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Guidelines

Guidelines for the management of norovirus outbreaks in acute and community health and social care settings☆

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☆ NICE has accredited the process used by the Healthcare Infection Society (HIS) to produce: 'Guidelines for the management of norovirus outbreaks in acute and community health and social care settings'. The NICE accreditation of HIS methodology is valid for 5 years from March 2020. More information on accreditation can be viewed at http://www.nice.org.uk/about/what-we-do/accreditation

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Executive summary

Norovirus remains the most prevalent gastrointestinal pathogen. Outbreaks in healthcare and non-healthcare settings are still reported, and norovirus is estimated to cost the UK National Health Service (NHS) more than £100 million annually. Previous UK guidelines [1] were published over a decade ago, and new knowledge and technologies have since emerged. These updated guidelines focus on infection prevention and control (IPC) principles which aim to reduce the norovirus burden in health, care and social settings (e.g. acute hospitals, nursing and residential homes, child care, day centres and prisons), while maintaining essential services and minimizing disruptions during the outbreaks. Specifically, they discuss the currently available evidence for outbreak prevention, outbreak control at ward/unit level and the management of infected individuals. Additionally, the guidelines highlight the poor quality of evidence that underpins the current IPC strategies for controlling norovirus outbreaks, and emphasize the gaps in knowledge with recommendations for future research.

Summary of recommendations and good practice points

What is the role of building design in the occurrence of norovirus outbreaks?

1.1: No recommendation.

GPP 1.1: Perform risk assessment of the ward/unit 'hierarchy of controls' to establish the risk of norovirus transmission between patients.

GPP 1.2: Where risk of transmission is high, consider making small changes to the ward/unit layout (e.g. installing partitions, bay doors or including flexible designs). However, consider and risk assess any potential adverse effects of doing this (e.g. on ventilation systems).

GPP 1.3: Assess individual risk of norovirus infection to the patient, and consider additional control measures for patients at the highest risk (i.e. those who are immunocompromised).

What is the clinical and cost effectiveness of preparing for a norovirus outbreak?

2.1: No recommendation.

GPP 2.1: Wherever possible, prepare staff for potential norovirus outbreaks by providing reminders, guidance, training and education so that staff are able to act quickly.

What is the clinical and cost effectiveness of avoiding admission/incarceration (in prisons) of individuals who are suspected or confirmed to be infected by norovirus?

3.1: No recommendation.

GPP 3.1: Where feasible, avoid admitting patients with suspected/confirmed norovirus and offer suitable supportive treatment (e.g. rehydration therapy) in the community.

When should the beginning and the end of the outbreak be declared?

4.1: No recommendation.

GPP 4.1: If an outbreak is suspected, consider introducing control measures (including transmission-based precautions) before laboratory results are available.

GPP 4.2: If a sporadic case of norovirus is identified, consider introducing control measures (including transmission-based precautions) to prevent an outbreak (for the next 72 h).

GPP 4.3: Whenever possible, maintain the control measures in place for 72 h after the last episode of vomiting or diarrhoea in the last known case before declaring the end of an outbreak.

What is the effective communication at the start of an outbreak?

5.1: Communicate with the IPC team, patients and their families as soon as a norovirus outbreak is suspected or confirmed.

GPP 5.1: Seek support from the local IPC team about the management of sporadic (suspected and confirmed) cases of norovirus.

GPP 5.2: Inform all local facilities of any outbreaks occurring in your area i.e. if they occur in the community and vice versa.

What is the clinical and cost effectiveness of testing all patients with vomiting and/or diarrhoea at admission?

6.1: No recommendation.

GPP 6.1: Wherever possible, test all symptomatic patients for norovirus at admission.

What is the clinical and cost effectiveness of testing all individuals who develop vomiting and/or diarrhoea?

7.1: No recommendation.

GPP 7.1: Wherever possible, test all symptomatic patients to establish whether their symptoms are due to norovirus infection.

What is the clinical and cost effectiveness of follow-up testing for norovirus?

8.1: No recommendation.

GPP 8.1: Do not offer routine follow-up testing for norovirus.

GPP 8.2: Consider follow-up testing if there is a suspicion that the individual may be chronically infected with norovirus.

What is the cost effectiveness of using different types of testing for screening/diagnosing norovirus infection?

9.1: Wherever possible, use PCR (single or multiplex) for confirmation of presence or absence of norovirus infection.

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9.2: Do not use enzyme or immunochromatography assays as a sole negative test to exclude cases of norovirus.

GPP 9.1: Consider using enzyme or immunochromatography assay testing if PCR is not readily available, and where these assays may provide a more rapid confirmation of positivity.

What is the best method for storing and transport of specimens intended for norovirus screening/diagnosis?

10.1: No recommendation.

GPP 10.1: Use faecal samples when sending specimens for norovirus testing.

GPP 10.2: If there is an expected delay in transport or processing of the specimens intended for norovirus testing, store the faecal samples at $\leq 4^{\circ}C$.

What are the alternatives to faecal (stool) sampling for screening/diagnosing norovirus infection?

11.1: Use faeces to test.

GPP 11.1: Use a rectal swab or vomit sample if it is not possible to use faeces, but be aware that detection of norovirus from this specimen type is less sensitive than from a faecal sample.

What is the clinical and cost effectiveness of closing and cohorting in the areas/facilities affected by norovirus?

12.1: Undertake clinical risk assessments regularly with regards to consideration of rapid closure of an affected area(s) during a norovirus outbreak.

What is the effectiveness of restricting staff and visitor access in the areas affected by norovirus?

13.1: No recommendation.

GPP 13.1: Undertake a risk assessment and consider whether staff and visitor restrictions are necessary in particular outbreaks or settings.

GPP 13.2: Consider communication with visitors before restrictions are introduced.

GPP 13.3: When visitor restrictions are not in place, communicate with visitors about the control measures that the visitors are expected to follow (e.g. hand hygiene policies, use of PPE, etc.).

GPP 13.4: When visitor restrictions are in place, consider alternatives for the patients to maintain contact with their family and friends (e.g. by providing facilities for virtual/no contact visits).

What is the effectiveness of a hand gel in comparison with handwashing in removing norovirus from contaminated hands?

14.1: During norovirus outbreaks, encourage all individuals to perform hand hygiene as per defined technique using soap and water.

14.2: Consider monitoring whether appropriate handwashing takes place.

GPP 14.1: Encourage the use of appropriate handwashing technique with the World Health Organization's Five Moments of Hand Hygiene.

GPP 14.2: Support patients with appropriate hand hygiene. Consider the use of a suitable hand hygiene alternative (e.g. detergent hand wipes) when it is not feasible for patients to use soap and water.

GPP 14.3: Provide appropriate information to educate staff, patients and visitors that the use of soap and water is more effective than alcohol hand rub in preventing norovirus transmission.

GPP 14.4: Ensure suitable facilities are provided to enable appropriate hand hygiene. Consider using hand wipes and portable handwash stations where fixed sinks are not available.

What is the effectiveness of different types of personal protective equipment in preventing norovirus transmission?

15.1: Use gloves and aprons when caring for symptomatic patients with norovirus.

GPP 15.1: Consider using type IIR fluid-resistant surgical mask/eye protection when there is a risk of splashes of bodily fluids to the face.

What is the value of performing environmental sampling in the management of norovirus outbreaks?

16.1: Do not screen the environment routinely for norovirus, neither during outbreaks nor in non-outbreak situations.

GPP 16.1: Consider environmental sampling for norovirus to inform IPC measures during prolonged, unusual or uncontrolled outbreaks.

What are the most effective cleaning agents and technologies for reducing contamination of the environment and minimizing the transmission of norovirus?

17.1: Ensure that appropriate cleaning, including the removal of organic soiling, precedes disinfection.

17.2: Ensure that all staff involved in environmental cleaning are trained to achieve appropriate cleaning standards.

GPP 17.1: Use 0.1% (1000 ppm) hypochlorite for disinfection of all appropriate surfaces during norovirus outbreaks.

GPP 17.2: Consider using automated room decontamination devices for norovirus outbreaks when, despite the standard IPC measures being in place, there is evidence of ongoing transmission from the environment.

GPP 17.3: Avoid soft furnishings and use wipeable materials that are non-permeable and easy to decontaminate (e.g. vinyl).

How should terminal cleaning be conducted?

18.1: Conduct terminal cleaning as per local policy.

GPP 18.1: For occupied single rooms, delay terminal cleaning until at least 48 h after the patient's symptoms of norovirus have resolved. Consult the IPC team to establish if there is a need for this period to be extended.

GPP 18.2: For occupied, shared patient areas or multi-occupancy rooms, undertake terminal cleaning a minimum of 72 h after symptoms in the last case of norovirus have resolved.

How should the cleaning equipment be handled after being used in areas affected by norovirus?

19.1: Ensure that appropriate decontamination is performed on any re-usable cleaning equipment following the cleaning of contaminated areas.

GPP 19.1: Provide training to staff to ensure that an appropriate sequence of cleaning takes place, and that the equipment is changed when required.

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What is the clinical and cost effectiveness of enhanced routine cleaning during a norovirus outbreak?

20.1: No recommendation.

GPP 20.1: Introduce a higher frequency of manual cleaning and disinfection during outbreaks, with particular emphasis on high-touch areas and toilets/commodes.

GPP 20.2: Clean up spills of blood or body fluids immediately.

How should food and drinks be stored and handled in areas affected by norovirus?

21.1: No recommendation.

GPP 21.1: To reduce potential transmission, offer food which is covered, individually wrapped, or placed in closed drawers/cupboards.

GPP 21.2: Remove all exposed and communal food and utensils.

GPP 21.3: In addition to regular replacement and disinfection of crockery/glasses/utensils, replace all drinks and drinking vessels which have been exposed to contamination (i.e. uncontained vomiting and diarrhoea) immediately.

GPP 21.4: Ensure that appropriate support is offered to maintain nutrition and hydration status.

How should communal items/equipment be handled in areas affected by norovirus?

22.1: No recommendation.

GPP 22.1: Ensure that any shared (communal) re-usable items are decontaminated as per manufacturers' instructions and local policy.

GPP 22.3: Where manufacturers' instructions do not provide sufficient detail on equipment decontamination, use local guidelines or contact the infection control team for advice.

GPP 22.4: Ensure that appropriate decontamination notification/certification is addressed where equipment requires transfer for maintenance.

GPP 22.5: Be aware that disinfectants may cause damage to some equipment, and ensure this issue is addressed in local cleaning guidelines.

GPP 22.6: For equipment that is not readily decontaminated, provide single-use items which can be removed easily, discarded and replaced.

GPP 22.7: To ensure that shared items are decontaminated easily, perform a risk assessment at the time of procurement.

How should used and/or infectious linen be handled to avoid norovirus transmission?

23.1: No recommendation.

GPP 23.1: Ensure that all laundry is handled and segregated according to national guidance.

What is the clinical and cost effectiveness of excluding staff affected by norovirus from work? When should these staff be allowed to return to work and how should their return be managed to ensure patient safety?

24.1: Consider excluding symptomatic staff with norovirus infection for a minimum of 48 h after symptom resolution.

GPP 24.1: In outbreaks where staff exclusion policy is not feasible (i.e. when it is not possible to replace skilled members of staff), conduct a local risk assessment that takes into account skills and staffing levels before allowing staff to return within 48 h of symptomatic norovirus infection.

What approaches to the management of transfer of individuals infected with norovirus are most practical and effective at minimizing the risk to others?

25.1: Avoid transfers to/from affected areas during norovirus outbreaks. This includes transfers within and between facilities.

GPP 25.1: Use a local risk assessment to determine whether the transfer of the individual is clinically necessary.

GPP 25.2: Where a transfer is clinically necessary, inform the receiving institution/department that the patient is infected with norovirus so that appropriate precautions can be taken.

GPP 25.3: Where transfer is necessary, and where appropriate (e.g. for urgent radiology), consider placing patients last on the list in order to minimize opportunities to transmit norovirus to others.

GPP 25.4: Ensure that appropriate cleaning takes place post transfer.

When should a patient affected by norovirus be discharged home or to another facility?

26.1: No recommendation.

GPP 26.1: If a patient is medically stable (fit), discharge them home only when there is no clinically vulnerable person in the same household.

GPP 26.2: Unless the individual risk assessment dictates otherwise, avoid discharging individuals with known or suspected norovirus infection to another facility until 48 h have elapsed since the last episode of diarrhoea or vomiting.

GPP 26.3: If the patient with norovirus infection is discharged to another facility sooner than 48 h after symptoms cease, inform the receiving facilities so that appropriate arrangements can be made.

GPP 26.4: If receiving discharged patients with confirmed or suspected norovirus infection from other facilities, ensure that appropriate arrangements are in place so that norovirus is not transmitted to others (e.g. isolation is recommended for at least 24 h for asymptomatic/suspected patients and 48 h after the symptoms have resolved for infected/confirmed patients).

What is the clinical effectiveness of different medications given to alleviate the symptoms of norovirus infection?

27.1: No recommendation.

GPP 27.1: Consider appropriate treatment for secondary conditions (e.g. rehydration therapy for individuals at risk of dehydration).

What are the best strategies for preventing and managing norovirus infection in immunocompromised patients? How should patients with chronic norovirus excretion be managed?

28.1: No recommendation.

What is the clinical effectiveness of conducting norovirus surveillance in different settings?

29.1: Introduce surveillance for symptoms/cases during a norovirus outbreak.

GPP 29.1: If initiating surveillance for norovirus is considered outside outbreaks, ensure that appropriate resources are available to put in place.

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GPP 29.2: Participate in national surveillance programmes for norovirus outbreaks.

Overarching recommendations

OR 1: During norovirus outbreaks, undertake continuous risk assessment to establish which good practice points need to be introduced to minimize transmission.

OR 2: Provide staff with sufficient information and training so they are able to recognize and act quickly when a norovirus outbreak occurs.

Plain English summary

Norovirus remains the most common gastrointestinal disease. Epidemics in hospitals and other settings are still being reported, and they are calculated to cost the UK NHS approximately £100 million every year. Previous UK guidelines were published over 10 years ago [1], and new knowledge and technologies have since appeared. These updated guidelines, which are now National Institute for Health and Care Excellence (NICE) accredited, focus on IPC principles that aim to reduce the norovirus burden in healthcare settings, while maintaining essential services and minimizing disruptions during the outbreaks. The guidelines discuss the currently available evidence to prevent and control outbreaks, and how infected people need to be managed. A glossary is available in the online supplementary material (Part A).

Introduction

Noroviruses are an important and increasingly recognized cause of acute gastroenteritis in human populations worldwide. A genus within the Caliciviridae family, noroviruses represent a genetically diverse group of single-stranded RNA viruses. Norwalk-like virus (NLV), the prototype norovirus, was first identified following an outbreak of gastroenteritis at a primary school in Norwalk, Ohio, USA in 1972 [2]. Noroviruses affect all age groups and are recognized to cause both outbreak-associated gastroenteritis, which typically occurs in semi-enclosed settings and may be healthcare associated (e.g. on a hospital ward) or non-healthcare associated (e.g. on a cruise ship); and sporadic cases of gastroenteritis in the general community. Noroviruses are classified using genetic analysis due to the lack of a robust culture system, and are divided into 10 distinct genogroups (GI—GX), with genogroups GI, GII and GIV most implicated as causing gastroenteritis in humans [3]. Genogroups are further divided into genotypes and variants (subtypes) based on genomic sequence diversity. The majority of newly emerging variants associated with outbreaks are genogroup II genotype 4 (GII.4) noroviruses [4]. These variants are typically named using the geographic location where the strain was first isolated and the year in which they were detected (e.g. GII.4 Sydney 2012).

Human-to-human transmission occurs via the faecal/vomitus oral route, with contaminated fomites, food and water playing important roles. Following an average incubation period of 24 h, acute-onset gastroenteritis with vomiting and/or non-bloody diarrhoea typically lasts 24—48 h [5], but illness may be more prolonged and severe in young infants and hospitalized patients [6]. Healthcare-associated infection typically occurs in semi-enclosed settings that allow for rapid transmission, including hospital wards, nursing/residential homes and day care centres. Immunity following norovirus infection is short-lived, and there are currently no effective licensed vaccines. There are no effective medical treatments other than supportive care with oral or intravenous rehydration, replacement of lost electrolytes and nutrition.

The incidence of norovirus in the UK has been estimated at 3 million cases annually [7], and the impact and control of norovirus gastroenteritis is associated with significant costs to global healthcare systems. Annually, direct costs from norovirus to the NHS in England have been estimated at £107.6 million [8]. These guidelines provide an update to the previous guidelines [1] published in 2012 for the management of norovirus outbreaks in acute and community health and social care settings.

Guideline development team

Relationship of authors with sponsor

HIS commissioned the authors to undertake this Working Party Report. The authors are members of the participating societies mentioned in Section Acknowledgements.

Responsibility for guidelines

The views expressed in this publication are those of the authors. They have been endorsed by HIS, IPS and BIA, and approved following a consultation with external stakeholders (see online supplementary material, Part C).

Working Party Report

What is the Working Party Report?

This Working Party Report contains recommendations which aim to minimize the risk of norovirus transmission in health and care settings. The Working Party recommendations represent examples of good practice; they have been developed systematically through a multi-professional group based on published evidence and professional experience. These recommendations may be used in the development of local protocols for all health, care and social settings. It is also recognized that some other closed and semi-closed settings may benefit from these guidelines.

Why do we need a Working Party Report for this topic?

The previous guidelines relating to this topic were published in 2012 [1]. During this time, there have been some improvements in how norovirus is handled in different settings, and some technologies (i.e. molecular testing and some disinfection devices) have become more available. Additionally, there is now more evidence that immunocompromised and immunosuppressed individuals may suffer from chronic infections and may require different management. These guidelines fill a clinical gap by providing up-to-date recommendations on what actions need to be taken by health and care facilities to minimize the risk of norovirus transmission and prevent the outbreaks.

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What is the purpose of the Working Party Report's recommendations?

The main purpose of these guidelines is to inform IPC practitioners about the current UK policy and best available options for preventing and controlling norovirus outbreaks in health, care and social settings. These guidelines also highlight current gaps in knowledge, which will help to direct future areas of research.

What is the scope of the guidelines?

These guidelines were developed with hospitals and other closed and semi-closed facilities in the health, care and social settings, including, but not limited to, hospices, nursing homes and residential homes. The guidelines are suitable for patients of all age groups. While the focus of these guidelines is health and care facilities, the Working Party acknowledge that some of these recommendations may also be relevant in other institutions such as prisons or day care centres.

What is the evidence for these guidelines?

Topics for these guidelines were derived from stakeholder meetings and were designed in accordance with the Population Intervention Comparison Outcomes framework (Appendix 1, see online supplementary material). In the preparation of these recommendations, systematic searches and systematic reviews of published literature were undertaken. Evidence was assessed for methodological quality and clinical applicability according to NICE protocols [9].

Who developed these guidelines?

The Working Party included academic and medical experts, virologists and microbiologists, clinical scientists, infection control practitioners, systematic reviewers and two lay member representatives.

Who are these guidelines for?

Any healthcare practitioner can use these guidelines and adapt them for local use. Users should include clinical medical, nursing and estates staff. Healthcare IPC teams should use these guidelines to develop local policies and to aid their decision-making process during norovirus outbreaks. The available reported studies were predominantly conducted in hospital and nursing home settings. The Working Party believes that while many sections of these guidelines are particularly relevant to these facilities, some evidence and recommendations can be extrapolated to other institutions [e.g. sections on environment and equipment decontamination, use of personal protective equipment (PPE), and options for management of infected individuals].

How are the guidelines structured?

Each section comprises an introduction, a summary of evidence with levels (known as evidence statements), a summary of the Working Party's discussions, and the recommendations graded according to the available evidence.

How frequently are the guidelines reviewed and updated?

