electron microscopy the estimated incidence had been 8.0 per 100 person years (44.3 in those <5) [17].

Although this is based on 1993–96 data, Philips et al. report this as the best available information on NoV disease burden in England [17]. Validation of the use of cyclic threshold limits is needed before this method is applied in other studies and laboratories [18].

Confirmed norovirus outbreak in child care facility

Norovirus, or other viral, outbreaks in school and child care settings are most likely to be associated with person-to-person transmission, via the faecal-oral route, aerosolised particles or contaminated environmental surfaces. Hence, infection control, rather than investigation, will be the focus of management. The principle aims of the outbreak investigation team are likely to be concerned with assessing the environment, ensuring that the necessary control and preventative measures are in place, and reporting the outbreak [1]. There is no need for further specimen collection unless the nature of illness changes [1].

Health Protection Scotland provide a summary of measures that staff should take during an outbreak at a child care facility [8]:

- ensuring staff understand standard infection control precautions and how to apply them
  - documents signed and dated to record that understanding is in place
- keeping an up-to-date list of:
  - names of children/staff who are ill
  - presenting symptoms of infection
  - when the children/staff became ill and when first reported symptoms
  - date of last attendance at child care setting
  - when parents were contacted and when the child was collected
  - who informed of the outbreak
  - advice received
- keeping unless directed otherwise:
  - recent menus
  - foods prepared but not eaten
  - raw food samples (if some people ate cooked portions of the same food)
  - samples of any food that people may have eaten labelled and sealed in cling film or containers and stored in freezer

Health Protection Scotland suggest use of a checklist to record such measures taken during an outbreak of gastroenteritis [8].

Note on foodborne or food-handler-borne norovirus outbreaks

Though foodborne transmission may be expected to have less of a role in the institutional setting, CDC report that of 21 million outbreaks of NoV-associated illnesses estimated to occur every year in the United States, one quarter are attributed to foodborne transmission [2]. Norovirus is also recognised to be the leading cause of all foodborne disease outbreaks in the United States: CDC report that 35% of foodborne outbreaks between 2006 and 2007 (822 of 2 367) were due to NoV [2].

An earlier review by CDC of all confirmed foodborne outbreaks occurring in United States restaurants between 1982 and 1997 had similarly found that NoV could be attributed to 38% them [19]. While salmonella accounted for the majority of the 697 outbreaks with laboratory-confirmed aetiology, 54% of 1 549 outbreaks with undetermined aetiology matched the epidemiological and clinical profile for NoV. Combined with the few laboratory-confirmed NoV outbreaks during this period (which would be expected to be much higher today due to improved diagnostic capacity), NoV was the pathogen associated with the highest number of outbreaks (855). In those restaurants with information available on contributing factors, improper hand hygiene was the factor associated with the majority of NoV outbreaks (40%), with lower associations to improper holding of food (e.g. temperature control) and use of contaminated kitchen equipment [19].

In particular, handling of ready-to-eat items by infected food employees is a commonly identified contributing factor in outbreaks in food-service establishments [2]. A recent study by Boxman et al. [20] demonstrates the importance of hygienic catering standards. Boxman et al. examined the prevalence of NoV in environmental swabs taken from the kitchen and bathroom areas of various catering companies in the Netherlands, including restaurants, canteens, lunchrooms, cafeterias, etc. (though none reportedly in schools). Over a one-year period (January 2008 to February 2009), samples were taken from 832 randomly chosen companies who had not had a recently reported outbreak of gastroenteritis. In total 1.7% of swabs from 4.2% of companies tested positive for NoV. The majority of positive samples (62%) were obtained from bathroom areas, and the remainder from kitchen areas. Eighty percent of positive swabs had been sampled during the NoV season running from November to March. These results were compared with samples taken from 72 companies involved in gastroenteritis outbreak investigations from 2006–2009. In this case 39.7% of swabs from 61.1% of companies tested positive for NoV; with the majority of positive samples again taken from bathroom areas [20].

The study highlights that NoV can be detected in environmental samples taken from various catering facilities, with a much higher prevalence rate among those recently associated with gastroenteritis outbreaks, but also at low prevalence among companies without recent outbreaks, and highlighting a potential source of infection via catering staff.

The foodborne viruses in Europe network, consisting of 26 institutes in 13 countries [21], is a laboratory and epidemiological network that investigates outbreaks of viral gastroenteritis associated with all modes of transmission (in particular foodborne) in order to obtain an overview of viral activity in the community. In 2001 the FBVE established a database to which all members report outbreaks of viral gastroenteritis, with details on diagnostic testing results, sequences and strain characteristics and other epidemiological data (setting, attack rates, mode of transmission) [21]. According to reporting standards of the FBVE, suspected mode of transmission during a NoV outbreak is considered to be foodborne when the infection is related to consumption of food contaminated during production or processing; food-handler–borne when associated with food prepared by an infected food handler; person-to-person when related to direct contact between infected people; or unknown [22].

Due to the high infectivity of NoV and rapidity of secondary transmission from one infected individual to another, outbreaks initially linked to a food source can often appear to be caused by person-to-person transmission. The Communicable Disease Network Australia and WHO suggest that though foodborne outbreaks can be difficult to distinguish, they may be suspected by a higher number of cases than would be expected during an outbreak associated with person-to-person transmission [1,14].

In suspected foodborne or waterborne outbreaks, public health investigation is likely to be more extensive. The following points summarise the key aspects of public health action following confirmed diagnosis of NoV in an outbreak suspected to be due to foodborne transmission, as outlined by CDNA [1]:

- formation of an outbreak management/control team
- formation of a case definition
- case finding
- hypothesis-generating interviews to identify possible food source of infection
- determine source of infection - whether outbreak is related to contaminated food at the source (foodborne), or at the point of service by an infected food handler (food-handler-borne)
- food sampling and investigation of the food preparation and storage environment
- trace back to origin of food products
- epidemiological assessment using a case-control study design

Many factors can make it difficult to identify a common food source of outbreaks in the setting of the global food market. Aside from the rapid transfer to person-to-person transmission, the longevity of NoV in frozen food products, under-reporting of some cases and outbreaks, the uncertain background level of NoV in the community, and the unknown role of asymptomatic shedding from food handlers can all contribute to difficulty in recognition of the source of contamination [22].