The guidelines will be reviewed at least every 4 years and updated if change(s) are necessary, or if evidence emerges that requires a change in practice.

Aim

The primary aim of these guidelines is to provide advice on all aspects relating to the IPC of norovirus. The secondary aim is to identify the areas in need of further research to inform future norovirus guidelines.

Implementation of these guidelines

How can these guidelines be used to improve clinical effectiveness?

The guidelines can be used to inform local protocols for preventing norovirus transmission and managing patients infected with norovirus. They also provide a framework for clinical audit and quality improvement initiatives. In addition, future research priorities identified by these guidelines will allow researchers to refine their applications to funding bodies.

How much will implementation of these guidelines cost?

It is anticipated that cost would be incurred by any facility affected by norovirus outbreaks; thus, the recommendations set in these guidelines aim to reduce the impact of these outbreaks by minimizing the number of individuals affected and reducing the duration of the outbreaks. The Working Party believes that, while additional cost would be incurred during an outbreak, failure to implement the recommendations early would result in greater cost both in terms of economics and quality of life. For the topics where recommendations aim to prevent the outbreaks from occurring, there is no anticipated additional cost unless existing practice falls below the currently accepted standard.

Summary of the audit measures

Regular audit remains an important part of any guideline implementation. Audit is effective only when the results are fed back to staff and when there is a clear plan for their implementation. Many organizations have already developed their local policies and audit measures, which may need to be updated following the publication of these new guidelines. The Working Party suggests that the following aspects should be audited:

- Compliance with informing IPC team promptly if an outbreak is suspected.
- Compliance with the introduced control measures (e.g. transmission-based precautions, handwashing, appropriate

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use of PPE, appropriate environmental cleaning, decontamination of equipment, compliance with guidelines for appropriate laundry handling).
- Compliance with informing the receiving unit/facility and the ambulance/transport service that a patient is confirmed/suspected to be infected with norovirus.
- Compliance with case surveillance during the outbreak.

Supplementary tools

Lay materials and continuing professional development questions are available in the

online supplementary material (Parts D and E).

Methodology

Evidence search and appraisal

The topics for these guidelines were derived from the initial discussions of the Working Party during the stakeholder meeting. To prepare these recommendations, the Working Party collectively reviewed relevant evidence from published peer-reviewed literature. Methods were followed in accordance with the NICE manual for conducting evidence syntheses [9].

Data sources and search strategy

Three electronic databases (Medline, Embase, EMCare) were searched for articles published until January 2022. Additionally, the Food Science and Technology Abstracts database was searched until February 2021, but as it revealed no additional evidence, the searches were not updated to 2022. Search terms were constructed using relevant MeSH and free-text terms (Appendix 1, see online supplementary material). Reference lists of identified articles were scanned for additional studies, and forward reference searching (identifying articles which cite relevant articles) was performed. The searches were restricted to primary articles published in the English language.

Study eligibility and selection criteria

The search results were downloaded to an Endnote database and screened for relevance. One of two reviewers (AB, GM) reviewed the titles, abstracts and full-text papers. As per NICE methodology, the second reviewer checked 5% of the excluded studies for discrepancies. If discrepancies were found, the second reviewer checked all excluded records. Any discrepancies were addressed by a third reviewer (PC). The guidelines included any controlled trials, cohort studies, interrupted time series (ITS) studies, case—control studies, cross-sectional studies, diagnostic accuracy studies (DAS) and controlled/uncontrolled before/after (CBA/UBA) studies. Due to the limited evidence available, outbreak studies were included. For data on the efficacy of disinfecting and sanitizing agents, laboratory studies were also included. For the question about environmental sampling, environmental surveys were used. Where evidence was lacking, excluded studies which provided additional information were also described in some sections, with the limitations of using this information clearly highlighted. The results of study selection and the list of excluded studies are available in Appendix 2 (see online supplementary material).

Data extraction and quality assessment

Included epidemiological studies were appraised for quality using checklists recommended in the NICE guideline development manual [9]. The quality checklists included:

- Randomized controlled trials (RCTs): RoB_2.0 for RCT
- Non-RCTs: ROBINS for non-RCTs and cohort studies
- Cohort studies: ROBINS for non-RCTs and cohort studies
- ITS studies: EPOC RoB for ITS and before/after studies
- Case—control studies: CASP for case—control studies
- Cross-sectional studies: JBI checklist for analytical cross-sectional studies
- UBA studies: EPOC RoB for ITS and before/after studies
- DAS: QUADAS-2 for diagnostic accuracy studies
- Outbreak studies, case series and case studies: Institute of Health Economics checklist for case series.

Environmental surveys and laboratory studies were not appraised for quality as no checklists exist for these types of studies. Critical appraisal and data extraction were conducted by one reviewer and checked by another reviewer. The results of quality appraisal are available in Appendix 3 (see online supplementary material).

Data were extracted by one reviewer and checked/corrected by another reviewer. For each question cluster, the data from the included studies were extracted to create the study description, data extraction and summary of findings tables (Appendix 4, see online supplementary material). The list of the studies rejected at full-text stage, with a reason for this decision, is included in the excluded studies table (Appendix 2b, see online supplementary material). Due to limited evidence, most of the data were described narratively. Meta-analyses were only possible for DAS.

Rating of evidence and recommendations

The strength of the evidence was defined by GRADE (Grading of Recommendations Assessment, Development and Evaluation) tables (Appendix 5, see online supplementary material) and using the ratings 'high', 'moderate', 'low' and 'very low' to construct the evidence statements, which reflected the Working Party's confidence in the evidence. The strength of recommendation was adopted from GRADE and reflects the strength of each evidence statement. In instances where no evidence was identified from searches, the statement 'No evidence was found in studies published so far' indicates that no studies have assessed this as an outcome. Where there was no evidence or a paucity of evidence, expert-based recommendations were made by expert experience. All disagreements were resolved by discussions

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and voting by members of the Working Party during the meetings.

When writing the recommendations, the Working Party considered the following:

- Who should act on these recommendations?
- What are the potential harms and benefits of the intervention and any unintended consequences?
- What is the efficacy and the effectiveness of each intervention?
- Is it possible to stop another intervention because it has been superseded by the new recommendation?
- What is the potential effect on health inequalities?
- What is the cost effectiveness of the intervention, including staff resources and other economic concerns?
- Can the recommended interventions be feasibly put into practice?

The wording of the evidence statements and the recommendations reflected the strength of the evidence and its classification. The following criteria were used:

- 'Offer', 'measure', 'advise', 'refer', 'use' or similar wording was used if the Working Party believed that most practitioners/commissioners/service users would choose an intervention if they were presented with the same evidence: this usually means that the benefits outweigh harms, and that the intervention is cost effective. This reflects a strong recommendation for the intervention. If there was a legal duty, or if not following a recommendation may have serious consequences, the word 'must' was used.
- 'Do not offer' or similar wording was used if the Working Party believed that harms outweighed the benefits or if an intervention was not likely to be cost effective. This reflected a strong recommendation against the intervention. If there was a legal duty, or if not following a recommendation may have serious consequences, the words 'must not' were used.
- 'Consider' was used if the Working Party believed that the evidence did not support a strong recommendation, but that the intervention may have been beneficial in some circumstances. This reflected a conditional recommendation for the intervention.
- The 'do not offer, unless…' or similar recommendation was made if the Working Party believed that the evidence did not support a strong recommendation, and that the intervention was not likely to be beneficial, but could be used in some circumstances, for instance if no other options were available. This reflected a conditional recommendation against the intervention.
- Good practice points were made when there was no evidence to support the recommendation, but the Working Party considered that the intervention was essential or beneficial to good clinical practice.

Consultation process

Feedback on draft guidelines was received from the participating organizations and through consultation with relevant stakeholders. The draft report and standard comments form were placed on the HIS website for 4 weeks. The availability of the draft was advertised via e-mail and social media. Stakeholders were invited to comment on format, content, local applicability, patient acceptability and recommendations. The Working Party reviewed stakeholder comments, and agreed revisions collectively (see online supplementary material, Part C). All reviews received from individuals with a conflict of interest or those who did not provide a declaration were excluded.

Rationale for recommendations

What is the role of building design in the occurrence of norovirus outbreaks?

There are inherent properties in building, ward and room design which can either have a primary effect on transmission or a secondary effect by modifying behaviour. Ensuring a layout with appropriate ventilation and minimizing horizontal surfaces are thought to decrease transmission. In addition, using materials which are easy to clean, and installing no-touch devices for operating doors or lights may help to reduce environmental transmission. Both the number of handwash stations and their positioning encourages appropriate hand hygiene. Hospital design should include sufficient side rooms with en-suite bathrooms for suspected and confirmed infectious cases. These are recommended not only in ward settings but also in assessment areas such as accident and emergency (A&E) departments and medical assessment units. In a ward setting, an assessment about the needs of the population being cared for is needed to help determine the correct ratio of side rooms. This would allow for balancing the benefits of side rooms (infection control) against the harms of individual rooms (increased risk of falls, unmet social need in long-stay patients). Flexibility in design, both on the ward/unit and at hospital level, may be important so that the institutions have the ability to adjust side room capacity depending on need at the time. It is generally accepted that multi-occupancy rooms carry a higher risk of transmission between the occupants. Previous UK guidelines [1] recommended that every opportunity should be taken within plans for new builds and refurbishment/renovation to maximize the ability to control outbreaks, and these should include adequate provision of single-occupancy rooms and bays with doors. However, this recommendation was not based on the published evidence which explored whether and how the building design contributes to the initiation and progression of norovirus outbreaks, and whether adapting the building design could help to prevent or control outbreaks.

There was moderate evidence of risk associated with multi-occupancy rooms from one prospective cohort study [10], one UBA study [11], one case-control study [12], one cross-sectional study [13] and one outbreak study [14]. All studies reported that multi-occupancy rooms were associated with increased risk of norovirus transmission. One study [10], which conducted surveillance in six hospitals in one NHS trust over a 3-month period during the norovirus season, reported that

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from a total of 20 outbreaks in the season, the majority [N=16 (80%), affecting a total of 44 patients] occurred in a hospital with Nightingale-style wards which only had 7% single-occupancy beds. This was also the only hospital which reported that staff were affected by norovirus. Of these 16 outbreaks, four (25%) were contained within one bay, 11 (69%) affected an entire ward, and one (6%) affected multiple wards. In contrast, the hospital with the highest number of single beds (46%) experienced two outbreaks (two patients in each), which were contained within the same bay. There were two additional outbreaks in two other hospitals (number of single beds not reported) which affected three and six patients, and there were two hospitals (number of single beds not reported) which did not experience any norovirus outbreaks during the 3-month study period. It is noteworthy that the data from laboratory testing showed that sporadic cases of norovirus were present in all hospitals throughout the study period. The authors concluded that outbreaks are more likely to occur, and are more difficult to control, in Nightingale-style wards. Another study [12] compared the data for risk factors from index cases who started an outbreak to sporadic cases who did not infect others. The study was conducted during three norovirus winter seasons in hospitals. The authors reported that the number of patients in the room was the most prominent factor for outbreak occurrence, and that in the multi-variate analysis, the presence of each additional patient was associated with increased risk of outbreak occurrence [odds ratio (OR) 1.9, 95% confidence interval (CI) 1.3–2.6; P<0.01]. A similar study [13], which was undertaken in hospitals over five norovirus seasons, reported that being cared for in a double room was not associated with increased risk of norovirus infection (OR 1.69, 95% CI 0.99–2.9; P=0.06). However, being in the same room with a roommate who had ongoing norovirus symptoms, or whose symptoms had resolved less than 48 h previously, was associated with increased risk. In the multi-variate analysis which was adjusted for age, colonization pressure and care in multi-occupancy rooms, having a roommate with norovirus symptoms was the only factor significantly associated with increased risk of infection (OR 25.2, 95% CI 7.8–81.6; P<0.01). The authors also mentioned that the risk of infection increased with exposure time (data not reported). One UBA study [11] did not report data on norovirus infections, but mentioned that single-occupancy rooms were beneficial because they resulted in fewer ward closures (one in year 1 and four in year two after moving to a building with more single beds vs 21, 34 and 13 in the 3 years preceding the move) and fewer beds lost due to norovirus outbreaks (57 vs 172 beds lost per 100,000 bed-days, respectively). Finally, one study [14], which reported an outbreak involving 173 cases, lasting 54 days in multiple wards in one hospital and costing £341,534, concluded that a Nightingale-style ward was one of the reasons why the outbreak continued and was difficult to control. This style of ward made some interventions ineffective and required specialist recommendations (e.g. ward closures were not effective, and entire floor closures were required as the wards shared some facilities such as kitchen, dining areas, toilets and hand-washing stations). The authors also reported that barrier nursing in Nightingale-style wards was difficult, and that isolation or cohorting by bay was not always possible. It was also reported that reducing bed capacity to increase the space between beds was one of the successful interventions which eventually led to outbreak resolution.

There was weak evidence of benefit from one UBA study [15] which assessed the effectiveness of installing bay doors in hospital wards. This was a quality improvement project which aimed to reduce the effect of the outbreaks. The authors reported that a number of different interventions were introduced, and the installation of the bay doors was the most important improvement. They stated that windows were also installed, so the patients could be seen from the nursing station, and their care was not compromised as a result of this conversion. Other interventions included more support from the IPC team, staff and patient cohorting (as opposed to staff restrictions and ward closures previously), and improved communication. The authors reported that the relative change in the ratio of confirmed hospital outbreaks to community outbreaks per month was 0.317 (95% CI 0.129–0.778; P=0.025) in the year after improvements took place compared with a year before the improvements. The median number of patients and staff affected remained the same (ratio of expected counts 1.080, 95% CI 0.85–1.370; P=0.517 for patients; 0.651, 95% CI 0.386–1.096; P=0.105 for staff), and the decreased incidence of outbreaks resulted in a decreased number of days of restricted admission (ratio of expected counts 0.742, 95% CI 0.558–0.987; P=0.041) and a decreased number of bed-days lost (ratio of expected counts 0.344, 95% CI 0.189–0.628; P=0.001).

There was weak evidence of benefit from one case–control study reported in two articles [16,17] which assessed the effect of partitions between beds on the risk of norovirus outbreaks in care homes for older people. The authors reported that the presence of partitions between beds was the only significant protective factor in a multi-variate analysis [relative risk (RR) 0.6, 95% CI 0.4–0.8; P=0.002].

The Working Party discussed the above evidence and concluded that particular hospital/unit layouts play a role in norovirus outbreak prevention or control. However, there is currently insufficient evidence to recommend particular designs or justify that any changes to current layouts should be made. It may be good practice to include as many single rooms as feasible if new buildings are built, but there is no evidence that the current building designs should be adapted to include more single rooms. Thus, the Working Party refrained from making any recommendations about the building design. There is some evidence that installing partitions and/or doors at the bay entry may provide some benefit. The Working Party also discussed a potential role of flexible designs which could be adapted to the future needs of the facility or the ward/unit. All members agreed that individual institutions should perform a risk assessment and, where feasible, consider making some changes to mitigate the risk of norovirus transmission between patients.

Recommendations

1.1: No recommendation.

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Good practice points

GPP 1.1: Perform risk assessment of the ward/unit 'hierarchy of controls' to establish the risk of norovirus transmission between patients.

GPP 1.2: Where risk of transmission is high, consider making small changes to the ward/unit layout (e.g. installing partitions, bay doors or including flexible designs). However, consider and risk assess any potential adverse effects of doing this (e.g. on ventilation systems).

GPP 1.3: Assess individual risk of norovirus infection to the patient and consider additional control measures for patients at the highest risk (i.e. those who are immunocompromised).

What is the clinical and cost effectiveness of preparing for a norovirus outbreak?

All services registered under the Health and Social Care Act 2008 are expected to have a policy for the control of outbreaks of communicable infections (governed in England by the Care Quality Commission). These are often developed through the IPC team. Outbreaks of norovirus can disrupt delivery of services to patients considerably. Closure of hospitals and care/nursing homes can have an indirect effect on other facilities. Thus, all facilities need to ensure minimal disruption to services by developing plans for use in outbreak situations. However, it is not clear what these plans should include, and how they impact on outbreak progression. Previous guidelines [1] stated that organizations must develop systematic business continuity plans for use in outbreak situations, and that the plans should include actions for safe environments, staffing, information, surveillance, communications and leadership, although none of these recommendations were supported by relevant evidence from published literature.

There was weak evidence of benefit from one UBA study [18] and one outbreak report [19] which assessed the effectiveness of preparedness for norovirus outbreaks on outbreak occurrence and the incidence of norovirus infection. One study [18] used a Plan—Do—Study—Act cycle model for introducing nationwide activities before the outbreaks occurred, based on the evaluation of experience of norovirus outbreaks from a previous winter season. The 'Plan' phase included recommended actions that hospitals could undertake before and during the norovirus season, a norovirus season start alert, a norovirus outbreak tracker, assistance with media messaging, and specific guidance on escalation plans. The 'Do' phase involved the hospitals introducing these interventions within their settings. The 'Study' phase was monitoring of the norovirus outbreaks during the winter season, and the 'Act' phase was learning from the results and subsequent planning for the next season (data for the next season not reported). In total, 15 NHS boards from Scotland participated in the study. The authors reported that the number of wards closed due to norovirus outbreaks (a proxy measure for number of outbreaks) reduced from 759 in the year before the intervention to 307 in the year when preparedness was introduced. It was also reported that there were 15 sudden peaks in ward closures before the intervention and only six after the intervention at the peak of the norovirus season, and 53 wards were closed before the intervention and 25 wards were closed after the intervention. The authors also reported that preparedness enabled the hospitals to introduce the control measures early, and, in some instances, these measures were in place before the outbreak was confirmed. Another study [19] reported two outbreaks which occurred in a geriatric rehabilitation hospital within 18 months of each other. The authors reported that both outbreaks were contained within one ward, but that the first outbreak involved more cases (41 vs 24 in the second outbreak). It was reported that due to previous experience and preparation, staff were able to act once they recognized a third case of norovirus, and were able to implement some control measures before an IPC nurse was informed. While the duration and number of patients affected were comparable in both outbreaks (16 vs 13 patients and 14 vs 16 days in the first and second outbreaks, respectively), the number of staff affected by the outbreak was reduced (21 vs 11 in the first and second outbreaks, respectively), and the ward reopened earlier after the second outbreak (data not reported) which resulted in less disruption to hospital activities for staff and patients.

No studies were found in the existing literature that assessed the cost of preparing for norovirus outbreak in any setting.

There was weak evidence of benefit from one UBA study [18] which assessed the effect of preparedness for norovirus outbreaks in the healthcare setting on staff experience. The authors mentioned that all IPC teams participating in the study reported a positive experience during the season when preparedness was in place, and this was not limited to the reduced number of outbreaks. The IPC teams believed that with preparation, staff attitudes towards norovirus changed and there was better co-operation between IPC teams and ward managers during the outbreaks. The authors also reported that IPC teams commented on a previous season (data collected before the introduction of interventions) and all teams reported only negative experiences.

No studies were found in the existing literature that assessed the effect of preparing for norovirus outbreak on patient experience.

In light of the low quality of evidence, the Working Party was unable to make any recommendations about preparation for norovirus outbreaks. However, the Working Party felt that, wherever possible, planning ahead for potential norovirus outbreaks was to be encouraged. To the extent that this is feasible, IPC teams should plan ahead and prepare with health and social care teams for potential norovirus outbreaks. Preparation may include reminders about the periods of heightened incidence, providing training and education so that staff are able to recognize potential outbreaks in a timely manner, and having plans in place for prompt communication with IPC teams and an introduction of initial control measures.

Recommendations

2.1: No recommendation.

Good practice points

GPP 2.1: Wherever possible, prepare staff for potential norovirus outbreaks by providing reminders, guidance, training and education so that staff are able to act quickly.

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What is the clinical and cost effectiveness of avoiding admission/ incarceration (in prisons) of individuals who are suspected or confirmed to be infected by norovirus?