Verhoef et al [22]. identified a critical gap in surveillance of foodborne NoV outbreaks and suggest a need for international collaboration to increase the number of foodborne outbreaks recognised. Based on the principle that strain sequences from outbreaks linked to a common source are expected to be similar, they conducted a retrospective analysis of NoV outbreak surveillance data collected by the FBVE from 1999–2008 with the aim of quantifying strain variability to identify outbreaks with probable links to others. During this time there were 5 499 NoV outbreaks reported among the participating countries, and 100 were related to 14 common source events in Europe. Their analysis suggested that around 7% of outbreaks reported through the FBVE are likely to be due to international distribution of food [22].

3. Infection control interventions during an outbreak

Norovirus is highly contagious. It can be spread through aerosolised particles of vomit being inhaled or contaminating environmental surfaces, and this can be a prominent mode of transmission among children where profuse vomiting is common. Norovirus can also similarly spread via the faecal-oral route, including contamination of food during preparation as discussed above. Only 18 viral particles are required to transmit infection, and CDC report that during peak shedding, a single gram of faeces can contain around 5 billion infectious doses [2]. Norovirus is also highly resilient to chlorine, heating and freezing [1], increasing the chance of persistence in the environment and upon food.

The role of host immunity to norovirus is poorly understood, although histo-blood group antigens are believed to influence susceptibility [2]. It is expected that in most people short-term, strain-specific immunity develops following infection [1], making individuals of all ages susceptible during an outbreak.

The high infectivity of norovirus makes infection control measures of paramount importance. The key interventions to reduce spread of viral gastroenteritis in institutional settings are:

- exclusion or isolation of infected individuals;
- effective hand washing technique; and
- environmental disinfection

Exclusion or isolation of infected individuals

Health Protection Scotland advise that any child with diarrhoea or vomiting, continuous or severe stomach pain, who appears unwell (flushed or feeling hot), or who has flu-like symptoms or any rash should be isolated, and the parents contacted to take the child home [8].

Immediate exclusion of children or staff with gastroenteritis is a key infection control measure. Guidelines are consistent that individuals with gastroenteritis (NoV or other cause) should be excluded from school until 48 hours after resolution of diarrhoea and vomiting [1,2,8,9,16]. The Centers for Disease Control and Prevention highlight that the principle underpinning isolation is to minimise contact with persons during the most infectious periods of their illness, and that actual evidence for the effectiveness of exclusion and isolation strategies is limited [2].

In residential settings where exclusion is not possible, isolation is necessary. The Communicable Disease Network Australia advise that unwell people should not use communal areas and should be restricted to their room, with people entering the room using personal protective equipment and following strict hand washing procedures [1].

It is also advised that non-essential visiting to affected institutions is limited during outbreaks [1], and this may be applied to the school setting as well. Individuals who do attend the setting are advised to wash their hands upon arrival and when leaving [1].

It is advised that food preparation areas are restricted to catering or kitchen staff. The Communicable Disease Network Australia also advise that communal dining areas should be closed during an outbreak, but if this is not possible, all areas should be sanitised after each use [1]. All utensils and kitchen equipment should be cleaned in the usual manner using detergent and hot water, and any food that may have been handled by an infected person, or been in close proximity to a person vomiting, should be disposed of [1].

Closure of the school or child care setting may be required to allow for terminal cleaning and disinfection (as covered below); though this will usually be a joint decision made at the local level between the facility and public and environmental health officials [1].

Communication of exclusion policy to parents

In cases of gastroenteritis (any cause), HPS advise that parents are informed that their child should be kept at home for at least 48 hours after symptoms stop, and that parents are advised on the importance of washing their own and their child's hands to reduce the risk of transmission [8].

As stated by the NHMRC, some parents may find an exclusion ruling difficult due to other work/family commitments, and hence the best way to avoid any conflict between staff and parents is to have a written policy that clearly states the centre's exclusion criteria [9]. This document, which may also include other policies such as immunisation, medication and infection control measures, is advised to be given to the parents when the child joins the school/care centre, giving the parents opportunity to review and discuss the policies beforehand if required [9]. Such a sample letter is provided in HPS guidance [8].

Evidence on transmission and primary and secondary attack rates during outbreaks

A United Kingdom study by Marks et al. (2003) [23] reported evidence for the airborne transmission of NoV during an outbreak of gastroenteritis in a primary school, diagnostically confirmed to be due to NoV. The local Environmental Health Department was contacted 11 days after the first case of absence due to diarrhoea and vomiting. Cases were defined if parents reported by questionnaire that their child had had NoV-compatible symptoms, or if the school recorded a child absent due to diarrhoea and vomiting (though there were a number of discrepancies between the two). This case definition was met by 153/492 pupils, giving a primary attack rate of 31%. Fifteen children were reported to have vomited in ten classrooms, and a significant linear trend was observed, with attack rates increasing with the number of vomiting episodes that a pupil was exposed to. The odds ratio for an affected child having been exposed to vomiting in the classroom was 4.1 (95% CI 1.8 to 9.3; adjusted for sex, age and classroom location). Secondary cases were household members reporting diarrhoea or vomiting after a child had been ill. Of 256 household contacts, 24 adults and 52 other children became ill, giving secondary attack rates of 17% for adults and 46% for children. The mean duration of illness was 2.3 days [23].

An earlier study by Gotz et al [24] reported the primary and secondary attack rates following a large foodborne NoV outbreak affecting 30 child centres (day care or after-school care) in Sweden in 1999. All centres prepare food, and a raw vegetable salad was suggested to be the cause of the outbreak, via contamination from one of the foodhandlers. A sample of 13 centres was randomly chosen and a cohort of 775 subjects selected, representing half of those exposed. Here, a primary case definition was a person in the centre developing diarrhoea, vomiting or nausea during the first three days of the outbreak; a secondary case a person who became ill on days 4–12; and a secondary household case being a household member who became ill within six hours to ten days of the affected centre attendee. Of 424 people (65%) responding to the questionnaire, there were 195 cases (142 primary and 53 secondary), with a primary attack rate of 54% among adults and 19% among children, and secondary attack rates 19 and 13%, respectively. Attack rates were higher among children aged 0–5 than children aged 6–10. Of 403 exposed household members there were 79 secondary household cases; an attack rate of 20%. Of symptoms reported during this outbreak, vomiting was significantly more common in children (affecting 80.6% vs. 64.1% of adults) and diarrhoea was significantly more common in adults (71.5% vs. 52.0% of children); although the most common symptoms affecting both adults and children with equal predominance were nausea and abdominal pain. Duration of vomiting ranged from 1–72 hours and diarrhoea, 1–99 hours. There was a borderline increased risk of secondary transmission if exposed to a person with vomiting, but not diarrhoea. The earlier analysis by Gotz et al. that had found a strong association between primary cases and consumption of a vegetable salad observed a median incubation for primary cases of 34 hours (range 2–61 hours) [24].

Duration of viral shedding

Peak viral shedding is believed to be during the first 24–48 hours of acute illness; molecular techniques have demonstrated the persistence of viral RNA in the stool for several weeks after symptom resolution [1]. Prolonged viral shedding may potentially increase the risk of secondary transmission, particularly in the community and among food handlers, though the true significance of viral excretion in asymptomatic individuals is unknown [1]. Given that the viral load in faecal samples after symptom resolution is known to be lower than during acute illness, and that diarrhoea has greater potential to spread the virus than normal bowel motions [9], CDNA state that there is no evidence to support the prolonged exclusion of individuals beyond 48 hours after symptom resolution (a recommendation that they specifically refer to food handlers) [1].

The Centers for Disease Control and Prevention and NHMRC advise that if during part of an outbreak investigation asymptomatic food service workers are tested positive for NoV, they may be excluded or their work restricted in line with the US Food and Drug Administration (FDA) food code [2,9]. The Royal College of Physicians guidance for infected food handlers also raises concern that the period of absence is not long enough when food workers have been infected with NoV, but due to the uncertainty regarding the role of post-symptomatic shedding in transmission of infection, support the recommendation that infected food handlers only need to be excluded until symptom-free for 48 hours [13].

The Australian National Health and Medical Research Council also state that exclusion of asymptomatic contacts of an individual with NoV gastroenteritis, or the exclusion of asymptomatic individuals with infective organisms in their faeces, is not required [9].

The Australian National Health and Medical Research Council provide guidance on the appropriate exclusion period for all cases and contacts with other infectious diseases besides NoV [9]. Supplementary to this, exclusion periods recommended by the HPA document *Guidance on infection control in schools and other childcare settings* published in April 2010 are also provided for comparison.

Evidence of prolonged post-symptomatic faecal shedding

A 2007 publication by Murata et al. [25] demonstrated prolonged viral shedding among infants aged six months or younger. A total 172 faecal specimens had been collected from young children (median age 18 months) presenting to paediatric clinics in Japan with acute gastroenteritis in Nov–Dec 2002, and 71 tested positive for NoV. A medical diary of symptoms was kept by parents and follow-up specimens were collected for 26 children. Overall, the median duration of illness was five days, with longer duration in the 7–24 month category than those aged 0–6 months or 2–5 years, though numbers in each age category were small. The median period of viral shedding (days from onset of illness to the last positive fecal sample) was 16 days, ranging from 5–47 days. NoV was detected more than two weeks after symptom onset in 6/8 babies aged <1 year; 5/7 aged 1 year; and 2/8 aged 2–3 years. Three of five infants aged ≤6 months had detectable virus to between 42 and 47 days. The median period of viral shedding was 42 days in infants aged ≤6 months, compared to 10 days in those above one year of age [25]. In particular this study highlights the importance of nappy hygiene and exercising caution when changing and disposing of nappies in babies and young children who have been ill with NoV gastroenteritis.

An experimental study by Atmar et al. [26] similarly demonstrated prolonged post-symptomatic and asymptomatic shedding among 16 adult volunteers orally inoculated with NoV in order to monitor the duration of viral shedding. Norovirus was first detected by RT-PCR in faecal samples taken 18 hours after inoculation, and shedding lasted for a median of 28 days, ranging from 13–56 days. Peak levels of NoV were $95x10^9$ genomic copies per gram of faeces. By the less sensitive method of ELISA, NoV was first detected at a median 42 hours after inoculation, and then the virus was detectable for only 10 days. All 16 volunteers had detectable NoV in their stool, but only 11 met predefined criteria for gastroenteritis (diarrhoea, >200g watery faeces continuous, for any 24 hour period, or one episode of vomiting in addition to another symptom). In individuals with gastroenteritis, no association was observed between symptoms and the time of peak shedding, though the average duration of their symptoms was only one day. It was observed that peak vital shedding was higher in individuals who developed gastroenteritis compared to those who did not. As the authors of this study and CDNA guidance highlights, the significance of post-symptomatic and asymptomatic faecal viral shedding requires sensitive methods for assessing the infective viability of the virus [1,26].

What both of these studies do highlight is the vital importance of hand washing among post-symptomatic and asymptomatic individuals.

Hand washing and personal protection

Hand washing as outlined in the first section of this report is a standard infection control precaution. During an outbreak it is one of the most important measures to prevent person-to-person transmission via the faecal-oral route. The Communicable Disease Network Australia states that effective hand washing has been demonstrated to prevent absenteeism, and prevent viral transfer to environmental surfaces [1]. Hand washing is also recognised as the most effective way of preventing the spread of food-handler-borne infection [13].

During NoV outbreaks, hands should be washed as above in line with WHO recommendations, using a liquid soap and running water and thoroughly drying with disposable paper towels. There is variable evidence on the efficacy of alcohol gels and they should only be used when hand washing facilities are not available, and are of no use if hands are visibly contaminated with faeces, vomit or other bodily fluids [10]. Of note, several trials have found that when using liquid soap or alcohol gel, it is the efficacy of hand rubbing, in addition to the time that soap or gel is rubbed in for, that has been demonstrated to have the greatest effect on reducing contamination (although, this information is not specific to NoV contamination) [1,10].

Use of alcohol gels and hand sanitisers

The World Health Organization has investigated the efficacy of different alcohol gels used in hand hygiene to reduce contamination with various microorganisms. As NoV cannot be grown in culture, studies of NoV activity typically use the surrogate of feline calicivirus (FCV), or else another non-enveloped single stranded RNA virus [16].