An increase of cases of norovirus in institutions usually reflects increased incidence of these infections in the community. Therefore, by minimizing the number of individuals being admitted, it may be possible to minimize secondary infection clusters in different institutions. Admission avoidance (also known as 'hospital at home'), where active treatment is provided by healthcare professionals in the patient's home, may be a suitable alternative. This usually comprises treatment for a condition that otherwise would require acute hospital inpatient care. Different models of care currently exist in the UK, some of which do not require initial assessment in secondary care. These services often have the ability to perform hospital-level diagnostic tests (e.g. point-of-care blood and molecular testing) and provide interventions such as treatment with intravenous fluids. Previous guidelines [1] recommended that the admission of unnecessary cases should be avoided and that, whenever possible, patients should be cared for at home. They also recommended that rapid risk assessment of an infected individual should be undertaken by a competent doctor to ensure patient safety is not compromised. Little is currently known about whether this strategy is clinically and cost effective, specifically whether it helps to prevent outbreaks of norovirus in institutions while still providing adequate care for infected individuals.

No studies were found in the existing literature that assessed the clinical benefit of avoiding admission or incarceration of individuals who are suspected or confirmed to be infected with norovirus in any setting.

No studies were found in the existing literature that assessed the cost benefit of avoiding admission or incarceration of individuals who are suspected or confirmed to be infected with norovirus in any setting.

No studies were found in the existing literature that assessed the effect of avoiding admission or incarceration of individuals who are suspected or confirmed to be infected with norovirus on patient satisfaction in any setting.

There was very weak evidence of risk from two outbreak studies [14,20] which reported the effect of allowing patients suspected or confirmed to be infected with norovirus to be admitted into hospital. One of these studies [14] reported a prolonged outbreak which affected a total of 173 individuals and lasted 54 days. The authors reported that one of the reasons for the prolonged duration of the outbreak was the continuous admission of new cases from the community with a known ongoing epidemic of norovirus, which infected other individuals in hospital. The second study [20] reported an outbreak in hospital which occurred after the admission of some symptomatic cases from a nursing home. The authors reported that the index case illness was initially mistakenly assumed to be due to foodborne salmonella, and this resulted in the hospital admitting patients without appropriate precautions. Subsequently, as a result of an outbreak in hospital, 28 cases became ill over the course of 18 days. The authors also mentioned that the outbreak in the nursing home met the Kaplan criteria, which would have helped in implementing the interventions earlier, and their report illustrates how admitting symptomatic cases with no IPC measures leads to outbreaks in hospitals.

The Working Party has reviewed the above evidence and concluded that admitting patients suspected or confirmed to be infected with norovirus could put staff and other patients at risk of acquiring the infection. However, there is currently very limited evidence that suggests that avoiding admission is beneficial. It is possible that taking other IPC measures, such as prompt isolation and precautions, for infected individuals could be equally effective. The Working Party discussed the potential implications of avoiding admission to a healthcare setting, especially potential complications and the risk to the affected individuals, and they concluded that the decision whether to admit the patient should be made on an individual basis (i.e. whether there is a risk that a patient infected with norovirus could suffer negative events when not admitted).

Recommendations

3.1: No recommendation.

Good practice points

GPP 3.1: Where feasible, avoid admitting patients with suspected/confirmed norovirus and offer suitable supportive treatment (e.g. rehydration therapy) in the community.

When should the beginning and the end of the outbreak be declared?

Declaration of an outbreak requires careful balancing. On one hand, prompt declaration and an introduction of appropriate measures may help facilities to contain the outbreak quickly. On the other hand, this declaration can have a reputational and financial impact, and may lead to unnecessary service disruptions. Previous guidelines [1] acknowledged that declaring an outbreak is needed but did not provide clear recommendations when this should occur. The guidelines also stated that outbreaks may not necessarily need laboratory confirmation, and the occurrence of multiple cases may not necessarily warrant the declaration of an outbreak. Additionally, the guidelines asserted that the outbreak declaration 'can be tailored to suit the prevailing circumstances'. This, however, may be confusing for individual facilities, and clarity is needed regarding the definition of an outbreak and when an outbreak should be considered. This is especially important when IPC specialists are not readily available (e.g. in community settings). For these settings, a period of increased incidence rather than an outbreak can be declared, but there still needs to be a clear definition when this action should be triggered. Historically, Kaplan's criteria [see Glossary (Part A of online supplementary material) for definition] were applied to declare a norovirus outbreak, although with molecular testing, which provides more rapid confirmation, these criteria may now have less clinical value. There also needs to be a clear recommendation for when an outbreak could be declared over. This also needs to be balanced carefully so that patient services can recommence but without the risk of the outbreak recurring.

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When should the beginning of the outbreak be declared?

There was weak evidence from one cross-sectional study [21] which evaluated the effect of recognizing a norovirus outbreak and introducing interventions early. The study evaluated outbreaks which occurred in nursing homes during the norovirus season prospectively. The authors reported that in outbreaks in which control measures were in place within 3 days, there were significantly lower attack rates for staff (20% vs 33.4%; P=0.019) but no observed benefit for residents (35.9% vs 39.5%; P=NS), and early control measures did not influence the duration of the outbreaks (15.9 vs 18.5 days; P=NS).

There was inconsistent evidence from outbreak studies [19,20,22–40] which reported different triggers for recognizing outbreaks in healthcare settings. Fourteen studies [19,22–34] reported that an outbreak was recognized when an increase in cases of gastroenteritis was observed, and the control measures were introduced before norovirus was confirmed as an aetiological agent. The duration of the outbreak before it was recognized varied from 0 days (day 1) to 6 weeks. These outbreaks affected between three and 355 cases (median 51 cases) and lasted between 5 days and 2 months (median 18 days). The study which reported that it took 6 weeks to recognize the outbreak [34] reported the highest number of cases and the longest duration. The outbreak which was recognized on the first day [28] involved three cases and lasted 7 days. One study [35] reported that the outbreak was declared as soon as the first person (who was also later confirmed to be an index case) became ill with symptoms of gastroenteritis (day 1). This outbreak still affected a total of 60 cases and lasted 22 days. Two studies [36,37] reported that an outbreak was recognized when laboratory results confirmed norovirus as an infectious agent causing gastroenteritis in patients (days 5 [36] and 2 [37]). These outbreaks were reported to affect 28 [36] and 14 [37] cases, lasting 8 [36] and 14 [37] days. One study [38] reported that the outbreak was recognized when cases of gastroenteritis occurred on more than one ward (day 2), eventually affecting 42 cases and lasting 17 days. Two studies [20,39] reported that they recognized the outbreak after they became aware that the cases fit the Kaplan criteria for viral gastroenteritis (days 2 [39] and 7 [20]). These studies were reported to affect 95 [39] and 24/28 (nursing home/hospital) [20] cases (in this study, the outbreak was reported to spread from a nursing home to a local hospital), and lasted 22 [39] and 9/18 (nursing home/hospital) days [20]. Lastly, only one study [40] reported that the institution failed to recognize an outbreak until the second wave of cases occurred (day 17). This outbreak affected 101 cases and lasted 44 days. None of the studies assessed the cost or patient/staff experience.

There was weak evidence from outbreak studies [41–48] which reported different triggers for recognizing outbreaks outside healthcare settings. Seven studies [41–47] reported that an outbreak was recognized when an increase in cases of gastroenteritis was observed, and the control measures were introduced before norovirus was confirmed as an aetiological agent. The duration of the outbreak before it was recognized varied between 1 (day 2) and 5 days (day 6). These outbreaks affected between 15 and 427 cases (median 158 cases) and lasted between 5 and 22 days (median 13.5 days). One study [40] reported that the outbreak was recognized when surveillance identified a large number of cases of gastroenteritis and triggered an alert. This outbreak affected 156 cases and lasted 17 days. None of the studies assessed the cost or patient/staff experience.

There was additional evidence from excluded studies which retrospectively evaluated the utility of clinical symptoms [49,50] or diagnostic tests [51–54] for the detection of norovirus outbreaks. One study [49] reported that, in comparison with polymerase chain reaction (PCR) testing, Kaplan's criteria were 63.9% sensitive and 100% specific in distinguishing confirmed norovirus outbreaks from non-viral outbreaks. However, they also reported that only 3.3% of norovirus outbreak reports and 1.2% of non-viral outbreak reports provided sufficient clinical information for Kaplan's criteria to be applied. Newly developed CART (classification and regression tree) modelling which assessed the proportion of cases with bloody stools, the proportion of cases with diarrhoea, the proportion of cases with fever, the proportion of cases with vomiting, the fever-to-vomiting ratio and the diarrhoea-to-vomiting ratio was 85.7% sensitive and 92.4% specific. It was also reported that 24.9% of norovirus outbreaks and 20.6% of non-viral outbreaks had sufficient data to apply the CART characteristics. Another study [50] reported that Kaplan's criteria were the most useful clinical criteria with sensitivity and specificity of 68% and 99%, respectively. They reported that the fever-to-vomiting and the diarrhoea-to-vomiting ratios were more sensitive but less specific, and therefore have less utility in recognizing norovirus outbreaks. However, it needs to be noted that both studies based their conclusions on published reports of resolved outbreaks, and it is not possible to determine whether these criteria would be sufficiently sensitive to recognize the outbreak early when only a small number of cases are affected. Four studies used PCR and enzyme immunoassays (EIA) to evaluate their ability to identify norovirus outbreaks. The study used two different EIA kits and assessed them for their utility to identify norovirus outbreaks. Two studies [51,54] concluded that EIA is less sensitive than PCR, and while the kits have some value in recognizing the outbreaks early, any gastroenteritis outbreak which tested negative by EIA should still be investigated by PCR for confirmation. Another study [52] reported that obtaining at least one norovirus-positive sample by either EIA or PCR from a total of two to four submitted samples was sufficient to establish norovirus as a cause of an outbreak. However, they also reported that, in order to avoid false-negative results for an outbreak affecting under 10% of patients, at least three samples need to be submitted for testing with PCR and at least six samples for testing with EIA. The last study [53] reported that if all outbreak specimens contained norovirus, there would be over 99% likelihood of identifying norovirus as a causative agent when at least three specimens are sent for testing with PCR and EIA. They also reported that testing more than five true-negative samples may result in false-positive results.

When should the end of the outbreak be declared?

There was moderate evidence from 11 outbreak studies [22,25,28,30–32,34,36,38,39,55] which reported different triggers for declaring the end of outbreaks in healthcare settings. Three studies [25,28,33] declared the end of an outbreak

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5 days after the last case was identified, one study [30] 5 days after the last symptoms occurred, one study [39] 72 h after the last symptoms occurred, one study [38] 2 days after the last symptoms occurred, one study [22] 24 h after the last case was identified, three studies [34,36,55] on the day the last case was identified, and one study [31] when the number of cases started to decrease. None of the studies reported a second wave or any cases occurring after the outbreak was declared over, except in one outbreak [25] where three new cases were identified which were transferred from elsewhere and represented a re-introduction rather than a continuing outbreak. None of the studies assessed the cost or patient/staff experience.

There was inconsistent evidence from three outbreak studies [41,47,48] which reported different triggers for declaring the end of outbreaks in healthcare settings. One study [48] reported that the end of the outbreak was declared a day after the last case was identified, and two studies [41,47] reported that the end of the outbreak was declared on the last day that cases were identified. None of the studies reported a second wave or any cases occurring after the outbreak, and none of the studies assessed the cost or patient/staff experience.

Upon a review of the above evidence, the Working Party concluded that they have no reason to disagree with the currently agreed definition of a confirmed outbreak. It may be prudent to apply the guideline recommendations earlier, when there is a suspicion that there may be an outbreak. An outbreak may be confirmed following the diagnosis of norovirus using molecular methods. The Working Party agreed that Kaplan's criteria are less relevant as molecular testing would confirm the outbreak sooner. However, Kaplan's criteria may still be useful for retrospective diagnosis in settings where molecular testing is not readily available. The Working Party noted that there is no agreed definition of declaring an end to a norovirus outbreak, but there is moderate evidence that a variable period of up to 5 days is adequate. Pragmatically, the Working Party recommends that an outbreak can be declared over after 72 h following uncontained diarrhoea or vomiting, but that a local risk assessment may be used to declare an earlier end point if vomiting and diarrhoea has been contained, or if the clinical risk of closure is greater than the risk of remaining open (e.g. critical care, renal dialysis, neonatal, coronary care). The reasoning behind the 72-h period considers an incubation period, which is usually approximately 24 h, and the shedding of infectious virus, which occurs for approximately 48 h for most individuals. Thus, the period of 72 h should cover most cases where symptomatic and asymptomatic individuals shed an infectious virus.

Recommendations

4.1: No recommendation.

Good practice points

GPP 4.1: If an outbreak is suspected, consider introducing control measures (including transmission-based precautions) before laboratory results are available.

GPP 4.2: If a sporadic case of norovirus is identified, consider introducing control measures (including transmission-based precautions) to prevent an outbreak (for the next 72 h).

GPP 4.3: Whenever possible, maintain the control measures in place for 72 h after the last episode of vomiting or diarrhoea in the last known case before declaring the end of an outbreak.

What is the effective communication at the start of an outbreak?

Effective communication can mean different things to different people; therefore, by stating and recommending to whom and what to communicate could alter the course of the outbreak, potentially preventing further cases and shortening its duration. Consideration of what to communicate may depend on the role that individual has within the management of the outbreak. For example, bed managers or discharge coordinators may need different information than the Director of Public Health or Director of Adult Social Services. The start of an outbreak could mean that independent organizations may be required to inform regulatory bodies, which could lead to further independent investigations. Clear and precise communication may also be beneficial for friends and families whose loved ones are affected by the outbreak, as they may have concerns regarding their rehabilitation or deterioration. Previous guidelines [1] did not make any specific recommendations about the communication at the start of an outbreak, but they did acknowledge that IPC teams should inform the managerial team of the facilities affected, as well as the local health protection organizations, and when the outbreak was declared. They also stated that control measures should be introduced at the same time. It is, however, not clear whether this action is necessary, especially if control measures have been put in place.

There was moderate evidence from 12 studies [19,22,23,26–30,32,38,55,56] describing a total of 13 outbreaks, all in hospital settings, which stated that the outbreak was reported to a hospital IPC/epidemiology team. These outbreaks affected between three and 355 cases (median 25 cases), lasting from 5 days to more than 2 months (median 14 days). None of the studies specifically mentioned that reporting to the hospital team was beneficial for outbreak management; however, in all except one study, it was evident that the IPC/epidemiology team was responsible for outbreak investigation and providing advice about the control measures that needed to be implemented. Only in one outbreak [19] was it reported that some (but not all) control measures were introduced before the hospital team was informed. Following the introduction of control measures, the outbreaks affected a further one to 51 cases (median eight cases, based on nine studies [19,22,23,28–30,32,55,56] reporting 10 outbreaks), lasting from 2 to 16 days (median 6 days, based on 10 studies [19,22,23,28–30,32,38,55,56] reporting 11 outbreaks). None of these studies reported cost or patient/staff experience.

There was moderate evidence from 14 studies [19,20,24–26,31,33–36,39,40,57,58] describing a total of 15 outbreaks, occurring in hospitals [19,20,25,26,31,36], nursing homes [20,34,58] or long-term care facilities (LTCFs) [24,33,35,39,40,57], which stated that the outbreak was reported to the local public health unit. Two of these studies [19,26] mentioned that this was done in addition to reporting to their own hospital

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IPC team. These outbreaks affected between 10 and 355 cases (median 74 cases), lasting from 8 days to more than 2 months (median 22 days). None of the studies specifically mentioned that reporting to the local public health unit was beneficial for the outbreak management; however, the unit was responsible for outbreak management in all except two studies. One of these studies [26] mentioned that interventions were introduced as recommended by the hospital IPC team but the outbreak continued, which prompted the hospital to report the outbreak to the local authorities. The other study [19] reported that assistance from the local health authority was needed for the first outbreak, but during the second outbreak, the recommendations from the IPC nurse in hospital were sufficient. There was also one study which mentioned that the local public health unit erroneously classified an outbreak as a foodborne outbreak due to salmonella, which delayed the introduction of interventions necessary for controlling a norovirus outbreak and resulted in the outbreak spreading to the local hospital. The authors reported that norovirus was recognized by the local authorities only when laboratory results became available, which was 1 day after the nurse in the nursing home realized that the outbreak fit the Kaplan criteria for viral aetiology and introduced appropriate control measures. Following introduction of the interventions, the outbreaks lasted from 3 to 59 days (median 14 days, based on 12 studies [19,20,24,25,33–36,39,57,58] reporting 13 outbreaks) and affected a further four to 98 cases (median 29 cases, based on 11 studies [19,20,25,33–36,39,57,58] reporting 12 outbreaks). In addition to reporting to the local health authority, one study [34] mentioned that they reported an outbreak, which occurred in a nursing home, to the emergency department in a local hospital to prevent transmission in the new setting. The authors reported that only one staff member became ill as a result of this communication. One study [20] also mentioned that the above-mentioned outbreak, which was mistaken for salmonella, was reported to the national department of health. This, however, was to report an incident and not to seek advice in order to prevent further cases. None of these studies reported cost or patient/staff experience.

There was weak evidence from eight studies [41–47,59] describing outbreaks occurring outside healthcare settings which were reported to the local public health unit. These outbreaks affected between 15 and 427 cases (median 137 cases) and lasted from 5 to 22 days (median 14 days, based on six studies [41,43–47]). Only one study, which occurred on a cruise ship [45], specifically stated that reporting to and co-operation with the local health authorities was beneficial in controlling an outbreak, although in the other seven outbreaks, the local authorities were responsible for investigations and introducing outbreak control measures. Following the implementation of recommended interventions, the studies reported that a further three to 137 cases were affected (median 28 cases, based on four studies [41,43–45]), lasting a further 1–15 days (median 7 days, based on five studies [41,43–46]). None of these studies reported cost or patient/staff experience.

There was very weak evidence from one study [48] describing an outbreak occurring outside the healthcare setting (military base) which was reported to the organization's outbreak investigation team. This outbreak was reported to affect 156 cases and lasted 17 days. The authors did not specifically mention that the involvement of the outbreak investigation team was beneficial, but the team was responsible for investigating the source of an outbreak and introducing the interventions. It was reported that following an introduction of control measures, the outbreak lasted for a further 12 days, but the incidence of infection decreased, with a further 68 cases affected. The study did not report the cost or patient/staff experience.

Upon reviewing the above evidence, the Working Party concluded that prompt communication to the IPC team may be beneficial for the facility in controlling an outbreak. However, current literature did not address other means of communication which could prevent norovirus being spread to other facilities. The Working Party concluded that there is a need for all facilities to communicate the outbreaks in the local area. Prompt communication between community and acute settings may prevent outbreaks from occurring in other institutions. Any suspected or confirmed norovirus cases, even if sporadic, need to be communicated to local A&E departments and/or assessment units so that appropriate action can be taken before these persons are admitted for treatment.

Recommendations

5.1: Communicate with the IPC team, patients and their family as soon as a norovirus outbreak is suspected or confirmed.

Good practice points

GPP 5.1: Seek support from the local IPC team about the management of sporadic (suspected and confirmed) norovirus cases.

GPP 5.2: Inform all local facilities of any outbreaks occurring in your area i.e. if they occur in the community and vice versa.

What is the clinical and cost effectiveness of testing all patients with vomiting and/or diarrhoea at admission?

Admission testing of all patients with symptoms of vomiting and/or diarrhoea could be beneficial, as this would assist in the detection of norovirus or other diagnosis. Early detection of norovirus would trigger early commencement of treatment for the patient, and could also prevent the spread of the virus by supporting the decision to isolate known or suspected cases. As a result, testing on admission could potentially reduce the economic burden by preventing outbreaks. Previous UK guidelines [1] recommended testing of patients admitted with diarrhoea and/or vomiting where alternative, non-infectious causes cannot be diagnosed confidently. However, it is currently not known whether this approach is clinically and cost effective for the institutions, and whether any benefits in terms of severity or duration of the illness are observed for the individuals.