Though 60–70% alcohol gels have been demonstrated to have good effect against gram-positive and negative bacteria, enveloped viruses, mycobacteria and fungi, WHO conclude that they have only moderate effect against non-enveloped viruses, including rotavirus, adenovirus and rhinovirus. The reduction in contamination is uncertain and there have been variable results from recent studies: some have demonstrated that 60% alcohol gel can give a 3–4 log reduction in the infective titre of non-enveloped viruses, though others have demonstrated only 1–2 log reduction [1,10,16]. A product that provides less than 2 log (99%) reduction is not considered an effective hand disinfectant [16].

Ethanol has also been demonstrated to be more effective against NoV surrogates than other alcohols such as n-propanol and isopropanol: when testing various 70% alcohol solutions, ethanol when rubbed into the hands for 30 seconds gave the most effective viricidal activity [10]. While higher alcohol concentrations above 80% have been demonstrated to have lower efficacy in some studies [1,10], the Maritime and Coastguard Agency (MCA) report the results of one study demonstrating that with 30 second contact time, only 95% ethanol could produce the required minimum 2 log reduction in FVC, with lower ethanol concentrations ineffective [16].

The World Health Organization report the efficacy of other hand disinfectant agents against non-enveloped viruses10:

- iodophors: moderate effect
- chlorhexidine: poor effect
- chloroxylenol: variable effect
- hexachlorophene, triclosan, and quaternary ammonium compounds: uncertain effect

Overall the guidelines and collated evidence suggest that the most effective way to remove NoV contamination is to wash hands with liquid soap and running water for at least 20 seconds [2] and to dry them thoroughly. With the effect of alcohol gels and hand sanitisers uncertain, they should be considered as an adjunct to hand washing, but not a substitute.

Use of gloves and other personal protective equipment

The Communicable Disease Network Australia and HPS advise that personal protective equipment (PPE) (i.e. single-use disposable gloves and apron) is used in circumstances where the staff member is likely to come into contact with faeces or vomit, to reduce risk from splashing or aerosolised transmission [1,8]. This includes cleaning and nappy changing or other contact with an ill child where the hands or body are likely to be contaminated.

Guidance highlights that reliance should not be placed on gloves, and hands must be washed before applying and after removing PPE [1,8]. In particular, the RCP raise concerns that when gloves are used by food handlers they can give a false sense of security and result in a reduction in hand washing. The Royal College of Physicians state that there is no evidence to suggest that use of gloves can reduce the transfer of micro-organisms from hand to food, though they discuss that this may be due to the quality of gloves or the way in which gloves are used and removed [13].

The Communicable Disease Network Australia advise that surgical filter masks should also be used when attending a vomiting person or when cleaning surfaces visibly contaminated by vomit or faeces to reduce risk of transmission through aerosolised particles [1].

Environmental cleaning

Sodium hypochlorite (chlorine bleach) is advised by CDC and CDNA as the gold standard disinfectant for use in NoV outbreaks. The Centers for Disease Control and Prevention state that the required concentration for cleaning of environmental surfaces is between 1 000 and 5 000 parts per million (1:50–1:10 dilution of 5.25% bleach; 5–25 tablespoons per gallon of water) [2]; though the standard concentration accepted by most guidance is 1000ppm [1,16]. This must be freshly prepared due to the potential for evaporative dilution [1,16] (although CDC advise that it may be prepared for storage for up to 30 days if the concentration is doubled to 2000–10,000ppm [2]).

This concentration has been demonstrated to have limited effectiveness on surfaces visibly contaminated with faeces, and hence cleaning with detergent and warm water prior to use of bleach is required to remove all organic matter [1,10]. Disinfectant applied directly to urine can also cause release of chlorine gas [9]. The Communicable Disease Network Australia and MCA advise that sometimes a combined detergent/sodium hypochlorite solution may be used as a 'one-step' clean [1], though these products have not been demonstrated to be as effective as cleaning with detergent before applying disinfectant [16].

Any disinfectant used is required to give a minimum log 4 reduction in viral titre (99.99%) [10,16]. The CDNA advise that a 1000ppm sodium hypochlorite solution, when used on cleaned surfaces, requires a contact time of at least ten minutes to provide sufficient inactivation of the virus [1]. The Centers for Disease Control and Prevention report the findings of a recent study which found that when the higher 5 000ppm concentration was used, approximately four minutes of exposure was sufficient to reduce NoV surrogates by log 4, even when applied to faecal contaminated surfaces [2]. However, application of 1 000ppm sodium hypochlorite solution to surfaces that have previously been cleaned with detergent and water is the accepted standard.

Disinfection procedures

The Communicable Disease Network Australia advise that during NoV outbreaks, frequently-touched environmental surfaces are cleaned and disinfected more frequently than the daily cleaning schedule normally recommended: they advise toilet seats, flush handles, taps, tables and door handles to be cleaned at least twice daily, and after any high usage times [1]. Children's toys and items in play areas may also be heavily contaminated and all items should be capable of withstanding disinfection [16].

Sodium hypochlorite is damaging to many textiles. For contaminated items not suitable for chemical disinfection, CDC state that the efficacy of heat disinfection at 60C has been demonstrated in laboratory conditions [2]. Clothing, linen, non-disposable mop-heads and other soiled washable items should be laundered in a hot wash with detergent for the maximum cycle [1]. The Maritime and Coastguard Agency recommend that this is at minimum 70C, and that if this cannot be achieved they advise adding sodium hypochlorite to the penultimate rinse (at least five minutes) at a concentration of 150ppm [16]. It is advised that carpets and furnishings that cannot be laundered are cleaned with detergent and warm water and then steam cleaned [1,16]. Vacuum cleaning is not recommended as it can re-circulate NoV; if used, a separate ducted system or HEPA-filtered (high efficiency particulate air) vacuum is recommended [1,16].

Summary of recommended cleaning procedure for any environmental spillages of body fluids [1,8,9]:

- wash hands and put on PPE
- prepare a solution of general-purpose (preferably neutral) detergent and warm water, and a fresh solution of disinfectant (following manufacturer's instruction for dilution)
- use disposable paper towels to soak up spillage and place in disposable, leak-proof plastic bag
- apply detergent solution using disposable towels/cloth, rinse to remove residue, wipe dry with disposable towel, or leave to air dry, and place all used towels in a disposable, leak-proof plastic bag
- discard gloves and apply new gloves prior to disinfecting
- apply disinfectant according to manufacturer's instruction and leave for sufficient time
- remove all PPE and place in a disposable plastic bag and seal it, then wash hands
- the area should be closed/sealed off for a minimum of two hours after the incident [16]
- all non-disposable cleaning equipment (e.g. buckets) should be cleaned and disinfected and dried between uses [16]

Terminal cleaning

The Communicable Disease Network Australia advise that terminal cleaning of the entire affected area, unit or section (e.g. all surfaces, all furnishings, etc.) should be carried out 72 hours after resolution of symptoms in the last case, thus allowing for a 24 hour incubation and 48 hour peak infectivity of any newly infected individuals [1]. They recommend a minimum time elapse of 72 hours since the onset of symptoms in the last case and 72 hours since vomiting or diarrhoea in the environment. Terminal cleaning is carried out before the outbreak is declared to be over [1].

Note on other disinfectants

The efficacy of triclosan and quaternary ammonium compounds against non-enveloped viruses has not been demonstrated [1,10,16]. Of note, the study by Marks et al.[23] reporting on a NoV outbreak at a primary school in the United Kingdom, observed that the first period of environmental cleaning took place on days 13–14 of the outbreak, but this was with a quaternary ammonium compound, due to concerns about the health and safety of chlorine-releasing products. This disinfection was ineffective and the school had to be cleaned again on days 19–20, this time using chlorine-based products. The school was closed between days 18 and 21, and the last reported illness in a child was on day 22 [23].

The efficacy of ethanol as a surface disinfectant has also not been demonstrated, despite it having some efficacy as a hand sanitiser [1,16]. There would further be safety issues if alcohols were used for surface disinfection of large areas.

Iodine-based, glutaraldehyde-based and phenol-based disinfectants, hydrogen peroxide and chlorine dioxide, have all been demonstrated in the laboratory to have effectiveness against FCV, though their use is not recommended due to toxicity risks or difficulties with practical use [16].

Testing of all disinfectants is limited to the surrogates of NoV, [1,10,16] and the CDC note the conclusion of recent reports that FCV, the most commonly used in testing, is not the most resistant surrogate virus to predict NoV inactivation [2]. The Maritime and Coastguard Agency provide lists of the actions of commonly used disinfectants against FCV [16].

Evidence supporting infection control measures

Systematic reviews

A key 2008 systematic review by Harris et al.[27] concluded that the current published literature does not provide an evidence base for the value of infection control measures during norovirus outbreaks in semi-enclosed settings.

The review included 47 papers (all in developed countries; 15 reports from Europe), the majority of which covered outbreaks in hospitals and nursing homes. Only three papers reported child care settings, one school and one day care centre in the US, and one nursery in Japan. Specific analysis of these settings was not conducted. Outbreaks were significantly longer in hospitals and nursing homes (median 19 and 16 days, respectively) than in non-healthcare settings (median seven days).

There was no effect of infection control measures on overall outbreak duration, which was 16 days (range 1–44 days) when infection control measures were used, and 14 days (range 2–92 days) when they were not (reported by 29 papers covering 47 outbreaks in all settings). There was also no effect of infection control upon attack rates in all settings: 47.6% of patients/customers and 34.4% of staff were affected in reports where infection control was used, compared to 36.1% and 32.4%, respectively, where infection control was not described [27].

Though this review found no effect of infection control measures, the authors report that the quality of the included literature prevented a firm conclusion either way. The assumption was made that infection control measures were not implemented if they were not discussed, and many reports did not specifically describe the infection control measures used. There was also a lack of post-intervention evaluation [27].

Randomised controlled trials

One randomised controlled trial has investigated the efficacy of infection control interventions for preventing absenteeism due to gastroenteritis or respiratory illness in the school setting (not during an outbreak). Sandora et al. [28] performed an eight-week cluster-based RCT where 15 classrooms (including a total 285 students) were randomised to an intervention of alcohol-based hand sanitiser (70% ethyl alcohol) and quaternary ammonium wipes to disinfectant surfaces, or to the control of standard hand washing and cleaning practices. Students in intervention classrooms were instructed to use the hand sanitiser after using the bathroom and before and after lunch; and teachers disinfected classroom surfaces once daily after lunch.

The intervention significantly reduced the primary outcome of absenteeism due to gastroenteritis (defined as ≥2 very loose/watery stools and/or vomiting in a 24-hour period): 16% of intervention students missed ≥1 days vs. 24% control. Swabs of classroom surfaces were taken for viruses and bacteria; only NoV was detected on classroom surfaces and significantly fewer positive swabs were from intervention classrooms (9% of samples vs. 29%).

By contrast the intervention had no effect on reducing absenteeism due to respiratory illness [28].

Non-randomised controlled trials

A further non-randomised trial was identified in the residential care setting, though few conclusions could be drawn from it about the effectiveness of individual infection control measures. Friesema et al. [29] aimed to investigate the effect of three infection control protocols in 37 laboratory-confirmed NoV outbreaks reported at 49 nursing homes in the Netherlands during the November–April 05/06 and 06/07 seasons. The three levels of interventions were a basic protocol of cohorting/exclusion, hand hygiene and frequent toilet cleaning; an intermediate protocol which included cleaning and disinfection with 250ppm chlorine; and an extensive protocol of specific measures including cleaning and disinfection with 1000ppm chlorine, use of face masks when exposed to vomit, and exclusion until symptom-free for 48–72 hours.

In 54 of 75 affected wards, protocols were commenced within three days of symptom onset in the first case. Compared to later implementation of infection control this was associated with a significant decreased attack rate among staff (20% vs. 33%), and decreased, though non-significant, attack rates among residents (36% vs. 40%), and decreased outbreak duration (mean 15.9 days vs. 18.5 days) [29].