Outbreak situations

There was very weak evidence from one outbreak study [14] which reported testing all symptomatic patients for norovirus before they were admitted to a ward. This was a prolonged outbreak which lasted 54 days and affected 173 patients and staff on multiple wards in the hospital. The authors attributed the prolonged duration to a few factors,

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including Nightingale-style wards and high transmissibility of the Sydney 2012 strain which caused 10 known relapses and the ongoing epidemic in the community. No clinical outcomes were reported in terms of clinical benefit of testing at admission, but the authors reported that approximately 25–30% of all norovirus cases were from the community, and that testing at admission was one of the interventions which worked well and helped staff to identify and isolate/cohort infected patients.

No studies were found in the existing literature that assessed the cost effectiveness of testing all patients with vomiting and/or diarrhoea at admission.

Non-outbreak situations

No studies were found in the existing literature that assessed the clinical or cost effectiveness of testing all patients with vomiting and/or diarrhoea at admission to prevent norovirus outbreaks.

There was additional evidence from two excluded studies [60,61]. The first [60] was a UBA study conducted in a hospital which introduced routine norovirus testing for any diarrhoetic faecal sample submitted to the laboratory. The study was excluded because it included patients who had diarrhoea at admission as well as those already admitted, and because other interventions were introduced at the same time (staff education and observing hand hygiene). The authors reported that eight patients developed healthcare-associated norovirus after the introduction of routine testing, compared with 11 patients before routine testing. However, the number of patients increased in hospital during the intervention, thus the incidence per 1000 patient-days decreased from 131 to 16 ($P<0.001$). In the second study [61], the authors retrospectively tested faecal samples which were previously submitted for bacteriological but not virological testing. The study identified 45 patients who had norovirus-positive faeces but were not diagnosed as infected. Twenty of these patients were reported to be hospitalized, 18 of whom were admitted. Norovirus strains from these 20 patients were genotyped and compared with the strains identified in hospital before the study was conducted. The authors reported that there were three previously recognized clusters of two patients each, but if the missed patients were included, one of these clusters would have increased by three patients and another cluster by one patient. It was also reported that one of these clusters would have been identified 4 days earlier. Additionally, there were a further three, previously unrecognized clusters of norovirus cases. Based on the onset of symptoms, the authors estimated that five of these six clusters were triggered by undiagnosed index cases.

The Working Party concluded that there is currently no evidence to support any recommendations about testing all symptomatic patients at admission. Early detection of affected individuals may prevent the outbreaks from occurring, and with the advancements in technology, the practice of testing for gastrointestinal pathogens has become increasingly common. Therefore, the Working Party agree that, wherever possible (i.e. where these facilities are available), all symptomatic cases should be tested for norovirus so that appropriate actions can be taken before patients are admitted.

Recommendations

6.1: No recommendation.

Good practice points

GPP 6.1: Wherever possible, test all symptomatic patients for norovirus at admission.

What is the clinical and cost effectiveness of testing all individuals who develop vomiting and/or diarrhoea?

As with admission testing, early identification of possible norovirus cases on a ward or a unit could prevent transmission to others. However, there may be clinical areas where patients develop symptoms compatible with norovirus infection which are a result of an underlying illness or are triggered by treatment (e.g. chemotherapy). Previous guidelines [1] recommended that all inpatients who developed diarrhoea should be tested, and this approach may help to identify or rule out an outbreak. The guidelines also stated that testing all patients should be stopped once the outbreak is identified and confirmed. It is currently not clear whether routine testing is clinically and cost effective, and whether it should be applied in both the outbreak and non-outbreak settings.

Outbreak situations

There was very weak evidence from one outbreak study [62] which reported testing all symptomatic patients during a norovirus outbreak in the hospital setting. This outbreak, which was recognized late (day 27), occurred in a paediatric haematology and oncology unit, affecting a total of 13 cases and lasting 38 days. The authors stated that all symptomatic patients were tested, and this included most of the patients on the unit (67/92, 75%) as these patients frequently experienced diarrhoea due to the treatment they received. The authors reported that in this population of patients with a high prevalence of diarrhoea, testing all symptomatic patients helped them to distinguish between infected and non-infected cases for isolation and cohorting.

There was very weak evidence from one outbreak study [48] which reported testing all symptomatic individuals during a norovirus outbreak outside a health and care setting. This outbreak occurred on a military base and affected 156 cases, lasting 17 days. As part of the control measures, all symptomatic individuals were tested for norovirus and were given medical leave until they recovered. The authors reported that these control measures, together with thorough disinfection upon confirmation of norovirus being isolated from faecal samples, were effective in controlling and eventually terminating the outbreak, which lasted for a further 12 days and affected 68 cases.

No studies were found in the existing literature that assessed the cost effectiveness of testing all patients who developed vomiting and/or diarrhoea in any setting.

Non-outbreak situations

No studies were found in the existing literature that assessed the clinical and cost effectiveness of testing all patients who developed vomiting and/or diarrhoea to prevent outbreaks and pseudo-outbreaks in any setting.

Despite the lack of strong evidence for the benefits, the Working Party felt that it is good practice, where resources allow, to test all symptomatic patients for norovirus infection.

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Testing may have benefits in both outbreak and non-outbreak situations. Testing all symptomatic individuals may help to define an outbreak or even prevent an outbreak from occurring if the initial cases are promptly identified and managed. During outbreaks, testing can help to identify positive cases so that the control measures (i.e. isolation or cohorting) can be applied. This may be particularly important in acute settings where some patient populations (i.e. patients cared for on gastrointestinal wards) may demonstrate symptoms compatible with norovirus infection.

Recommendations

7.1: No recommendation.

Good practice points

GPP 7.1: Wherever possible, test all symptomatic patients to establish whether their symptoms are due to norovirus infection.

What is the clinical and cost effectiveness of follow-up testing for norovirus?

Norovirus is usually self-limiting, and symptoms and the infectious period typically pass within 24—48 h. There may be some individuals who shed the virus for longer and therefore may potentially infect others even after 48 h. For this reason, follow-up testing may be performed to establish whether the individual is still infectious. At the moment, it is not clear whether this approach provides any clinical or cost benefits, and it is not known whether positivity after this period indicates the shedding of infectious viral particles. Previous guidelines [1] did not address this issue and did not make any recommendations regarding whether follow-up testing should be performed.

There was inconsistent evidence from three outbreak studies [25,37,56] which reported using follow-up testing to prevent the transmission of norovirus during outbreaks in healthcare settings. One of these studies [56], which did not report the number of cases infected or the duration of the outbreak, tested all patients frequently and mentioned that some of them were tested more than once. It was reported that, in some cases, the testing, which was undertaken using PCR, was performed up to 8 days after symptom onset and these patients still tested positive, which the authors believed represented non-infectious virus being excreted. They suggested that no follow-up testing should be in place. The possibility of chronic infection was not considered in this study. Another study [25], which affected 22 patients and lasted 24 days, tested all symptomatic patients twice a week until negative results were obtained. Follow-up testing was one of the control measures introduced to manage the outbreak, and it was reported that the control measures were effective, with only four further cases occurring over the next 19 days. However, whilst these cases occurred, they were transferred from another ward, which suggested re-introduction rather than continuation of an outbreak. The last study [37] reported an outbreak in a paediatric oncology unit which lasted 23 days and affected 14 patients. The authors reported that 25 staff also had compatible symptoms, although only one of them was tested for norovirus. As part of the control measures, follow-up testing was performed until patients received a negative result. The authors reported that only four cases (patients) occurred after control measures were introduced. They also stated that retesting might have been beneficial because seven patients tested positive for a prolonged period of time, with an index patient still excreting the virus 123 days after symptom onset. They also reported that three staff were likely infected from this patient 59 days after norovirus was first detected. There was also at least one more long-term shedder in this unit.

No studies were found in the existing literature that assessed the clinical effectiveness of follow-up testing to prevent transmission of norovirus during outbreaks outside health and care settings.

No studies were found in the existing literature that assessed the cost effectiveness of follow-up testing to prevent transmission of norovirus during outbreaks in any setting.

No studies were found in the existing literature that assessed the number of asymptomatic patients who still tested positive for norovirus at follow-up testing.

No studies were found in the existing literature that assessed the viral load of patients at follow-up testing.

The Working Party concluded that there is currently no evidence to support routine follow-up testing. Most infected cases experience spontaneous symptom resolution within a day or two, and the infectious period for most individuals does not last longer than 48 h after symptom resolution. There is a possibility that molecular testing could detect an inactive norovirus being shed after this period; therefore, follow-up testing is likely to yield false-positive results. Follow-up testing would therefore not be beneficial for most individuals infected by norovirus. The Working Party agreed that there may be circumstances when this may be beneficial (e.g. when chronic infection is suspected). The decision on whether follow-up testing would be beneficial to establish chronic infection needs to be made based on individual risk factors (e.g. immunocompromised patients), and the benefit that the knowledge of patient status would offer (e.g. risk of transmission to others).

Recommendations

8.1: No recommendation.

Good practice points

GPP 8.1: Do not offer routine follow-up testing for norovirus.

GPP 8.2: Consider follow-up testing if there is a suspicion that the individual may be chronically infected with norovirus.

What is the cost effectiveness of using different types of testing for screening/diagnosing norovirus infection?

There are several technologies available for screening and diagnosis of norovirus infection, which vary in sensitivity, specificity and cost. The most commonly available options for norovirus testing include molecular tests (nucleic acid amplification tests, such as PCR tests) or EIA. There are also

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multiplex platforms available which test for other pathogens causing infectious diarrhoea. The cost of testing comes not only from running the assays themselves but also for the time of laboratory technicians. Additionally, if not available on site, there may be additional costs for storage and transportation. Molecular assays are more expensive than EIAs; however, they usually offer greater diagnostic accuracy than EIAs. At the moment, it is not clear whether EIAs and other tests can be used reliably to detect norovirus infection, and whether they can offer any cost saving and whether this benefit outweighs the potential risk associated with obtaining false-negative results. Previous UK guidelines [1] mentioned PCR and EIA testing but did not make any specific recommendations about which should be used.

Enzyme immunoassays

There was moderate evidence from the meta-analysis of seven studies [63—69] and one additional study which did not provide data suitable for meta-analysis [70] which assessed the diagnostic accuracy of EIAs compared with PCR-based assays for testing patients with symptoms suggesting norovirus infection. Overall, meta-analysis showed that the sensitivity of these assays was poor, ranging from 0.26 (95% CI 0.10—0.48) in one study which used IDEIA NLV assay [63] to 0.90 (95% CI 0.83—0.95) in another study which used Denka EIA [70]. This was the only study which achieved sensitivity of 0.90 of more, which is generally accepted as an indicator of good diagnostic performance. Overall, specificity of these tests was acceptable, ranging from 0.94 (95% CI 0.89—0.97) in a study which used IDEIA NV [7] assay to 1.0 for three studies that used IDEIA NLV (95% CI 0.81—1.00) [63], an unspecified EIA assay (95% CI 0.92—1.00) [64] and IDEIA NVL (95% CI 0.75—1.00) [67]. The study which did not meet the criteria for the meta-analysis [70] (did not provide data on positive and negative values) reported similar poor sensitivities of two different assays that were used [0.77 for IDEIA NV and 0.59 Ridascreen (95% CI not reported)], and reported low specificities of these assays [0.86 for IDEIA NV and 0.73 for Ridascreen (95% CI not reported)]. Additional data important for diagnostic accuracy of these assays were reported by two studies [71,72] describing pseudo-outbreaks in neonatal intensive care units. Both studies reported a high rate of false-positive results [25/37 (68%) for an unspecified EIA [71] and 22/43 (51%) for IDEA NLV EIA [72]] when premature neonates with diarrhoea were tested for norovirus, with all PCR tests returning negative. The authors in both studies concluded that these assays may not be suitable for neonates, especially those born prematurely.

No studies were found in the existing literature that assessed the clinical or cost effectiveness of using EIAs compared with PCR-based tests for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the turnaround time for EIAs compared with PCR-based tests for testing patients with symptoms suggesting norovirus infection.

Immunochromatography assays

There was moderate evidence from a meta-analysis of 11 studies [65,68,69,73—80] and three additional studies which did not provide data suitable for meta-analysis [81—83] which assessed the diagnostic accuracy of immunochromatography assays (ICAs) compared with PCR-based assays for testing patients with symptoms suggesting norovirus infection. Overall, meta-analysis showed that the sensitivity of these assays was poor, with the lowest reported as 0.57 (95% CI 0.47—0.67] in one study which used RidaQuick Norovirus ICA assay [73]. Two studies reported a sensitivity of at least 0.90 with the use of Quick-Navi ICA (0.90, 95% CI 0.74—0.98) [79] and CerTest Norovirus ICA (1.00, 95% CI 0.69—1.00) [74], although the second study only used 24 samples of which 10 (42%) were positive. Overall, the specificity of these tests was acceptable (over 0.90); however, the two studies which reported high sensitivity were also the only two studies which reported specificity to be below 0.90 (0.43, 95% CI 0.30—0.56 for Quick-Navi ICA [79]; 0.86, 95% CI 0.57—0.98 for CerTest Norovirus ICA [74]). The studies which did not meet the criteria for the meta-analysis [81—83] (did not provide data on positive and negative values) reported poor sensitivity of two assays (0.11, 95% CI 0.29—0.31 for IP-Triple I ICA [81]; 0.28, 95% CI not reported for QuickNavi NV2 ICA [83]) and high sensitivity of Immunoprobe NoV ICA [82] for norovirus GI (0.99, 95% CI not reported) but not for GII (0.85, 95% CI not reported). Specificities of these assays were above 0.90 for all except for Immunoprobe NoV ICA [82] for detecting norovirus GII (0.87, 95% CI not reported). Additional information important for diagnostic accuracy of these assays was reported by one study [84] describing a pseudo-outbreak in a growing care unit for premature infants. The study reported that five babies with diarrhoea tested positive using Immuno-Probe Noro ICA (11/13 of samples), but none of these results were confirmed by PCR. The authors concluded that ICAs were not suitable for norovirus testing in premature infants.

No studies were found in the existing literature that assessed the clinical or cost effectiveness of using ICAs compared with PCR-based tests for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the turnaround time for ICAs compared with PCR-based tests for testing patients with symptoms suggesting norovirus infection.

Multiplex PCR assays

There was weak evidence from a meta-analysis of five studies [85—89] and one additional case series study which did not provide data suitable for meta-analysis [90] which assessed the diagnostic accuracy of multiplex PCR systems compared with single PCR-based assays for testing patients with symptoms suggesting norovirus infection. The studies used Luminex xMAP [86,87], Luminex xTAG [89,90], BD Max [88] or developed their own multiplex system [85]. Overall, meta-analysis showed that sensitivity was high, although two studies reported it to be below 0.90 {0.87, 95% CI 0.69—0.96 for Luminex xMAP [24]; 0.75, 95% CI 0.35—0.97 for the authors' own developed multiplex assay for GI [85] [although this was highly sensitive for GII (0.94, 95% CI 0.90—0.97) [85]]. Specificities of all assays were very high, reaching at least 0.99. The study which did not meet the criteria for the meta-analysis [90] (did not provide data on true-/false-positive and negative values) reported that more samples were identified to be positive for norovirus when a multiplex system was used (28/217, 12.9%) than with a single PCR assay (15/217, 6.9%). The authors reported that the reason that the multiplex system detected more pathogens was that, in some cases, standard PCR did not detect multiple infections, and in some cases, the diagnoses

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were missed because the physicians did not request the samples to be tested for certain micro-organisms.

No studies were found in the existing literature that assessed the clinical or cost effectiveness of using multiplex PCR systems compared with single PCR-based tests for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the turnaround time for multiplex PCR systems compared with single PCR-based tests for testing patients with symptoms suggesting norovirus infection.

Point-of-care testing PCR assays

There was weak evidence from one study [91] which assessed the diagnostic accuracy of point-of-care testing (POCT) PCR systems compared with laboratory-based PCR assays for testing patients with symptoms suggesting norovirus infection. The study used a Cepheid GeneXpert NV platform which was operated by nurses and healthcare assistants in hospital wards where samples were obtained. Compared with a standard PCR assay, sensitivity was 0.83 (95% CI 0.36—1.00) and specificity was 0.99 (95% CI 0.95—1.00). However, the authors reported that from a total of 225 samples, there were four errors, two 'no results' and 34 'not valid' results, which means that the test would need to be repeated on approximately 18% of occasions. The authors reported that the platform was well accepted by healthcare workers, with the majority agreeing that the test was easy to perform, gave faster results and improved bed management.

No studies were found in the existing literature that assessed the clinical or cost effectiveness of using POCT PCR systems compared with laboratory-based PCR assays for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the turnaround time for POCT PCR systems compared with laboratory-based PCR assays for testing patients with symptoms suggesting norovirus infection.

Scanning electron microscope

There was weak evidence from one outbreak study [56] which assessed the use of a scanning electron microscope (SEM) in comparison with PCR assays for detecting norovirus in symptomatic patients involved in a norovirus outbreak. The authors reported that of 12 samples sent to the laboratory for analysis, seven (58%) tested positive by PCR and only one sample, which was taken from a patient with confirmed norovirus infection, was positive by SEM. Additionally, the authors reported that, in one individual (staff member), PCR detected norovirus 2 days before they became symptomatic, which provided the opportunity to manage the person before they became ill. The authors concluded that SEM was not sufficiently sensitive for diagnosing norovirus infection during outbreaks.

Overall, the Working Party agreed that there was moderate evidence that PCR (single or multiplex) testing is more sensitive compared with other assays for detecting norovirus. The Working Party acknowledged that other assays may still provide some benefit in settings where PCR is not readily available (i.e. where specimens need to be sent out and there is an expected delay in confirmation). A positive EIA or ICA result may, in these situations, help with early identification of norovirus cases, as it is expected that the turnaround time for these assays may be significantly shorter. However, due to low sensitivity of these assays, the Working Party stressed that, where negative results are obtained, there is still a need to confirm the absence of norovirus by PCR testing. There remains a question which (if any) of these diagnostic methods provide any clinical or cost benefit in the management of patients with norovirus during outbreaks.

Recommendations

9.1: Wherever possible, use PCR (single or multiplex) for confirmation of presence or absence of norovirus infection.

9.2: Do not use enzyme or immunochromatography assays as a sole negative test to exclude cases of norovirus.

Good practice points

GPP 9.1: Consider using enzyme or immunochromatography assay testing if PCR is not readily available, and where these assays may provide a more rapid confirmation of positivity.

What is the best method for storing and transport of specimens intended for norovirus screening/diagnosis?

While it is desirable for samples to be transported and processed as soon as possible, this may not always be feasible. A delay in processing may reduce the sensitivity of testing, especially in situations when the viral load is low or when samples are not stored and transported appropriately. Thus, specific issues such as optimal transport time, container type, storage temperature and the type of testing which will be used need to be considered in order to optimize testing outcome. Previous UK guidelines [1] did not make any recommendations in relation to this topic.