Compliance with the assigned protocols was poor and this prevented comparison between protocols. Therefore Friesema et al. looked at individual infection control measures reported across centres. Measures implemented in at least 90% of all wards were immediate cleaning of a room contaminated with stool or vomit; stringent hand washing with water and soap; and staff using gloves. The individual measures associated with the largest effect upon attack rate were the refusal of symptomatic visitors (when implemented attack rates were 36% among residents and 13% among staff, vs. 41% and 20%, respectively, when not) and exclusion of ill staff until 48–72 hours after symptom resolution (36% and 17%, vs. 48% and 26%) [29].

Experimental studies

A 2004 experimental study by Barker et al [30] used RT-PCR to study the transfer of NoV from contaminated faecal matter on fingers and cloths to other hand-contact surfaces. They also compared the effectiveness of detergent-based cleaning alone with sodium hypochlorite disinfection of contaminated surfaces. For the study they used a laboratory faecal sample positive for NoV genogroup GII, with a negative faecal sample used as a control.

Fingertips were pressed onto contaminated tissue (previously soaked with 150microlitres of faecal sample in 1:5 phosphate-buffered saline) and allowed to dry before testing for NoV. Ten replicate tests showed that after washing with liquid soap and water for one minute, rinsing for 20 seconds and thoroughly drying with disposable paper towels, no virus was detectable. To test environmental transfer, contaminated fingertips were sequentially pressed onto eight melamine surfaces for 10 seconds and then sampled 15 minutes later. In four replicate tests, the first four surfaces all tested positive for NoV; the second two were positive on three of four tests; the seventh surface was positive on one of four tests; and the eighth surface was negative on all four tests. To test secondary transfer, 15 minutes after surface contamination, clean dry fingers touched the surface and then touched three secondary environmental surfaces. In 10 tests, 40% of secondary surfaces were positive [30].

Six surfaces were then directly contaminated with a 1:5 faecal suspension contaminated with NoV, and three different methods of surface decontamination were tested: detergent solution alone; 5000ppm hypochlorite disinfectant applied directly for one minute or five minutes then wiped away with detergent; or initial detergent solution to remove soiling followed by hypochlorite disinfectant. Fourteen replicate tests revealed that washing with a cloth soaked in detergent solution did not eliminate NoV and also facilitated transfer via the cloth to other surfaces and to fingers. In replicate tests where hypochlorite disinfectant was applied directly, 21% of surfaces remained positive after one minute contact, and 28% remained positive after five minutes contact. The most efficacious method was cleaning with detergent followed by hypochlorite disinfection for one minute, after which no NoV was detected on surfaces [30].

Surveys

Surveys by the CDC's Vessel Sanitation Program from cruise ships affected by NoV outbreaks also support the efficacy of hand hygiene and isolation [31]. Survey responses were received from a total 1 323 passengers who travelled on three affected ships. Affected cases were more likely to report exposure to an ill cabin mate or social contact, or exposure to another's diarrhoea or vomit. Compared to controls, affected cases were significantly less likely to believe that hand washing or hand sanitiser were effective means of preventing gastrointestinal illness; less likely to wash their hands after using the bathroom; and less likely to believe that isolation was an effective method of preventing spread of infection.

Between 43 and 70% of affected cases delayed reporting or did not report their illness to the ship's infirmary, mostly because they did not think it was serious, or were self-treating. All three ships had been associated with passengers (range 5–12) who were ill with gastroenteritis prior to embarkation [31]. The survey findings highlight the need for passenger education about signs, symptoms and public health impact of gastrointestinal illness, which may also be relevant to other institutional settings.

4. Post-event review and remediation planning

Conclusion of an outbreak

During an outbreak, the institution updates the public health unit on the number of cases, and review of infection control measures may be taken if there is a change in nature of illness, or an alternative mode of transmission is suspected.

The outbreak management team declare the end of a NoV outbreak, but CDNA report that there is no consensus on when this should be [1]. A previous recommendation given for residential facilities is when seven days have elapsed since resolution of symptoms in the last case; another recommendation is when two incubation periods for the organism have passed since the end of symptoms in the last case [1]. The Communicable Disease Network Australia consider that an appropriate time for declaration of the end of a NoV outbreaks is when no new cases have occurred in 72 hours from the onset of symptoms of the last case [1]. This is assuming the unknown role of asymptomatic and post-symptomatic viral shedding in the transmission of infection.

The end of the outbreak should then be communicated to all institutional staff and all those involved in the investigation. The Communicable Disease Network Australia and WHO advise that a public health report on the outbreak should include investigations made, findings and recommendations; and that copies should be kept of all laboratory results, minutes of meetings, and other communications and documentation. A summary report should be forwarded to appropriate stakeholders [1,14].

Debriefing between the public health outbreak management team and all other individuals involved in reporting and managing the outbreak is recommended to allow opportunities to identify strengths and weaknesses in the outbreak investigation and how future situations may be better managed.

World Health Organization guidance lays out the aims of debriefing, which are to [14]:

- ensure that control measures for the outbreak are effective
- identify long-term and structural control measures and plan their implementation
- assess whether further scientific studies should be conducted
- clarify resource needs, structural changes or training needs to optimise future outbreak response
- identify factors that compromised the investigations and seek solutions
- change current guidelines and develop new materials as required
- discuss legal issues that may have arisen
- arrange for completion of the final outbreak report

Training and remediation planning

Education and training are vital to the prevention of future outbreaks. The Communicable Disease Network Australia advise that all institutions provide a programme of education for their staff concerning the key methods of management and prevention of future outbreaks [1].

Health Protection Scotland advise that a run-through of outbreak procedures (e.g. notification of public health authorities, action to take, records to keep, etc.) are performed annually in child care facilities [8].

Systematic review evidence of preventative strategies employed in institutions

A 2010 systematic review by Grieg et al.[32] indentified investigation reports (most from government sources) for gastroenteritis outbreaks in prisons, and looked at infection control measures used, and preventative recommendations made for future outbreaks. The causal agent of each outbreak was identified by laboratory confirmation from faecal sampling of cases or food sampling. Seventy-two outbreaks were identified and 15 (21%) were due to viral causes, 14 of which were NoV. The attack rate in NoV outbreaks was 14%. A third of viral outbreaks were associated with person-to-person transmission, a third were of unknown transmission, and the remainder were associated with foodborne transmission.