There was weak evidence from two studies [92,93] which assessed the diagnostic accuracy of faecal samples which were stored and transported as swabs compared with the standard method for transporting faecal samples. In one study [92], faecal samples obtained from children with diarrhoea were placed on GenoTube Livestock flocked swabs and stored at ambient temperature for up to 1.5 years before being shipped and processed. The remaining faeces were stored at -80°C and shipped on dry ice. The authors reported that 60/239 (25.1%) swab samples were positive for norovirus, while 42/239 (17.6%) frozen faecal samples were positive, an agreement of 91.2%. The authors also reported that the median cycle threshold (Ct) values for positive PCR results were 25 for swabs and 24 for frozen faecal samples, which means that the number of viral copies did not decline during the time the swab samples were stored at ambient temperature. In the second study [93], faecal samples received in the laboratory for testing for gastrointestinal pathogens were placed on to the FecalSwab system containing a flocked swab and a 2-mL tube containing modified Cary—Blair medium. These were processed together with the remaining faeces sample using the FilmArray system. The study reported that 17/103 (16.5%) samples were positive for norovirus, and all were identified from the swab and the standard method with no discrepant results. Additionally, the authors reported that 25/103 samples, known to contain at least one gastrointestinal pathogen (five of which were positive for norovirus), were retested 24 h later to determine stability. Norovirus was still detected in all samples by both methods. Interestingly, one additional sample was identified as positive

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for norovirus by both methods after 24 h, and this positivity was confirmed as a true positive after testing the faeces by PCR. The authors concluded that the diagnostic accuracy of the swab system was comparable to that of the traditionally stored and transported faecal samples; however, the new system provides a more convenient way for transporting samples to a laboratory.

No studies were found in the existing literature that assessed the clinical or cost effectiveness of using the swab system compared with traditional methods for storing and transporting faecal samples for norovirus testing.

No studies were found in the existing literature that assessed the practicality of using the swab system compared with traditional methods for storing and transporting faecal samples for norovirus testing.

There was weak evidence from one study [92] which assessed the diagnostic accuracy of faecal samples which were stored and transported on Whatman FTA elute cards compared with the standard method for transporting faecal samples. In this study [92], faecal samples obtained from children with diarrhoea were placed on elute cards and stored at ambient temperature for up to 1.5 years before being shipped and processed. The remaining faeces were stored at -80°C and shipped on dry ice. The authors reported that 45/239 (18.8%) card samples were positive for norovirus, while 42/239 (17.6%) frozen faecal samples were positive, an agreement of 94.6%. The authors also reported that the median Ct values for positive PCR results were 29 for Whatman cards and 24 for frozen faecal samples.

No studies were found in the existing literature that assessed the clinical or cost effectiveness of using the elute card system compared with traditional methods for storing and transporting faecal samples for norovirus testing.

No studies were found in the existing literature that assessed the practicality of using the elute card system compared with traditional methods for storing and transporting faecal samples for norovirus testing.

There was additional evidence reported by an excluded study [94] (which used archived specimens) which retested 994 known norovirus-positive faecal specimens collected over a 20-year period and stored at 4°C. The study reported that the majority of the specimens (79%) still tested positive, but there was an estimated 1 $\log_{10}$ loss of viral titre per 7 years of sample storage. The authors concluded that faeces containing norovirus can be stored at this temperature for up to 10 years with only a minimal loss in PCR positivity, thus demonstrating that freezing samples may not be necessary to test faecal samples intended for confirmation of norovirus infection in patients.

The Working Party agreed that the standard methods, which involve sending whole faecal samples for norovirus testing, should be used whenever possible. Sending the entire specimen offers an additional opportunity for further testing (i.e. when norovirus is not detected and there is a need to test the specimen for other pathogens). There is a concern, although this has not yet been demonstrated by the evidence, that the diagnostic accuracy of faecal specimens may deteriorate after prolonged storage. Therefore, in addition to obtaining entire specimens, the Working Party recommend that these should be stored at 4°C or below if there is a delay. There was weak evidence that swab and elute card systems may be beneficial when used as an alternative to transport samples for norovirus testing, but further studies are needed before these can be recommended as routine practice.

Recommendations

10.1: No recommendation.

Good practice points

GPP 10.1: Use faecal samples when sending specimens for norovirus testing.

GPP 10.2: If there is an expected delay in transport or processing of the specimens intended for norovirus testing, store the faecal samples at 4°C or below.

What are the alternatives to faecal (stool) sampling for screening/diagnosing norovirus infection?

The optimal specimen for laboratory diagnosis of norovirus infection is a diarrheal faecal sample (i.e. a sample that takes the shape of the container). In some circumstances, this may be difficult to obtain (e.g. if a patient has a paralytic ileus). Waiting for a faecal sample may also cause time delays which have significant effects on subsequent patient management and infection prevention measures; for example, waiting for faeces to be produced and collected may delay sampling and miss a run at the laboratory. Vomitus or rectal swabs may be potential alternatives to faecal sampling; however, it is not clear whether these samples provide diagnostic accuracy which is similar to faecal samples. Rectal swabs are more prone to degradation compared with faeces, which may render testing less sensitive, and they may be less acceptable to the public. Previous UK guidelines [1] did not make any specific recommendations whether samples other than faeces could be used as alternatives.

Rectal swabs

There was moderate evidence from a meta-analysis of seven studies [95—101] which assessed the diagnostic accuracy of rectal swabs compared with faecal samples for testing patients with symptoms suggesting norovirus infection. All studies except one used flocked swabs for collecting samples [96—101], and the remaining study used a traditional polyester-tipped swab [95]. Overall, meta-analysis showed that sensitivity varied from 0.53 (95% CI 0.36—0.69) [100] to 1.00 (95% CI 0.92—1.00) [98], with only two studies reporting sensitivity over 0.90 [98,101]. All studies reported high specificity of the swabs, ranging from 0.91 (95% CI 0.82—0.96) [95] to 1.00 (95% CI 0.92—1.00) [98].

No studies were found in the existing literature that assessed the clinical or cost effectiveness of using rectal swabs compared with faecal samples for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the time until the sample was obtained using rectal swabs compared with faecal specimens for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the ease of obtaining a sample when using rectal swabs compared with faecal specimens for testing patients with symptoms suggesting norovirus infection.

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There was weak evidence from one study [98] which assessed the acceptability of obtaining rectal swabs. The study collected data from children's parents who rated the acceptability of rectal swabs using a five-point Likert scale, with answers ranging from acceptable to unacceptable. From 279 responses received, 266 (95%) parents reported that this method was acceptable, eight (3%) reported it was slightly acceptable, three (1%) reported it was neutral, and two (1%) reported that this method was unacceptable.

Vomit

There was weak evidence from one DAS [102] and one outbreak report [56] which assessed the diagnostic accuracy of vomit samples compared with faecal specimens for testing patients with symptoms suggesting norovirus infection. The DAS [102] reported that sensitivity was low (0.67, 95% CI 0.49—0.81) and specificity was high (0.96, 95% CI 0.89—0.99). The outbreak study [56] reported that vomit specimens were not sufficiently sensitive to detect norovirus, with only two of eight (25%) symptomatic cases testing positive for norovirus.

No studies were found in the existing literature that assessed the clinical or cost effectiveness of using vomit compared with faecal samples for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the time until the sample was obtained using vomit compared with faecal specimens for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the ease of obtaining a sample when using vomit compared with faecal specimens for testing patients with symptoms suggesting norovirus infection.

Saliva

There was weak evidence from one study [103] which assessed the diagnostic accuracy of saliva compared with faecal specimens for testing patients with symptoms suggesting norovirus infection. The study reported that sensitivity was only 0.12 (95% CI not reported) while specificity was high (0.95, 95% CI not reported). The authors reported that saliva positivity was not associated with any symptoms of norovirus infection, but was more likely to be positive for subjects who were aged 65 years or older.

No studies were found in the existing literature that assessed the clinical or cost effectiveness of using saliva compared with faecal samples for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the time until the sample was obtained using saliva compared with faecal specimens for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the ease of obtaining a sample when using saliva compared with faecal specimens for testing patients with symptoms suggesting norovirus infection.

Mouthwash

There was weak evidence from one study [104] which assessed the diagnostic accuracy of mouthwash specimens compared with faecal specimens for testing patients with symptoms suggesting norovirus infection. Mouthwash samples in this study were obtained by swirling 3 mL of sterile water within the oral cavity; the patients were known to have norovirus infection. The study reported that, of a total of 66 individuals who had their faecal samples tested, 59 were confirmed to be positive for norovirus. Of these 59 individuals, 14 (24%) also had positive mouthwash samples.

No studies were found in the existing literature that assessed the clinical or cost effectiveness of using mouthwash compared with faecal samples for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the time until the sample was obtained using mouthwash compared with faecal specimens for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the ease of obtaining a sample when using mouthwash compared with faecal specimens for testing patients with symptoms suggesting norovirus infection.

Serum

There was weak evidence from one study [105] which assessed the diagnostic accuracy of serum samples compared with faecal specimens for testing patients with symptoms suggesting norovirus infection. The study reported that sensitivity was low (0.20, 95% CI 0.13—0.29) and specificity was high (1.00, 95% CI 0.99—1.00).

No studies were found in the existing literature that assessed the clinical or cost effectiveness of using serum compared with faecal samples for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the time until the sample was obtained using serum compared with faecal specimens for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the ease of obtaining a sample when using serum compared with faecal specimens for testing patients with symptoms suggesting norovirus infection.

Throat

There was weak evidence from one outbreak study [56] which assessed the accuracy of using throat samples compared with faecal specimens for testing patients with symptoms suggesting norovirus infection. The study reported that these specimens were not sufficiently sensitive to use for testing, with only two of 16 symptomatic patients (1.5%) testing positive.

No studies were found in the existing literature that assessed the clinical or cost effectiveness of using throat compared with faecal samples for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the time until the sample was obtained using throat compared with faecal specimens for testing patients with symptoms suggesting norovirus infection.

No studies were found in the existing literature that assessed the ease of obtaining a sample when using throat compared with faecal specimens for testing patients with symptoms suggesting norovirus infection.

The Working Party concluded that the current evidence was weak, but it suggests that there is a limited benefit for using rectal swabs, vomit samples and other specimens as alternatives to faecal samples. These specimens appear to have

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inadequate sensitivity for the diagnosis of norovirus infection compared with faecal samples; therefore, a negative test does not guarantee the absence of infection. If alternative specimens are used, confirmation from a faecal sample would still be required to avoid false-negative results.

Recommendations

11.1: Use faeces to test.

Good practice points

GPP 11.1: Use a rectal swab or vomit sample if it is not possible to use faeces, but be aware that detection of norovirus from this specimen type is less sensitive than from a faecal sample.

What is the clinical and cost effectiveness of closing and cohorting in areas/facilities affected by norovirus?

It is generally accepted that, once a norovirus outbreak has been declared, affected areas (e.g. wards or bays) should be closed to admissions and transfers. This practice, which was recommended in previous UK guidelines [1], is employed widely, and it is argued that the earlier closure occurs the better in terms of limiting the overall size and duration of an outbreak. Closure involves restricting the movement of people (patients and staff), equipment and materials (e.g. patient notes) as far as is practicable. Keeping access to a closed area to a minimum should reduce the risk of virus transmission. Admissions to a closed area are limited to patients (with or without symptoms) who have known exposure to norovirus. Closure creates cohorts of patients and staff to limit exposure of non-affected areas to norovirus. It can be difficult to assess the clinical and cost effectiveness of closure and cohorting because they tend to be enacted as part of a bundle of measures to limit the spread of norovirus.

Effect of closure

There was moderate evidence from two UBA studies [15,106], one cross-sectional study [107] and 24 outbreak studies [14,19,22,23,25,28–32,34,38,40,56–58,108–115] which evaluated the effect of closure for controlling norovirus outbreaks in healthcare settings. One UBA study [106], which aimed to increase the number of bay closures in order to reduce the closure of entire wards in hospital, reported that, after an intervention, closing entire wards was necessary in 44/95 (54%) norovirus outbreaks compared with 36/40 (90%) outbreaks before the intervention (*P*-value not reported). This resulted in a reduction of the number of bed-days closed during the outbreak by half {median 96 [interquartile range (IQR) 28–175] after the intervention and 180 [IQR 102–259 before the intervention]; *P*-value not reported} without an impact on the number of cases affected [median number of patients per outbreak 14 (IQR 11–18) after the intervention and 17 (IQR 11–21) before the intervention; median number of staff two (IQR 1–4) after the intervention and two (IQR 0–5) before the intervention; *P*-values not reported]. A cross-sectional study [107] which assessed the characteristics of 3437 norovirus outbreaks occurring in hospitals reported a significant difference in the duration of outbreaks based on the timing of ward closures [median 7 days (IQR 4–10) for outbreaks when closures were introduced within 3 days, 9 days (IQR 7–12) for closures within 4–6 days, 14 days (IQR 11–18) for closures after 6 days, and 6 days (IQR 4–11) for outbreaks without ward closures; $P<0.001$]. The number of patients and staff affected was also significantly different [median 11 patients (IQR 7–15) for outbreaks when closures were introduced within 3 days, 12 patients (IQR 9–16) for closures within 4–6 days, 14.5 patients (IQR 10–18) for closures after 6 days, and seven patients (IQR 4–12) for outbreaks without ward closures; $P<0.001$; median two staff (IQR 0–5) for outbreaks when closures were introduced within 3 days, three staff (IQR 1–6) for closures within 4–6 days, two staff (IQR 1–5) for closures after 6 days, and one staff (IQR 0–3) for outbreaks without ward closures; $P<0.001$]. It is not possible to determine the cause and effect of closures in these outbreaks. It is therefore possible that the closures influenced the number of cases in these outbreaks, or that the number of cases influenced the decision as to whether or not closures were needed. Another UBA study [15], which aimed to reduce the number of ward closures, introduced enhanced environmental cleaning and disinfection, converted Nightingale-style wards into bays with doors, and introduced patient and staff cohorting during outbreaks. The study reported that the median number of bed-days lost per outbreak reduced significantly from 8 to 6 days (relative change 0.742; $P=0.041$) and the median number of days of restricted admissions to affected wards reduced from 29 to 5 days (relative change 0.344; $P<0.001$), while the mean number of patients and staff affected by the outbreaks remained the same (mean 10.75 vs 9.95 patients, $P=0.517$; mean 2.5 vs 3.84 staff, $P=0.105$). The authors concluded that ward closures were not always necessary, and that an introduction of other control measures could either prevent the closures or reduce the number of days for the wards to remain closed. The outbreak studies reported different approaches to closures, which included bay closures [108], closure of wards or units [14,19,22,23,25,28–32,34,38,40,56–58,108–114], or closure of the entire facility [31,115]. The study that used bay closures [108] reported that an outbreak, which lasted 42 days (number of cases not reported) was not controlled, and the number of cases only started to decline when phased ward cohorting was introduced. A total of 23 studies, describing 26 outbreaks, reported that wards and units were closed. These outbreaks affected three to 281 cases (median 42 cases, based on 22 studies reporting 25 outbreaks [14,19,22,23,25,28–32,34,38,40,56–58,109–114]), lasting from 3 to 54 days (median 16 days). Fourteen (54%) of these studies reported that ward/unit closures, together with other control measures, were beneficial in controlling the outbreaks. Following introduction of the interventions, the outbreaks affected a further one to 98 cases (median 21 cases, based on 13 studies reporting 14 outbreaks [19,22,23,25,28–32,34,56–58]) and lasted a further 2–19 days (median 10 days, based on 14 studies reporting 16 outbreaks [19,22,23,25,28–32,34,38,56–58]). Additionally, two studies [31,115] reported that the entire facility was closed during the outbreak. One of these studies [31] reported that ward closures, which were introduced as part of initial control measures, did not have an effect on the course of the outbreak. This was a large outbreak which affected 164 cases and lasted 18 days. The authors reported that the cases started to decline when the entire hospital was closed and other interventions were implemented,

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although it still affected a further 60 cases and lasted 11 days. Another study [115] reported a common source norovirus outbreak which affected 195 cases across four hospitals and three affiliated rehabilitation units, and lasted 12 days. The authors reported that closure of the entire facility for 10 days, together with other control measures, resulted in termination of the outbreak.

There was weak evidence from one cross-sectional study [116] and six outbreak studies [43,44,46,117,118] which evaluated the effect of closure for controlling norovirus outbreaks outside healthcare settings. The cross-sectional study [116], which investigated outbreaks in schools and 'elderly care facilities' (not specified), reported that median attack rates were significantly different when comparing outbreaks in which units were closed [1.7% (IQR 1.0–3.2)], entire facilities were closed [4.1% (IQR 2.7–5.9)] and when symptomatic cases were isolated [2.2% (IQR 1.2–3.8); P=0.006], although there was no difference in outbreak duration [median 5.0 days (IQR 3.0–7.0) for outbreaks in which units were closed, 5.0 days (IQR 3.5–13.5) when entire facilities were closed, and 3.0 days (IQR 2.0–10.0) when symptomatic cases were isolated; P=0.167]. The authors did not report how the decision to close was made. Five outbreak studies [43,44,46,117,118] reported closure of entire facilities to control an outbreak. These outbreaks affected between 77 and over 800 cases (median 158 cases) and lasted from 5 to 22 days (median 18 days). All five studies reported that closure, together with other control measures, resulted in outbreak resolution. After the closures, two studies reported that three [44] and five [43] further cases occurred, and three studies reported that the outbreak lasted for a further 1 [44], 2 [43] and 15 days [46] One study of an outbreak, which occurred in a senior residence community [119] and affected 307 cases over 7 weeks, reported that the management decided to close some facilities (e.g. a café and a shop) and to inform new residents of an outbreak so that they could decide whether they would delay their admission. The authors did not specifically report whether this approach was beneficial; however, they mentioned that, due to the nature of the community, many traditional control measures, including closures, were challenging to implement.

There was additional evidence from an excluded study [120] which reported the results of the surveillance of outbreaks in hospital wards undertaken over a 1-year period. It was reported that the wards closed to admissions for a period of 3–7 days during 24/54 (56%) outbreaks. The authors reported that the higher patient turnover resulted in a longer duration of the outbreaks. They illustrated this by reporting one outbreak in a geriatric care unit which was not terminated until the unit closed for 1 week.

Effect of cohorting

There was inconsistent evidence from one cross-sectional study [21] and 23 outbreak studies [14,22–26,28,29,31,36,40,50,55–57,62,109–111,113,121–123] which reported using cohorting to control norovirus outbreaks in healthcare settings. The cross-sectional study [21] reported no significant difference in the incidence of resident norovirus infections in nursing homes which used cohorting compared with those which did not (OR 0.66, 95% CI 0.40–1.09; P=NS). The outbreak studies used different approaches to cohorting. A total of 22 studies [14,22,23,25,26,28,29,31,36,40,50,55–57,62,109–111,113,121–123] described 27 outbreaks which affected between three and 355 cases (median 29 cases) and lasted 3 days to over 2 months (median 15 days, based on 21 studies reporting 26 outbreaks [14,22,23,25,26,29,31,36,40,50,55–57,62,109–111,121–123]). Of these studies, 14 (64%) found that patient cohorting was beneficial when introduced as part of the control measures. Following the introduction of control measures, the outbreaks affected a further one to 98 cases (median seven cases, based on 11 studies [22,23,25,28,29,31,36,55–57,62]) and lasted for a further 2–19 days (median 8 days, based on 12 studies [22,23,25,28,29,31,36,55–57,62,121]). Four studies described seven outbreaks in which patients were cohorted by ward [24,32,108,123]. These outbreaks affected between 13 and 145 cases (median 42 cases, based on three studies reporting six outbreaks [24,32,123]) and lasted 9–63 days (median 19 days). Three (75%) of these studies reported that cohorting by ward was beneficial. One of these studies [108] specifically stated that the previously introduced control measures, which included closure of bays and wards, had no effect on the course of the outbreak. The authors reported that they decided to introduce phased ward cohorting, following which the outbreak was controlled within 16 days. The one study which did not report a benefit of cohorting by ward [24] described a large outbreak which affected 146 cases and lasted 63 days. The authors reported that it was challenging due to staff and residents not complying with suggested interventions.

There was weak evidence from one outbreak study [124] which reported cohorting hotel guests. This was a large outbreak in a hotel which affected over 1000 cases and lasted over 26 weeks. The authors reported that the hotel ensured that, as part of the control measures, there was no contact between the groups of guest arriving and those leaving. It was reported that these interventions did not influence the outbreak.

The Working Party agreed that there is moderate evidence to support rapid closure of clinical areas affected by norovirus outbreaks, but there is little evidence for the benefit of cohorting within affected areas. The decision to close the clinical areas is difficult as this may not be required in all outbreaks, and there will be situations where closure may have a detrimental effect (clinical and financial). Thus, the Working Party recommends that the need for closure should be assessed regularly throughout the course of an outbreak, and the risk of doing so does not outweigh the benefits of closing. Some of the factors that need to be considered include the type of ward/area/facility, patient risk factors, design of facilities, availability of shared facilities, staffing levels, number of affected patients and other contextual circumstances.

Recommendations

12.1: Undertake clinical risk assessments regularly with regards to consideration of rapid closure of an affected area(s) during a norovirus outbreak.

Good practice points

None.

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What is the effectiveness of restricting staff and visitor access in areas affected by norovirus?

Temporarily restricting visiting is a recognized way of limiting the spread of norovirus. Visitors are thought to pose a risk of spreading norovirus and could potentially prolong an outbreak. There are hazards posed by visitors; for example, acquiring norovirus through community transmission, which they then bring into the care setting. There are also hazards posed to visitors who can be exposed to norovirus in the care setting and become infected, leading to more widespread contamination of the care environment by, for example, transferring virus to uncontaminated surfaces. Restricting visiting also allows staff to concentrate on patients without being distracted by the need to attend to visitors as well. It is considered good practice to allocate staff to duties in either affected or non-affected clinical areas but not both unless this is unavoidable (e.g. for therapists). This approach was recommended in previous UK guidelines [1]. Furthermore, it is currently recommended that the use of bank and agency staff in areas affected by a norovirus outbreak should be kept to a minimum. However, it is currently not clear whether any of these recommendations are supported by the current evidence.

There was inconsistent evidence from one cross-sectional study [21] and 11 outbreak studies reporting a total of 18 outbreaks [19,20,22,29–31,37,40,58,108,123] which assessed the effectiveness of staff restrictions on the incidence of norovirus infection in healthcare settings. The cross-sectional study [21] reported that restricting staff movement between units had no effect on the incidence of norovirus infection when comparing nursing homes which used this intervention with those which did not (OR 1.40, 95% CI 1.02–1.91 for residents; OR 0.67, 95% CI 0.45–1.00 for staff). The outbreak studies reported different approaches to staff restrictions which included staff being allowed to work on single units only [19,20,30,31,40,58,108], essential staff only allowed to work on outbreak units [20,22,29,37], special rotas which ensured that sufficient time elapsed between a shift on an outbreak unit before the same staff member worked on another unit [29], and allowing fewer staff to enter outbreak wards less frequently [123]. The reported outbreaks affected between 11 and 164 cases (median 30 cases) and lasted between 3 and 44 days (median 17 days). Of these 11 studies, eight (73%) [20,22,29,30,37,40,58,108] reported the benefit of introducing staff restrictions. From the studies which did not report a benefit, one study [19] compared two outbreaks which occurred close to each other and reported that initial interventions, which included staff restrictions, were less successful than additional measures which were introduced in a second outbreak (increased sick pay for staff, visitor restrictions and rapid cleaning/disinfection). One study [31] reported that further interventions needed to be introduced to contain the outbreak, and one study [123] did not mention whether staff restrictions together with other interventions had any effect on the course of an outbreak. Only one study specifically stated that staff restrictions may have prevented outbreaks in other units [30], but four studies [19,22,29,108] also reported that the outbreak was contained within one ward or unit. After the introduction of staff restrictions as part of outbreak control measures, there were a further two to 98 cases (median 24 cases, reported by eight studies [19,20,22,29,30,32,37,58]) and the outbreaks lasted for a further 2–16 days (median 10 days, reported by seven studies [19,20,22,29,30,32,37,58]).

No studies were found in the existing literature that assessed the effect of staff restrictions on the incidence of norovirus infection in non-healthcare settings.

No studies were found in the existing literature that assessed the effect of staff restrictions on cost during norovirus outbreaks in any setting.

No studies were found in the existing literature that assessed the effect of staff restrictions on staff and patient experience during norovirus outbreaks in any setting.

There was inconsistent evidence from one cross-sectional study [21] and 18 outbreak studies reporting a total of 24 outbreaks [14,15,19,22,25,29–31,34,36,37,40,55,57,108,121,123,125] which assessed the effectiveness of visitor restrictions on the incidence of norovirus infection in healthcare settings. The cross-sectional study [21] reported that the nursing homes which did not allow symptomatic visitors had a lower incidence of norovirus infections in residents than the nursing homes which did not introduce such restrictions [in multi-variate analysis, OR 0.52, 95% CI 0.37–0.73, although no benefit was seen for staff (OR 0.66, 95% CI 0.39–1.12)]. This study also reported that there seemed to be no benefit for the nursing homes which introduced policies where visitors were not allowed at all compared with those which did not (OR 1.45, 95% CI 1.02–2.07 for residents; OR 1.56, 95% CI 0.88–2.75 for staff). The outbreak studies reported different approaches to visitor restrictions which included no visitors being allowed to enter the affected units [15,25,31,34,36,37,57], allowing fewer visitors [14,19,22,29,30,40,108,121], screening the visitors and not allowing those who were symptomatic to enter [15,22,55], providing PPE for visitors [29,125], and mandatory hand cleaning with alcohol hand rub (AHR) upon entry [123]. The reported outbreaks affected between 10 and 355 cases (median 31 cases) and lasted between 3 days and over 2 months (median 16 days). Of these 18 studies, 14 (78%) [14,15,19,22,25,29,30,36,37,40,57,108,121,125] reported a benefit of introducing visitor restrictions. From the four studies which did not report a benefit, one study [31] mentioned that additional control measures needed to be introduced, two studies did not report whether these interventions had any influence on the course of the outbreaks [34,123], and one study reported that the control measures, including no entry for symptomatic visitors, eventually had a beneficial effect but that many of them were difficult to implement [55]. Two studies specifically stated that allowing fewer visitors, together with other control measures, prevented outbreaks in other units [30,36], and five studies [19,22,25,29,108] reported that the outbreak was contained within one ward or unit. After introducing control measures, which included visitor restrictions, there were a further three to 98 cases (median 21 cases, reported by 12 studies [19,22,25,29–31,34,36,37,55,57,121,123]), and the outbreaks lasted for a further 3–19 days (median 9 days, reported by 10 studies [19,22,25,29–31,36,55,121,123]). Additionally, one of the above studies [125] reported that visitor restrictions may not be needed as their data suggested that visitors wearing masks and gowns did not become infected, and the number of cases decreased soon after interventions were introduced.

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There was very weak evidence from one outbreak study [45] which reported the use of restricting guest entry during a norovirus outbreak outside the healthcare setting. This study reported an outbreak on a cruise ship which affected 196 cases and lasted 12 days. The authors reported that the initial interventions did not have an effect on the course of the outbreak, and that it was terminated only when all guests disembarked, the ship was disinfected and no guest entry was allowed for 24 h afterwards.

No studies were found in the existing literature that assessed the effect of staff restrictions on cost during norovirus outbreaks in any setting.

There was very weak evidence from one outbreak study [14] which reported the effect of not allowing visitors during a norovirus outbreak in a healthcare setting on patient and visitor experience. The authors reported that in order to balance the visiting restrictions, the hospital provided additional snacks for patients, laundered all personal clothing on site, and communicated with staff and visitors. As a result, no complaints were made, and no adverse events were reported. The authors reported that the hospital management considered this to be one of the interventions which were implemented successfully and were well accepted during the outbreak.

No studies were found in the existing literature that assessed the effect of visitor restrictions on staff and guest experience during norovirus outbreaks outside healthcare settings.

There was weak evidence from three outbreak studies which reported the effect of allowing staff to work in multiple institutions [126] or in more than one unit [30,114] during norovirus outbreaks in healthcare settings. One of these studies [126] reported on outbreaks that affected eight LTCFs. The outbreaks affected a total of 394 cases and lasted between 5 and 33 days [overall 47 days from the first case (Facility A) to the last case (Facility E)]. The authors reported that they found clear connections of staff working at multiple sites between all these facilities except one, and that some of these staff developed symptoms suggestive of norovirus infection. They concluded that these outbreaks were the result of staff working in multiple institutions. Another study [114] reported on an outbreak which occurred in four wards in a psychogeriatric hospital, affecting 97 patients and staff, and lasting 29 days. The authors reported that the epidemic curve suggested person-to-person spread, but there was no direct contact between patients and there were no transfers between different units. The authors concluded that the most plausible route of transmission was via staff who were working on multiple units. Similar conclusions were reached by another previously reported outbreak [30] which demonstrated that a nurse who worked in one area affected by norovirus became infected and returned to work in another unit 2 days later while symptomatic, subsequently transmitting the virus to others.

The Working Party agreed that there is currently insufficient evidence which justifies the recommendation of routine restrictions. The decision to restrict staff and visitors needs to be based on a risk assessment as to whether staff and visitor restrictions are required to limit transmission in particular outbreaks or settings. Consideration needs to be given to any potential negative effects of these restrictions (e.g. resultant staffing issues, service disruption, well-being of the patients). When the decision to restrict visitors is made, appropriate communication with all relevant stakeholders will be necessary and the units need to provide alternative means of contact between patients and relatives.

Recommendations

13.1: No recommendation.

Good practice points

GPP 13.1: Undertake a risk assessment and consider whether staff and visitor restrictions are necessary in particular outbreaks or settings.

GPP 13.2: Consider communication with visitors before restrictions are introduced.

GPP 13.3: When visitor restrictions are not in place, communicate with visitors about the control measures that the visitors are expected to follow (e.g. hand hygiene policies, use of PPE, etc.).

GPP 13.4: When visitor restrictions are in place, consider alternatives for the patients to maintain contact with their family and friends (e.g. by providing facilities for virtual/no contact visits).

What is the effectiveness of a hand gel in comparison with handwashing in removing norovirus from contaminated hands?

Handwashing with liquid soap is the current NICE recommendation for the prevention of transmission of gastroenteritis. Specific evidence is lacking on the effectiveness of hand hygiene agents for norovirus, in part due to the challenges around viral culture which is not performed routinely and, in turn, makes decontamination practices more difficult to evaluate. There are many different methods of decontamination or hand hygiene regimens which could be considered, including hand gel (with and without alcohol) and handwashing with soap. Varying ethanol (ETA) content and different soap-based products also influence the potential effectiveness of these methodologies. In addition, the amount of contamination will influence the effectiveness of different approaches. Trying to understand the impact of enhanced hand hygiene and which decontamination method is the most effective in reducing norovirus transmission is necessary to provide guidance in the prevention of transmission during norovirus outbreaks. Previous guidelines [1] recommended the use of liquid soap and water, and advised that tablets of soap should not be shared. The guidelines also acknowledged that AHR may be ineffective for norovirus inactivation, but did not specifically advise against the use ofAHR in healthcare settings.

There was weak evidence from one case—control study [127] and one cross-sectional study [21] which reported the use of different hand hygiene regimens during outbreaks in a healthcare setting. The case—control study [127] demonstrated that LTCFs were more likely to experience at least one norovirus outbreak if they used AHR as often as or more often than using soap and water for hand hygiene (adjusted OR 6.06, 95% CI 1.44—33.99). They also reported that the risk of a norovirus outbreak may not be dependent on the facilities available, as the risk ratio for facilities which had more than one handwashing sink per 10 residents compared with those which had one or fewer sinks per 10 residents was not significant

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(0.59, 95% CI 0.32–1.07). The cross-sectional study [21] reported no benefit for either residents or staff of the nursing homes when, during outbreaks, AHR was used only in addition to handwashing (OR 0.57, 95% CI 0.28–1.16 for staff, not reported for residents), or when stringent staff handwashing with soap and water was in place (OR 1.34, 95% CI 1.01–1.79 for residents, not reported for staff). In addition, no benefit was seen when stringent resident handwashing with soap and water was in place (OR 1.29, 95% CI 0.95–1.73 for residents; OR 1.31, 95% CI 0.90–1.90 for staff).

There was weak evidence from three outbreak studies [55,58,126] which reported using only soap and water during 10 outbreaks. These studies reported that the outbreaks affected between 17 and 100 cases (median 47 cases) and lasted from 5 to 33 days (median 12 days). One of these studies [58] reported that after introducing the interventions, which included the emphasis on handwashing with soap and water, cases started to decrease, although the authors also reported that these interventions were introduced at the peak of the outbreak, and therefore it was difficult to associate any control measures with outbreak control as the numbers were likely to decline on their own. The authors reported that it took a further 10 days to control the outbreak after the interventions were in place. Another study [55], which described an outbreak in an acute psychiatric ward, reported that compliance with interventions, and especially patient hand hygiene, was difficult to achieve due to the type of patients present on the ward. Nevertheless, the study reported that the outbreak was controlled 5 days after introducing the interventions.

There was weak evidence from one outbreak report [34] where the nursing home switched to using running water with AHR containing iodophors instead of soap. This outbreak was reported to affect 59 confirmed cases (eight asymptomatic) and lasted 9 days. The authors reported that the number of cases declined after introducing the interventions, which included the switch to AHR with iodophors, and the outbreak ended 7 days later.

There was weak evidence from 10 outbreak studies [19,20,26,28,37,39,56,108,111,123] which reported a total of 17 outbreaks during which AHR was added to the existing policy of handwashing with soap and water. These outbreaks affected between three and 355 cases (median 28 cases) and lasted between 3 days and over 2 months (median 15 days). In nine (53%) of these outbreaks [20,28,37,39,108,111,123], this intervention, along with others, contributed to outbreak resolution, with one study [39] specifically stating that AHR had a positive effect, with people more likely to perform hand hygiene and comply with other interventions. From the studies which did not report any benefit, two studies [26,56] reported that the outbreak was contained only after thorough disinfection of the entire units. One study [19] attributed the outbreak control to a set of enhanced measures (e.g. entry and exit restrictions), and one study [123] did not mention whether the introduction of AHR had any effect. After introduction of the interventions, the number of affected cases was reported to vary from one to 92 (median 8.5 cases, based on eight outbreaks reported by six studies [19,28,30,37,39,56]), with the outbreaks lasting a further 2–19 days (median 10 days, based on seven outbreaks reported by five studies [19,28,30,39,56]).

There was weak evidence from one outbreak study [23] which reported that a switch was made from washing with soap and water to sanitizing hands with AHR using a formula recommended by the World Health Organization. The outbreak affected eight cases and lasted 5 days. As part of this intervention, it was reported that staff were closely observed for hand hygiene to ensure that it was performed correctly. The study reported that switching to AHR, together with other interventions, had a positive effect on termination of the outbreak, which ended within 2 days and affected a further five cases.

There was weak evidence from four outbreak studies which reported a switch from regular soap to chlorhexidine-based soap (CHG) alone [22,114,123] or in combination with povidone iodine-based soap (PVP) [35] for enhanced hand hygiene during the outbreaks. The outbreaks affected between 11 and 97 cases (median 58 cases) and lasted from 5 to 30 days (median 22 days). One of these studies [22] reported a positive outcome of using CHG soap with quick resolution of the outbreak and no second wave or recurrence. None of the remaining three studies which did not report a benefit [35,114,123] specifically commented on whether an introduction of CHG had any effect. Two studies reported that after introduction of the interventions, including hand hygiene with CHG, outbreaks lasted 3 [22] and 21 [35] days and affected between three [22] and 59 [35] cases.

There was weak evidence from two outbreak studies [27,128] which reported a switch from isopropanol (IPA)- to ETA-based sanitizer for hand hygiene during the outbreaks. The rationale for making the switch was provided by one study which mentioned that ETA was able to destroy non-enveloped viruses more quickly [27]. The outbreaks were reported to affect 63 [27] and 11 [128] cases each and lasted 32 and 38 days, respectively. One study [27] did not report a benefit of using this intervention, and reported that the outbreak spread to another unit (number of further cases and duration not reported), while the other study [128] reported a benefit with only two further cases occurring over the next 11 days before the outbreak was contained successfully.

There was weak evidence from one outbreak study [24] which reported that insufficient hand hygiene facilities were available during the outbreak. This large outbreak affected 145 cases and lasted 63 days. While the control measures were introduced within 4 days of the outbreak, the outbreak still lasted for a further 59 days (number of cases not reported), and the authors attributed this to poor compliance with the interventions and a lack of appropriate handwashing facilities, including none in the dining areas and patient rooms.

There was weak evidence from one surveillance study [129] which reported the effectiveness of using AHR during the norovirus season in the community setting. The authors compared 5 years of surveillance data, with an influenza pandemic occurring in one of these years. The authors reported that during the pandemic year, the peak of norovirus cases was delayed by approximately 7–8 weeks and the incidence of weekly cases was lower than in other years. The authors also reported a significant, strong, negative correlation between the risk of norovirus infection and the nationwide consumption of skin antiseptics and hand soap products (R^2=-0.97 and -0.93, respectively; $P<0.01$ for both).

There was weak evidence from 11 laboratory studies [130–140] which assessed the effect of alcohol-based sanitizers on the removal or inactivation of human norovirus (HNV),

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murine norovirus (MNV) and feline calicivirus (FCV) from the fingertips of volunteers. The studies used different concentrations of ETA [130–139] or IPA [130–133,137,140] alone or in combination with other agents [27,30,31,34]. In comparison with water, ETA performed better in removing or inactivating HNV or its surrogates in four studies [25,28,32,34]. Concentrations at which ETA was reported to be beneficial were 62% [133], 70% [130,137], 90% [130,139] and 99.5% [133]. In a further two studies, water was equally or more effective in removing norovirus when compared with 70% [132] and 62% [134] ETA. However, evidence suggests that a lower concentration was not necessarily associated with a reduced effect. Four studies showed that increasing the concentration of ETA may result in the sanitizer being less effective than when ETA is kept at mid-range concentrations [25,26,30,33]. In relation to isopropanol, four out of five studies [25,26,28,32] reported that, at similar concentrations, ETA performed better at removing or inactivating HNV or its surrogates. The fifth study [132] reported no significant difference between ETA and IPA. When ETA alone was compared with ETA-based sanitizers with other agents, it performed less efficiently in all four studies [132,135,137,139]. The efficiency of alcohol was affected by different types of organic loads present, with its efficiency reduced by almost half in faecal suspension (mean 1.45 log reduction) when compared with no organic load (mean 2.66 reduction) or fetal bovine serum (mean 2.62 reduction; $P<0.001$ for both) [131]. In comparison with water, IPA performed marginally better in two studies [131,133] and worse in three studies [130,132,140]. In comparison with another alcohol-based sanitizer (55% ETA + 10% 1-IPA + 5.9% propan-1.2-diol + 5.7% butan-1.3-diol + 0.7% phosphoric acid), IPA performed significantly worse ($P=0.0005$) [132]. Similar to ETA, IPA tended to perform better at mid-range concentrations of 50% compared with 90% or higher [130,133], and was less effective when a faecal load was present [131]. Additionally, 1-propanol performed better than 2-propoanol at similar concentrations [130]. For other alcohol-based sanitizers: Purell VF447® and VF481® performed significantly better than other sanitizers [original formula Purell® hand sanitizer (except VF447), Endure 300®, Sterillium Virugard®, Germstar Noro® and Anios Gel®) [135]; Purell VF447 performed better than 75% ETA [136]; ETA (45% or 55%) with phosphoric acid performed better than 90% ETA, CHG soap and water, and similar to PVP and triclosan soap [139]; and one test sanitizer (55% ETA + 10% 1-IPA + 5.9% propan-1.2-diol + 5.7% butan-1.3-diol + 0.7% phosphoric acid) performed significantly better than 70% ETA, 70% IPA and water [133].