Twenty-one of all 72 outbreaks reported measures taken to control the outbreak. For outbreaks associated with both foodborne and person-to-person transmission, exclusion (or restricting movements), particularly related to food preparation areas, was the main infection control measure reported, with enhanced hand washing, cleaning and disinfection reported less frequently. Thirty-two reports included recommendations to prevent future outbreaks. Of eight outbreaks associated with person-to-person transmission, three reports gave a total 24 different recommendations. The most common recommendation was exclusion/restricting movements of ill prisoners or staff (ten recommendations), and the second was for education in hand washing (three recommendations). Of 48 foodborne outbreaks, 29 reports gave future recommendations, and 68 (40%) of all recommendations related to food handling, the majority of which were for monitoring food temperatures and care with cooking, cooling and reheating [32].

Grieg et al. also conducted a 2008 systematic review [12] identifying outbreak reports of gastrointestinal illness occurring in long-term care facilities from 1997–2007, and assessed recommendations that were made for prevention. Seventy-five outbreaks met inclusion criteria, with reports from the United States and Canada, Australia, Europe and Asia. Viral agents were associated with 52 outbreaks (69%), of which 43 were NoV. The majority of viral outbreaks (71%) were associated with person-to-person transmission. None of the reports had evaluated the effectiveness of outbreak control measures, though recommendations for future prevention were given in 47 reports (63%).

Of a total 155 recommendations related to person-to-person transmission, the majority (27 recommendations) related to isolating ill residents/preventing their transfer between wards and preventing new admissions during an outbreak (three NoV outbreaks had been traced to the transfer of infected individuals between institutions). This was followed by effective cleaning and disinfection (in one NoV outbreak environmental swabs from multiple surfaces were positive); cancelling social events/restricting visitors during outbreaks; excluding ill staff until 48-hours symptom-free; effective hand hygiene; and preventing cross-contamination through use of PPE. Of outbreaks associated with foodborne transmission, the majority of recommendations (15 of 40) related to cross-contamination (mostly the sourcing and preparation of eggs, presumably from salmonella outbreak reports), followed by infection control measures (similar to person-to-person transmission recommendations), staff training about food hygiene, and food temperature control (when cooking, cooling and reheating) [12].

A summary of key strategies that Grieg et al.[12] highlighted for preventing gastrointestinal outbreaks associated with person-to-person transmission (most of which are viral) were:

- limiting movements of residents, staff, and visitors
- daily environmental cleaning with additional targeted disinfection of 'high touch' areas
- management to support effective hand washing and education for staff, residents, and visitors
- personal protective equipment to be worn as required, especially during direct contact with residents
- having infection control policies in place, seeking expertise of local health unit

Key strategies that Grieg et al.[12] highlighted for preventing gastrointestinal outbreaks associated with foodborne transmission (most of which are bacterial) were:

- training kitchen staff in safe food handling, emphasising temperature control for hazardous foods and methods for cleaning and sanitising surfaces
- using only pasteurised egg products
- food suppliers having quality assurance programmes
- prompt medical consultation for all affected cases

Possible training and remediation strategies based on findings the findings of this report

Based on the findings of this technical report, training and remediation planning for school personnel and facilitators may include:

- Education on norovirus, and viral gastroenteritis in general:
  - high virulence and infectivity
  - modes of transmission: hand-to-mouth/person-to-person, aerosolised particles, foodborne
  - that infants, children and other vulnerable individuals can be at risk from dehydration and its complications
- Emphasising the principles of correct hand hygiene, highlighting that people may be carrying infective organisms on their hands, even when not unwell themselves:
  - provision of sinks with running water, liquid soap and disposable paper towel in all necessary areas (e.g. kitchen and toilet areas)
  - education on when to wash hands
  - hand washing needs to be of adequate duration (at least 15–20 seconds)
  - need to apply adequate soap to all hand surfaces
  - need to dry hands thoroughly using disposable towel
  - ≥70% ethanol may be used as an adjunct between hand washes, but is not a substitute
- Emphasising the need for immediate exclusion of all individuals with diarrhoea and vomiting, both children and staff, until symptom-free for 48 hours:
  - clear written policies given to parents/guardians to enhance compliance
  - staff sick policies that do not compel staff to return to work early
- Emphasising the need for adequate environmental cleaning and disinfection:
  - a schedule of when and where to clean, signed and dated when performed
  - adequate provision of appropriate materials, e.g. detergent, cleaning equipment, gloves and other PPE, effective disinfectants
  - appropriate methods of cleaning, including separate equipment used for different areas (e.g. colour coded by area), and appropriate cleaning, drying and storing, or disposing, of equipment after use
  - how to manage spillage of body fluids, including appropriate use of PPE (e.g. need to wash hands)
  - disinfectant use: initial detergent and water cleaning to remove soiling, followed by disinfection with 1 000ppm sodium hypochlorite solution as the current standard
- Education for all catering staff in hand hygiene, correct food safety, storing, handling and preparation, in keeping with HACCP.
- Ensuring that schools have the necessary resources and information to prevent and manage future outbreaks; this may involve an outbreak response plan that facilitates early recognition and implementation of infection control measures, and outlines responsibilities for collection of relevant information and communication to public health authorities.

References

1. Department of Health and Ageing. Guidelines for the public health management of gastroenteritis outbreaks due to norovirus or suspected viral agents in Australia. Canberra ACT: Australian Government; 2010. Available from: http://www.health.gov.au/internet/publications/publishing.nsf/Content/cda-cdna-norovirus.html

2. Division of Viral Diseases, National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention. Updated norovirus outbreak management and disease prevention guidelines. MMWR Recomm.Rep. 2011;60(RR-3):1-18.

3. Hansen S, Stamm-Balderjahn S, Zuschneid I, Behnke M, Ruden H, Vonberg RP, et al. Closure of medical departments during nosocomial outbreaks: data from a systematic analysis of the literature. J Hosp Infect. 2007;65(4):348–53.

4. Health Protection Agency Hospital Outbreak Reporting Scheme. Weekly update of norovirus activity. Report date: 19 September 2011. London: Health Protection Agency; 2011. Available from: http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1287143931777.

5. Kroneman A, Vennema H, Harris J, Reuter G, von Bonsdorff C, Hedlund K, et al. Increase in norovirus activity reported in Europe. Euro Surveill. 2006;11(50).