There was weak evidence from two laboratory studies [139,141] which assessed the effect of CHG soap on the removal of MNV from the fingertips of volunteers. In one study, CHG was less effective in relation to soap or PVP regardless of the amount of product used (3 mL or 5 mL) or the exposure time (15, 30 or 60 s) [141]. In another study [139], CHG was significantly less effective than water ($P<0.001$), as well as other sanitizers and soaps tested including 90% ETA, ETA with phosphoric acid, triclosan soap and PVP soap.

There was weak evidence from three laboratory studies [133,139,141] which assessed the effect of PVP soap on the removal of MNV and FCV from the fingertips of volunteers. In one study [141], PVP was significantly more effective than water (except in one scenario when the shortest exposure time and the least amount of product was used, *P*-values not provided) as well as significantly better than CHG (in all scenarios, *P*-value not provided). In two other studies [133,139], PVP was the most effective compared with water, different alcohol-based sanitizers and different types of soap (*P*-values not provided).

There was weak evidence from one laboratory study [133] which assessed the effect of 3% hydrogen peroxide solution on the removal of FCV from the fingertips of volunteers. At 30 s, hydrogen peroxide was less effective than water, ETA, 70% IPA, PVP-based soap and 0.115% triclosan soap, and had a similar performance to 91% IPA, 0.6% triclosan soap and benzalkonium chloride (BAC). At 2 min, it performed marginally better than water but was still less effective than most sanitizers.

There was weak evidence from three laboratory studies [133,134,139] which assessed the effect of triclosan-containing soap on the removal of HNV, MNV and FCV from the fingertips of volunteers. In one study [133], triclosan at concentrations of 0.60% and 0.115% was as effective as water and less effective than other sanitizers (ETA, 70% IPA, PVP soap). In another study [134], it was more effective than not removing HNV at all (dry control), but similarly effective when compared with water. In the last study [139], at a concentration of 1%, triclosan was significantly more effective than water, although it was still less effective than PVP soap and 45% ETA with phosphoric acid.

There was weak evidence from two laboratory studies [133,142] which assessed the effect of BAC on the removal of HNV and FCV from the fingertips of volunteers. In one study [133], 0.13% water-based BAC product was less effective in removing FCV than water and other sanitizers and hand soaps. In another study [142], a sanitizer based on 60% ETA with BAC was significantly more effective than using 60% ETA alone. Additionally, when HNV was inoculated either immediately or 4 h after the application of ETA/BAC sanitizer, the sanitizer was less effective, although still effective, in reducing HNV contamination of fingerpads compared with ETA itself, which had no effect.

There was weak evidence from three simulation studies [143–145] which assessed the effect of different types of washing and sanitizing techniques on the removal of MNV and FCV from the hands of volunteers or the subsequent contamination of other surfaces. In one study [143], which compared using water with or without soap (hands dried with a paper towel) or ETA-based sanitizers (62% and 75%, hands air-dried) on the amount of virus transferred on to ham, lettuce and stainless steel surfaces, any method was significantly better than not washing or sanitizing at all ($P<0.004$ for all), but handwashing with or without soap was still more effective than using a sanitizer. In another study [144], handwashing with soap was significantly less effective (1.79 $\log_{10}$ reduction) than other protocols which used hand rub using 70% ETA (2.60 $\log_{10}$ reduction), handwash followed by hand rub (3.19 $\log_{10}$ reduction) or a protocol where hand sanitizer was used twice, with hands wiped on paper towels between the AHR applications (4.04 $\log_{10}$ reduction). However, it is worth noting that in the handwash protocol, hands were only pat-dried on the paper towels, which may have been less effective for removal of the virus compared with wiping the hands on the paper towels. In the last study [145], which compared different types of hand

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hygiene protocol for removal of FCV from natural and artificial nails, washing protocols which involved tap water only, water and soap, water with antibacterial soap, or water followed by hand sanitizer (concentration and ingredients not reported) were equally effective in removing the virus. Application of a hand sanitizer alone was significantly less effective than washing with water alone ($P<0.05$), and the best results were obtained when handwashing with soap, water and a hand brush was used to remove the virus ($P<0.05$). The authors also reported that hands with artificial nails were significantly more contaminated before handwashing/sanitizing compared with those with natural nails, and that, although all handwashing protocols removed FCV, hands with artificial nails had a significantly higher number of infectious virus copies compared with hands with natural nails.

The Working Party discussed the above evidence and concluded that hand hygiene with soap and water is currently the best option for removing norovirus. During outbreak situations, or when norovirus is present in the facility, there may be a need to temporarily remove AHR and encourage all individuals to wash their hands with soap and water. This can only be achieved by providing appropriate information to staff, patients and visitors, and ensuring that suitable facilities for handwashing are available. Additionally, there may be a need to monitor hand hygiene to ensure that handwashing takes place after the removal of AHR, rather than staff and other individuals omitting this essential process. Special consideration needs to be given to patients who require assistance in performing hand hygiene; depending on the type of patient, this may include either reminders, providing access to handwashing facilities, assisting with washing patients' hands, or providing alternatives to soap and water, as appropriate.

Recommendations

14.1: During norovirus outbreaks, encourage all individuals to perform hand hygiene as per defined technique using soap and water.

14.2: Consider monitoring whether appropriate handwashing takes place.

Good practice points

GPP 14.1: Encourage the use of appropriate handwashing technique with the World Health Organization's Five Moments of Hand Hygiene.

GPP 14.2: Support patients with appropriate hand hygiene. Consider the use of a suitable hand hygiene alternative (e.g. detergent hand wipes) when it is not feasible for patients to use soap and water.

GPP 14.3: Provide appropriate information to educate staff, patients and visitors that the use of soap and water is more effective than alcohol hand rub in preventing norovirus transmission.

GPP 14.4: Ensure suitable facilities are provided to enable appropriate hand hygiene. Consider using hand wipes and portable handwash stations where fixed sinks are not available.

What is the effectiveness of different types of personal protective equipment in preventing norovirus transmission?

Current advice for the prevention of norovirus is to use transmission-based precautions, which offer PPE advice based on the mode of transmission. As norovirus is transmitted through the contact route, contact precautions are recommended because they prevent and control infections that spread via direct contact with the patient or indirectly from the patient's immediate care environment (including care equipment). Plastic aprons and disposable gloves are usually recommended when staff are in direct contact with patients affected by norovirus or their immediate environment. Other PPE may be required following a risk assessment; for example, facial protection may be recommended when a risk of splashing and spraying of body fluids is identified, and gowns or long-sleeved aprons may be recommended for highly contaminated environments. The effectiveness of these different contact precautions, used in combination for varying exposure risks, is important to understand to ensure that healthcare workers choose the correct PPE to prevent onward norovirus transmission. On the other hand, there is a concern that PPE may be used inappropriately or overused, which would result in waste of valuable resources. Previous guidelines [1] recommended the use of gloves and aprons for contact with infected patients, and stated that masks should only be considered when there is a risk of droplets and aerosols. However, these recommendations were based on recommendations from another guideline, and no literature was reviewed to assess the effectiveness of different PPE.

Gloves

There was weak evidence from 18 studies [19,20,22,25–27,29,30,32,34,37,38,55,57,108,122,123,146] describing a total of 24 outbreaks which reported the use of gloves during outbreaks in healthcare settings. These outbreaks affected between 10 and 355 cases (median 31 cases) lasting from 3 days to over 2 months (median 17 days, based on 17 studies [19,20,22,25–27,29,30,32,34,37,38,55,57,108,122,123]). The studies introduced gloves exclusively for staff [19,20,22,25–27,30,32,34,37,38,55,57,108,123,146] or for staff and visitors [29,122]. Gloves were recommended to be used upon contact with symptomatic patients/residents [19,20,22,25,30,32,37,38,55,57], for cleaning [20,108] or universally [26,29,34,122,123,146], and one study did not indicate when the gloves were to be used [27]. Of these studies, 14 (78%) reported that the introduction of gloves as part of the control measures was successful in controlling the outbreak, with one study specifically recommending gloves and other PPE [27]. Of the four studies which did not find that the introduction of gloves as part of the control measures was successful in controlling the outbreak, one study reported that further control measures were necessary [25], one study reported that the cases declined in the original ward but the outbreak spread to another area [122], one study reported that the interventions did not seem to have an effect in an outbreak ward but might have been successful in preventing the spread to other areas [30], and one study stated that the introduction control measures did not stop transmission completely but the cases

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occurred at a lower rate [38]. Following the introduction of gloves and other control measures, the studies reported a further two to 51 cases (median 10 cases, based on 11 studies [19,20,22,25,29,30,32,34,37,55,57]), lasting between 2 and 19 days (median 10 days, based on 11 studies [19,20,22,25,29,30,32,34,38,55,57]).

No studies were found in the existing literature that assessed the effect of the use of gloves during outbreaks in non-healthcare settings. However, one excluded simulation study [147] explored the routes by which norovirus spreads in the food industry. The study simulated the process of making a cucumber sandwich by a person whose hands were contaminated with norovirus. The hands of the volunteers, protected by gloves, were contaminated with approximately 3.5 x $\log_{10}$ RT-QPCR-detectable virus unit (100 μL) of HNV. The volunteers were then asked to don a clean pair of gloves, either immediately after inoculation (wet conditions) or after 60 min (dry conditions). A swab was taken from the outside of the new glove to determine whether transfer of the virus occurred. The authors reported that transfer to new gloves occurred almost every time the experiment was repeated [10/12 (83%) for dry conditions and 11/12 (92%) for wet conditions], and that a sufficient amount was transferred to cause a possible infection. Further experiments showed that the virus was subsequently transferred from the gloves to a knife, bread and cucumber slices used for sandwich making. The same experiment was repeated with MNV with hands that were not protected by gloves. The results were similar, with MNV being transferred from contaminated hands to gloves. These findings could be extrapolated to other settings, as the experiment implied that when hands are not decontaminated before gloves are donned, the gloves can subsequently become contaminated with the virus and can be a source of contamination for other items and, potentially, individuals.

No studies were found in the existing literature that assessed the experience of using gloves or being cared for by a person wearing gloves during outbreaks in any setting.

Gowns

There was weak evidence from 15 studies [20,25,26,30,32,34,37,38,55,57,108,122,123,125,146] which described a total of 20 outbreaks that reported the use of gowns during norovirus outbreaks in healthcare settings. These outbreaks affected between 10 and 355 cases (median 31 cases) and lasted from 3 days to over 2 months (median 18 days, based on 14 studies [20,25,26,30,32,34,37,38,55,57,108,122,123,125]). These studies introduced gowns exclusively for staff [20,25,26,30,32,34,37,38,55,57,108,123], or for staff and visitors [122,125]. The gowns were recommended to be used upon contact with symptomatic patients/residents [20,25,30,32,34,37,38,55,57,125], for cleaning [20,108] or universally [26,122,123,146], and one study did not indicate when the gowns were to be used [108]. Of these studies, 11 (73%) reported that the introduction of gowns as part of the control measures was successful in controlling the outbreak. Of four studies which did not report that the introduction of gowns as part of the control measures was successful in controlling the outbreak, one study reported that further control measures were necessary [25], one study reported that the cases declined in the original ward but the outbreak spread to another area [122], one study reported that the interventions did not seem to have an effect in an outbreak ward but might have been successful in preventing the spread to other areas [30], and one study stated that the introduction of control measures did not stop transmission completely but that the cases occurred at a lower rate [38]. Following the introduction of gowns and other control measures, the studies reported a further two to 51 cases (median nine cases, based on eight studies [20,25,30,32,34,37,55,57]), lasting between 2 and 19 days (median 10 days, based on eight studies [20,25,30,32,34,38,55,57]).

No studies were found in the existing literature that assessed the effect of the use of gowns during outbreaks in non-healthcare settings.

No studies were found in the existing literature that assessed the experience of using gowns or being cared for by a person wearing a gown during outbreaks in any setting.

Aprons

There was weak evidence from one cross-sectional study [21] and three outbreak studies [19,27,29] which reported using aprons during norovirus outbreaks in healthcare settings. The cross-sectional study [21] compared the incidence of norovirus infection in staff and residents of nursing homes in which plastic aprons were used when caring for symptomatic residents with nursing homes which did not. The authors reported that there was no significant difference in the incidence of infection between these groups (OR 0.73, 95% CI 0.50—1.07 for residents; OR 0.67, 95% CI 0.41—1.08 for staff; *P*-value not provided). The three outbreak studies, which reported a total of four outbreaks, all occurring in hospital, affected between 24 and 63 individuals (median 59 cases) and lasted from 11 to 32 days (median 15 days). These studies introduced aprons exclusively for staff [19,27] or for staff and visitors [29]. The aprons were recommended to be used upon contact with symptomatic patients/residents [19] or universally [29]. One study did not indicate when the aprons were to be used [27]. All studies reported that the introduction of aprons, together with other control measures, was successful in controlling the outbreak. Following the introduction of control measures, the studies reported that a further 21—34 individuals were affected (median 27 cases, based on two studies [19,29]), lasting between 6 and 13 days (median 11 days, based on two studies [19,29]).

No studies were found in the existing literature that assessed the effect of the use of aprons during outbreaks in non-healthcare settings.

No studies were found in the existing literature that assessed the experience of using aprons or being cared for by a person wearing an apron during outbreaks in any setting.

Masks and respirators

There was weak evidence from one cross-sectional study [21] and 16 outbreak studies [19,20,22,25,27,33,34,37,39,55,57,62,122,123,125,146] which reported using surgical masks [19,20,22,25,27,33,34,37,39,55,57,62,122,123,125] or respirators [146] during norovirus outbreaks in healthcare settings. The cross-sectional study [21] compared the incidence of norovirus infection in staff of nursing homes in which masks were used for cleaning vomit with nursing homes which did not. The authors reported that staff had a lower incidence of norovirus infection in nursing homes which used masks (OR 0.36, 95% CI 0.23—0.57, controlled for other factors in a multi-variate analysis). The outbreak reports described a total of 20

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outbreaks affecting between 10 and 95 individuals (median 31 cases) lasting from 5 to 37 days (median 19 days, based on 15 studies [19,20,22,25,27,33,34,37,39,55,57,62,122,123,125]). These studies introduced masks exclusively for staff [19,20,22,25,27,33,34,37,39,55,57,62,123,146] or for staff and visitors [122,125]. The masks were recommended to be used upon contact with symptomatic patients/residents [19,33,37,39,54,62,125], for cleaning vomitus and faeces [19,39,55,62,146] or universally [22,25,34,122,123]. Two studies did not indicate when the masks were used [20,27]. Of these studies, 13 (81%) reported that the introduction of masks as part of the control measures was successful in controlling the outbreak, and one study specifically recommended the use of masks during outbreaks [27]. Of three studies which did not report that the introduction of masks as part of the control measures was successful in controlling the outbreak, two studies reported that further control measures were necessary [25,33] and one study reported that the cases declined in the original ward but the outbreak spread to another area [122]. Additionally, the only study which described the use of respirators [146] reported that after the outbreak ended, the hospital changed its policy and recommended the use of surgical masks rather than N95 respirators, although the authors did not state the reasons for this decision. Following the introduction of control measures, the studies reported that a further two to 92 individuals were affected (median 10 cases, based on 10 studies [19,20,22,25,34,37,39,55,57,62]), lasting between 2 and 19 days (median 11 days, based on nine studies [19,20,22,25,34,39,55,57,62]).

No studies were found in the existing literature that assessed the effect of the use of masks and respirators during outbreaks in non-healthcare settings.

No studies were found in the existing literature that assessed the experience of using masks and respirators or being cared for by a person wearing a mask or respirator during outbreaks in any setting.

Other PPE

There was very weak evidence from three outbreak studies [113,123,146] which reported the use of other forms of PPE during norovirus outbreaks in healthcare settings. One of these studies [146], which reported an outbreak involving 81 cases (duration not reported), mentioned that theatre scrub suits were introduced for all staff working in areas affected by norovirus as part of the bundle of interventions in response to the outbreak. The reasoning behind this action was that the scrub suits were easily identified, and staff were not able to leave the affected areas without changing. The authors reported that the control measures were beneficial in controlling an outbreak, with cases declining soon after these measures were put in place. Another study [123] reported that shoe caps and head caps, together with other PPE and other interventions, were in use each time an outbreak occurred in their hospitals. The authors believed that PPE, which was worn universally in the affected areas of the hospital, was one of the successful strategies which helped to control the outbreaks. The reported outbreaks (N=4) affected between 13 and 82 individuals (median 45 cases) and lasted between 15 and 30 days (median 24 days). The last study [113] did not provide any details about the type of PPE used, but stated that it was appropriate when working with symptomatic patients or in a pan room (sluice). This study described an outbreak that affected 281 individuals across three institutions, lasting over 32 days. The authors stated that the control measures were mostly successful in controlling the outbreak, but the reason for the prolonged duration was healthcare workers returning to work too soon after recovering from illness and infecting others.

No studies were found in the existing literature that assessed the effect of the use of other forms of PPE during outbreaks in non-healthcare settings.

No studies were found in the existing literature that assessed the experience of using or being cared for by a person using other forms of PPE during outbreaks in any setting.

Overall, the Working Party agreed that there is currently very weak evidence that PPE (gloves, aprons and masks) is effective during norovirus outbreaks. It is possible that PPE may not be cost effective, and there is also a danger that staff are provided with the false sense of security that the use of these items makes them protected. As a result, staff may be less compliant with other control measures which would be more effective (e.g. hand hygiene). Thus, due to the lack of evidence for or against PPE use, the Working Party have no reason to challenge the practice that was recommended by previous guidelines [1].

Recommendations

15.1: Use gloves and aprons when caring for symptomatic patients with norovirus.

Good practice points

GPP 15.1: Consider using type IIR fluid-resistant surgical mask/eye protection when there is a risk of splashes of bodily fluids to the face.

What is the value of performing environmental sampling in the management of norovirus outbreaks?

With advancement of a number of technologies, and molecular testing becoming widely available, the practice of environmental sampling during (and outside of) norovirus outbreaks has become increasingly popular. It is currently not clear what this practice can achieve and whether it provides any benefits. For example, it is not clear whether identification of positive environmental samples would change anything in the management of an outbreak which has already been declared and where control measures are already in place. If this practice was to continue routinely, it is not clear when, where and how often the sampling should take place. It is possible that environmental sampling may identify a source of continued transmission, but it is currently not clear whether this benefit can justify the cost of routine sampling during each norovirus outbreak, or whether routine sampling can prevent the occurrence of the outbreak. Previous guidelines [1] have not addressed this question and no recommendation was made in regard to environmental sampling.

Outbreaks in health and care settings

There was weak evidence of benefit from eight outbreak reports [24,33,56,57,123,125,148,149] and one case series study [128] which investigated the effect of environmental sampling in health and care settings during norovirus outbreaks

on the risk of transmission of norovirus to others. The outbreaks involved between 11 and over 300 cases (median 31 cases) and lasted between 11 and 63 days (median 37 days). Five of these studies [33,57,125,128,149] specifically mentioned that environmental sampling resulted in the identification of an environmental source of norovirus which enabled the institutions to remove the contamination and end the outbreak. Four of these studies [24,33,56,57] reported that, following the environmental sampling and decontamination, there were between zero and 21 further cases (median four further cases) and the outbreak ended between 3 and 59 days (median 12 days) later. However, one study [24], which reported the longest duration, reported that staff were not compliant with interventions which were put in place. In all studies, other interventions were also implemented and could have contributed to outbreak resolution. There was also an additional outbreak report [25] which did not use environmental sampling, but used an adenosine triphosphate (ATP) meter to assess the adequacy of cleaning, followed by recleaning if necessary. In this outbreak report, cases recurred after initial control measures were put in place, and the ATP meter was introduced when it was suspected that these cases were due to environmental contamination. While this technology is not able to detect viral particles, the authors suggested that it does have the ability to assess whether a surface has been decontaminated sufficiently. There were no further cases of norovirus, and the authors attributed the end of the outbreak, in part, to ATP monitoring.