6. Patel MM, Widdowson MA, Glass RI, Akazawa K, Vinje J, Parashar UD. Systematic literature review of role of noroviruses in sporadic gastroenteritis. Emerg Infect Dis. 2008;14(8):1224–31.

7. Phillips G, Tam CC, Rodrigues LC, Lopman B, Phillips G, Tam CC, et al. Prevalence and characteristics of asymptomatic norovirus infection in the community in England. Epidemiol Infect. 2010;138(10):1454–8.

8. Health Protection Scotland. Infection Prevention and Control in Childcare Settings (Day Care and Childminding Settings). Glasgow: Health Protection Scotland; 22-2-2011. Available from: http://www.documents.hps.scot.nhs.uk/hai/infection-control/guidelines/infection-prevention-control-child_care.pdf.

9. National Health and Medical Research Council. Staying Healthy in Child Care - Preventing infectious diseases in child care - Fourth Edition. Canberra ACT: Australian Government; 2006. Available from: http://www.nhmrc.gov.au/_files_nhmrc/file/publications/synopses/ch43.pdf.

10. WHO. WHO Guidelines on hand hygiene in health care. Geneva: World Health Organization; 2009. Available from: http://whqlibdoc.who.int/publications/2009/9789241597906_eng.pdf.

11. Ejemot RI, Ehiri JE, Meremikwu MM, Critchley JA. Hand washing for preventing diarrhoea. Cochrane Database Syst Rev. 2008;(1):CD004265.

12. Greig JD, Lee MB. Enteric outbreaks in long-term care facilities and recommendations for prevention: a review. Epidemiol Infect. 2009;137(2):145–55.

13. NHS Plus, Royal College of Physicians, Faculty of Occupational Medicine. Infected food handlers: occupational aspects of management. A national guideline. London: Royal College of Physicians; 2008. Available from: http://www.nhsplus.nhs.uk/providers/images/library/files/guidelines/InfectedFood_Guidelines.pdf.

14. WHO. Foodborne disease outbreaks: Guidelines for investigation and control. Geneva: World Health Organization; 2008. Available from: http://whqlibdoc.who.int/publications/2008/9789241547222_eng.pdf.

15. Lyman W, Walsh J, Kotch J, Weber D, Gunn E, Vinje J. Prospective study of etiologic agents of acute gastroenteritis outbreaks in child care center. J Pediatr. 2009;154:253–7.

16. Norovirus Working Group. Guidance for the management of norovirus infection on cruise ships. London: Health Protection Agency, 2011. Available from: http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1206520183347.

17. Phillips G, Tam CC, Conti S, Rodrigues LC, Brown D, Iturriza-Gomara M, et al. Community incidence of norovirus-associated infectious intestinal disease in England: improved estimates using viral load for norovirus diagnosis. Am J Epidemiol. 2010;171(9):1014–22.

18. Phillips G, Lopman B, Tam CC, Iturriza-Gomara M, Brown D, Gray J. Diagnosing norovirus-associated infectious intestinal disease using viral load. BMC Infect.Dis. 2009;9:63.

19. Hedberg CW, Palazzi-Churas KL, Radke VJ, Selman CA, Tauxe RV. The use of clinical profiles in the investigation of foodborne outbreaks in restaurants: United States, 1982–1997. Epidemiol Infect. 2008;136(1):65–72.

20. Boxman IL, Verhoef L, Dijkman R, Hagele G, Te Loeke NA, Koopmans M, et al. Year-Round Prevalence of Norovirus in the Environment of Catering Companies without a Recently Reported Outbreak of Gastroenteritis. Appl Environ Microbiol. 2011;77(9):2968–74.

21. Kroneman A, Harris J, Vennema H, Duzier E, van Duynhoven Y, Gray J, et al. Data quality of 5 years of central norovirus outbreak reporting in the European network for food-borne viruses. J Public Health. 2008;30:82–90.

22. Verhoef L, Kouyos RD, Vennema H, Kroneman A, Siebenga J, van PW, et al. An integrated approach to identifying international foodborne norovirus outbreaks. Emerg Infect Dis. 2011;17(3):412–8.

23. Marks P, Vipond IB, Regan F, et al. A school outbreak of Norwalk-like virus: evidence for airborne transmission. Epidemiol Infect. 2003;131(1):727–36.

24. Gotz H, Ekdahl K, Lindback J, de JB, Hedlund KO, Giesecke J, et al. Clinical spectrum and transmission characteristics of infection with Norwalk-like virus: findings from a large community outbreak in Sweden. Clin Infect Dis. 2001;33(5):622-8.

25. Murata T, Katsushima N, Mizuta K, Muraki Y, Hongo S, Matsuzaki Y. Prolonged norovirus shedding in infants <or=6 months of age with gastroenteritis. Pediatr Infect.Dis J. 2007;26(1):46–9.

26. Atmar RL, Opekun AR, Gilger MA, Estes MK, Crawford SE, Neill FH, et al. Norwalk virus shedding after experimental human infection. Emerg Infect.Dis. 2008;14(10):1553–7.

27. Harris J, Lopman B, O'Brien S. Infection control measures for norovirus: a systematic review of outbreaks in semi-enclosed settings. J Hosp Infect. 2010;74(1):1–9.

28. Sandora TJ, Shih MC, Goldmann DA, Sandora TJ, Shih MC, Goldmann DA. Reducing absenteeism from gastrointestinal and respiratory illness in elementary school students: a randomized, controlled trial of an infection-control intervention. Pediatrics. 2008;121(6):e1555–e1562.

29. Friesema I, Vennema H, Heijne J, et al. Norovirus outbreaks in nursing homes: the evaluation of infection control measures. Epidemiol Infect. 2009;1–12.

30. Barker J, Vipond IB, Bloomfield SF. Effects of cleaning and disinfection in reducing the spread of Norovirus contamination via environmental surfaces. J Hosp Infect. 2004;58(1):42–9.

31. Neri AJ, Cramer EH, Vaughan GH, Vinje J, Mainzer HM. Passenger behaviors during norovirus outbreaks on cruise ships. J Travel.Med. 2008;15(3):172–6.

32. Greig JD, Lee MB, Harris JE. Review of enteric outbreaks in prisons: Effective infection control interventions. Public Health. 2011;125(4):222–8.