There was weak evidence from eight outbreak reports [24,33,56,57,123,125,148,149], one case series study [128] and two environmental surveys [150,151] which investigated the extent of environmental contamination in health and care settings during norovirus outbreaks. The studies undertook environmental sampling during 48 norovirus outbreaks, and reported that in 39 of these outbreaks (81%, reported by nine studies [24,33,56,123,125,128,148,150,151]), at least one positive environmental sample was identified. Overall, the median proportion of positive environmental samples reported by these studies was 10% (min 0%, max 50%).

No studies were found in the existing literature that assessed the cost effectiveness of environmental sampling during outbreaks in health and care settings.

Outbreaks outside health and care settings

There was weak evidence of benefit from 18 outbreak reports [41,42,46,117,118,124,152–163] and one cross-sectional study [164] which investigated the effect of environmental sampling outside health and care settings on the risk of transmission of norovirus to others. The outbreaks involved between 10 and 1995 cases (median 77 cases) and lasted between 4 and 24 days (median 15 days, based on 11 reports [41,46,117,152,154–157,161–163]). Six [41,153,156,158,159,162] of the 19 studies reported that environmental sampling enabled them to end the outbreak after the source of environmental norovirus contamination was identified. One study [41] reported that there were only four cases which occurred up to 2 days after the source of environmental contamination was identified and eliminated, and one study [46] reported that the outbreak continued for a further 15 days but that the incidence of new cases was lower than before. The remaining 17 studies did not report the number of cases or duration after the source of environmental contamination was identified.

There was weak evidence from 18 outbreak reports [41,42,46,117,118,124,152–163], one cross-sectional study [164] and two environmental surveys [151,165] which investigated the extent of environmental contamination outside health and care settings during norovirus outbreaks. In 15 (71%) of these studies, at least one norovirus-positive environmental sample was identified. Overall, the median proportion of positive environmental samples reported by these studies was 15% (min 0%, max 71%).

No studies were found in the existing literature that assessed the cost effectiveness of environmental sampling during outbreaks outside health and care settings.

Environmental surveys outside outbreak situations

There was weak evidence from nine environmental surveys [166–174] in non-outbreak situations which investigated the extent of environmental contamination in health and care settings. These studies were performed in situations where either known sporadic norovirus cases were present on a ward, or the sampling was undertaken during the norovirus season. All reported that at least one norovirus-positive sample was recovered during the study period, but norovirus was not present on all sampling occasions. The recovery rate varied from 0.9% to 80% (median 5.8%), although the study [174] which reported a high recovery rate was undertaken in a ward where immunocompromised patients were present, some of whom were known to be chronic shedders.

There was weak evidence from four environmental surveys [158,166,173,175] in non-outbreak situations which investigated the extent of environmental contamination in settings other than health and care settings. These studies were undertaken during the norovirus season [166,173,175] or during a time when there was a norovirus outbreak in another nearby establishment [158]. Two of these studies (50%) [166,175] reported that at least one norovirus-positive sample was recovered during the study period, but the overall recovery rate was low (1.9% [166] and 4.4% [175]). One of these studies, which took environmental samples from 123 establishments (i.e. restaurants, catering, take away) reported that norovirus was found in five (4%) establishments without any known cases of noroviral illness [166].

No studies were found in the existing literature that assessed the cost effectiveness of environmental sampling in non-outbreak situations in any of the settings.

There were a further 46 studies [27,176–220] which did not meet the inclusion criteria because the environmental sampling involved water rather than surfaces. In 34 (74%) of these studies, water testing identified norovirus-positive samples, and the results enabled the authors to take corrective measures to either eliminate the source of contamination or impose restrictions to the public to reduce the risk of exposure.

The Working Party reviewed the above evidence and concluded that there is currently no reason to support routine environmental sampling during outbreaks caused by norovirus. Environmental sampling itself is not essential in controlling the outbreak. The Working Party agreed that there may be outbreak situations where this intervention can provide additional information about a potential continuing source of transmission, which may lead to the implementation of

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additional control measures. The decision to do so should be based on the nature of the outbreak.

Recommendations

16.1: Do not screen the environment routinely for norovirus, neither during outbreaks nor in non-outbreak situations.

Good practice points

GPP 16.1: Consider environmental sampling for norovirus to inform IPC measures during prolonged, unusual or uncontrolled outbreaks.

What are the most effective cleaning agents and technologies for reducing contamination of the environment and minimizing the transmission of norovirus?

It is generally accepted that person-to-person and foodborne routes are most common in norovirus transmission, but the evidence from some outbreak reports supports the assumption that transmission via fomites is also possible. Decontamination of surfaces is usually one of the measures introduced to control a norovirus outbreak. Noroviruses are known to be resistant to many disinfecting agents and require high temperatures to be deactivated. As they are also unculturable in the laboratory, it is difficult to establish which disinfectants are effective. Previous guidelines [1] recommended that 1000 parts per million (ppm, also sometimes described as 0.1%) sodium hypochlorite (NaCl-) is used to decontaminate all surfaces during a norovirus outbreak. However, NaCl- is corrosive and is therefore not suitable for decontamination of some surfaces, so alternative disinfectants are needed. Despite its widespread use during norovirus outbreaks, it is still not clear whether NaCl- is effective in deactivating norovirus. There are also further issues that need to be considered; for example, the concentration and the contact time required to achieve deactivation, the presence of organic soiling, and the variation in cleaning methods used by the cleaning personnel. In recent years, new technologies such as ultraviolet C (UVC) and hydrogen peroxide vapour (HPV) devices have been introduced, but it is still not known whether these are effective in norovirus deactivation. An additional complication is the potential presence of soft furnishings (e.g. carpets, curtains, chair/bed tapestry) on which NaCl- cannot be used, but these can still be sources as fomites during outbreaks. It is therefore important to identify which types of disinfectants are or are not effective, and which can be used on different types of surfaces.

Sodium hypochlorite (NaCl-)

There was inconsistent evidence from one prospective cohort study [221], one cross-sectional study [21] and 20 outbreak reports [14,19,22,23,25,26,29,30,32,34,36,38,39,108,111,112,115,121,123,125] which investigated the incidence and duration of norovirus infection during outbreaks in health and care settings with the use of NaCl-. The concentration of the disinfectant varied from 100 ppm [30] to 10% (100,000) [32], with six studies not reporting the concentration [14,34,112,121,125,221]. One study [221] reported that the transmission of cases in two hospital units was not due to environmental contamination and, as a result, concluded that NaCl- as well as steam used as an alternative are equally effective in minimizing environmental spread: 14/32 (44%) in a unit using NaCl- compared with 22/32 (69%) in a unit using steam (*P*-value not reported but not significant). In both units, the outbreaks lasted 5 days. One cross-sectional study [21] which compared nursing homes that used NaCl- with those that did not (details not reported) demonstrated that there was no reduced risk of norovirus infection for patients and staff when 250 ppm NaCl- was used (OR 0.83, 95% CI 0.40—1.73 for residents; OR 1.06, 95% CI 0.44—2.56 for staff), but there was a significant difference when 1000 ppm NaCl- was used (OR 0.45, 95% CI 0.25—0.80 for residents; OR 0.37, 95% CI 0.20—0.70 for staff). The outbreak studies [14,19,22,23,25,26,29,30,32,34,36,38,39,108,111,112,115,121,123,125] which reported using NaCl- for disinfection had between eight and 355 cases (median 31 cases) and lasted from 6 days to over 2 months (median 14 days). Of these 20 outbreak reports, 15 (75%) reported that, together with other measures, introduction of NaCl- disinfection [19,22,23,29,32,34,36,38,39,108,112,115,123,125] or an increase in concentration [25] were beneficial in controlling the outbreak. From the studies which did not report NaCl- to be beneficial, two studies did not provide information about the concentration that was used [14,121], one study used 1000 ppm [26] and one study used 100 ppm [30. Another report [111] stated that NaCl- disinfection (2%) was not fully implemented because it was corrosive to some surfaces (e.g. commodes), and was therefore avoided by staff. From a total of 10 reports which provided data after the introduction of NaCl- disinfection, there were between one and 92 further norovirus cases (median 16 further cases, based on 10 studies [19,22,23,25,29,30,32,36,38,39]) and the outbreaks lasted from 2 to 19 days (median 5 days, based on nine studies [19,22,23,25,29,30,32,36,39]). There was another outbreak report [37] which mentioned that 'bleach' (concentration not described) was used, and reported that only four cases of norovirus were identified after interventions were put in place, despite chronic shedders being present on a ward. There were five further outbreak reports [31,40,56,126,222] and one case series study [128] which described the use of NaCl- with other forms of disinfection {hot water [40,56], hypochlorous acid [222], alcohol wipes [31], HPV [128], ultraviolet light (UV) [128] and Environmental Protection Agency (EPA)-approved products (details not reported) [126]}. These studies reported outbreaks which affected between 17 and 394 cases (median 105 cases) and lasted between 10 and 47 days (median 18 days). Three studies [31,40,222] reported that implementation of disinfection, together with other control measures, was beneficial in ending the outbreak. From the studies which did not report that implementation of disinfection, together with other control measures, was beneficial in ending an outbreak, one study did not find environmental contamination and concluded that person-to-person spread from staff who were employed in multiple nursing homes was the reason for the prolonged outbreak [126], while another study used 500 ppm of NaCl- (and hot water) [56]. The remaining study [128] reported a prolonged outbreak due to a chronic carrier who had persistent diarrhoea. This patient had multiple stays on a ward over 10 months, and it was reported that other patients acquired norovirus during these admissions, despite the patient being isolated. Additionally, it was reported that the rooms were terminally disinfected with NaCl- (1000 or 2000 ppm) and HPV, yet patients who occupied the room after the

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index patient also became ill. Environmental sampling performed after disinfection with NaCl- and peroxide revealed persistent norovirus contamination, which was only eradicated after UV light was added to the protocol.

There was very weak evidence from one outbreak report [26] which reported the cost of using NaCl- disinfection in health and care settings. This was a large outbreak which affected 355 cases and lasted over 2 months. The authors reported that a total cost of cleaning and disinfection, which also included enhanced cleaning with instructions to domestic staff on how cleaning should be conducted, was $96,961 (approximately £73,722). The outbreak was extensive, and it was not recognized until 6 weeks after the first cases occurred.

There was inconsistent evidence of benefit from eight outbreak reports [41–43,48,117,183,223,224] which reported the use of NaCl- during outbreaks outside the healthcare setting. The reported outbreaks affected between three to over 800 cases (median 157 cases) and lasted from 14 to 22 days (median 16 days, based on four studies [41,43,48,117]). Only three studies provided the concentration at which NaCl- was used (1000 ppm) [41,117,183]. Five of these studies reported that disinfection with NaCl-, together with other measures in place, contributed to outbreak resolution [41,43,48,223,224]. Additionally, three of these outbreaks reported that, despite initial control measures being in place, outbreaks continued until NaCl- disinfection was introduced [43,223,224]. From the three studies which did not report any benefit, one study [42] stated that disinfection was only undertaken to comply with national guidelines because there were no further cases nor evidence of environmental contamination, and the other two studies [41,183] identified ongoing contamination of the water supply. Three studies [43,48,183] provided data for the number of cases after introduction of the interventions (between zero and 68 cases, median five cases) and the duration of the outbreaks after interventions (between 2 and 12 days, median 5.5 days). There were two further outbreak reports [44,45] in which NaCl- was used in combination with another disinfection agent (steam [44] and chlorine dioxide fogging [45]). In both studies, the outbreak was terminated after a thorough disinfection. One of these studies reported three further cases occurring a day after disinfection (transmission most likely before) [44], and another study reported no further cases [45].

No studies were found in the existing literature that assessed the cost of NaCl- disinfection in outbreaks outside healthcare settings.

There was inconsistent evidence from 13 laboratory and simulation studies [225,237] which reported the effect of NaCl- disinfection on HNV [225–229] or MNV/FCV as surrogates [230–237] on different types of surfaces. One study [225] reported that application of 5000 ppm NaCl- on melamine surfaces for 10 s resulted in the majority of HNV being removed from the surface, with only 7/42 (17%) surfaces remaining contaminated, while using water and detergent did not remove the virus from any surfaces (28/28, 100% contaminated). Another study [226] which used 1000 ppm NaCl- for 10 min on vinyl or granite slabs reported that HNV was removed from all surfaces (0/18 surfaces left contaminated). Another study [227] which used samples of surfaces from aeroplanes reported that the application of 6500 ppm NaCl- (duration not reported) resulted in sufficient reduction (over 5 x $\log_{10}$) of HNV copies from plastic tray and leather seat samples, but not from the seatbelt sample (data not reported, only used as control). Additionally, when organic soiling (simulated gastric fluid mimicking vomitus) was present, NaCl- was not able to remove HNV from any of these surfaces. Similar results were obtained from another study [228] which demonstrated that 5000 ppm NaCl- applied to stainless steel coupons for 8 min resulted in 1.4 x $\log_{10}$ reduction of HNV copies when organic soiling (human faeces) was present. Application of 500 ppm for 10 min resulted in less than 1 x $\log_{10}$ virus copies being removed. Further testing of the infectious virus (MNV and FCV surrogates) also found that, even at 5000 ppm applied for 8 and 6 min, respectively, complete deactivation of the virus was not achieved, although the majority of the infection virus was removed ($<$4 x $\log_{10}$ and $<$4.5 x $\log_{10}$, respectively). The authors concluded that even at the highest concentration, norovirus may not be removed sufficiently when organic soiling is present, and suggested that the removal of organic matter precedes the disinfection. Another study [229] confirmed these findings by demonstrating that HNV (GI4) copies were only removed sufficiently ($>$4 x $\log_{10}$ copies) when the NaCl- concentration reached 1000 ppm and a two-wiping method (removing organic matter, disinfection and removing the disinfectant) was applied. When a lower NaCl- concentration or only a one-wiping method was applied, the removal of the virus was not sufficient ($<$2 x $\log_{10}$ reduction). However, these results were not replicated when HNV GII4 and MNV were used; the highest concentration with a two-wiping method resulted in a reduction of less than 2.5 x $\log_{10}$ copies for both. Other studies performed on surrogates also showed that the efficacy of NaCl- depends on different variables. One study [230] of MNV on stainless steel coupons showed that application of 200 ppm NaCl- for 5 min was sufficient for complete elimination of the virus using a carrier method and when mechanical wiping (simulated cleaning) was applied ($>$7 x $\log_{10}$ removed), but not when NaCl- was sprayed on to a surface (1.16 x $\log_{10}$ reduction for each hydraulic and electrostatic spray). Another study [231] showed that the time required for complete inactivation of the MNV virus (defined as $>$5 x $\log_{10}$ reduction) differed depending on concentration (1 min needed for 2700 ppm and 10 min for 675 ppm for all types of conditions: wet/dry and soiled/not soiled), but the same results could not be replicated for FCV when only wet/soiled conditions resulted in sufficient FCV inactivation (5 min for 2700 ppm or 10 min for 1350 ppm). Another study [236] showed that to achieve complete removal of the MNV and FCV copies, more than 5 min is required for concentrations of 1000 ppm and more than 3 min when the concentration is 5000 ppm. Two further studies showed sufficient reduction of FCV copies ($>$5 $\log_{10}$) with 1000 ppm for 5 min [232] on stainless steel or 5000 ppm for 30 s or 1 min [233] exposure time on formica, but these results were not achieved when MNV was used. Furthermore, MNV was not inactivated [50] at concentrations of 5000 ppm on PVC or 1000 ppm on stainless steel for 30 s of exposure. However, another study [237] demonstrated that both infectious MNV and FCV were inactivated with NaCl- 5000 ppm with an exposure time of 5 min, but the data, which looked at the reduction of viral copies, suggested that the virus was not

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removed. The authors concluded that this was probably due to inactive but still intact virus remaining on the surfaces. Finally, one study [235], which simulated the removal of MNV from crockery, glasses and cutlery in the presence of organic soiling (cream cheese), demonstrated that neither manual washing nor washing in the dishwasher, both followed by disinfection with 200 ppm NaCl- (maximum concentration for food-contact surfaces), was sufficient to remove the virus completely.

Hypochlorous acid and other chlorine-releasing agents

There was very weak evidence of benefit from two outbreak studies [222,238] which used hypochlorous acid (concentration not reported) in combination with NaCl- [222] or alone [238] during outbreaks in healthcare settings. Both studies reported that hypochlorous acid, in combination with other interventions, resulted in outbreak resolution. One study [222] reported a total of 59 cases which occurred before hypochlorous acid was applied and no further cases occurred, and the outbreak was contained within 7 days in one facility and 4 days in another. The second study reported that disinfection with hypochlorous acid was implemented in the second wave of the outbreak (105 cases), and while it took a further 10 days to control the outbreak, the incidence of new cases decreased following disinfection.

No studies were found in the existing literature that assessed the cost of disinfection with hypochlorous acid in any setting.

There was very weak evidence from one laboratory study [239] which evaluated the effect of hypochlorous acid on stainless steel and ceramic surfaces. The study used HNV and evaluated the effectiveness by establishing the amount of time required to remove 3 x $\log_{10}$ (99.9%) of the virus from the surfaces. The disinfectant was delivered via a fogging system, and while only 1 min was required to remove the virus at a concentration of 188 ppm, 10 min was required to remove it at concentrations of 38 ppm or lower.

No studies were found in the existing literature that assessed the effectiveness of other chlorine-releasing agents in outbreak situations in any setting.

No studies were found in the existing literature that assessed the cost of other chlorine-releasing agents in any setting.

There was very weak evidence from five laboratory studies [235,240–243] which evaluated the effect of other chlorine-releasing agents on HNV [240,241] or its surrogates [235,241–243]. Four of these studies [235,240,242,243] used electrochemically activated (ECO) water. The water was generated by electrolysis of solution containing NaCl and HCl. This produced alkaline and acidic water with free chlorine, and neutral pH water was obtained by combining the two. One study [240] showed that up to 10 min of exposure (concentration of 33.22 free chlorine, pH 5.12) was required to remove HNV (GI and GII) by 3 x $\log_{10}$. After 30 min of exposure, HNV was removed sufficiently (>5 x $\log_{10}$) from stainless steel surfaces, but not from ceramic, glass and PVC surfaces. Another study [242] showed complete inactivation of FCV within 1 min of exposure on plastic coupons with free chlorine concentrations of 150 ppm or 500 ppm at neutral pH. One study [243], which used MNV on stainless steel coupons, reported that ECO water may be effective and that the availability of free chlorine and acidity may positively affect the disinfection. However, another study [235], which assessed the effectiveness of ECO water and NaCl- for deactivation of MNV from stainless steel and PVC surfaces, reported that when the concentration of free available chlorine was the same, NaCl- was superior to ECO water. Finally, one laboratory study [241] assessed the effectiveness of fogged chlorine dioxide on removal of HNV GI and GII and inactivation of MNV. The authors reported that chlorine dioxide at a concentration of 12.4% was not successful in removal of HNV nor in inactivation of MNV. Increasing the concentration to 15.9% resulted in even less removal and deactivation of the viruses.

Quaternary ammonium compounds

There was very weak evidence from one outbreak study [62] which used a quaternary ammonium compound (QAC) during outbreaks in a healthcare setting. The authors reported that a QAC (concentration not reported) was used routinely as a disinfectant in the unit when the outbreak occurred. The outbreak lasted 38 days and involved 13 cases. Disinfection continued using the same disinfectant and other interventions were introduced. It was reported that the outbreak ended 11 days after other interventions were implemented, and the authors did not comment on whether or not QAC was effective.

There was weak evidence from two outbreak studies [43,223] which used QACs during outbreaks outside healthcare settings. Both studies reported that QACs were used initially but that cases continued, and further interventions included switching to NaCl-. Both studies also reported that switching to NaCl- resulted in outbreak resolution, with one study reporting no further cases [223] and the other study reporting five additional cases which occurred within 2 days of disinfection [43].

No studies were found in the existing literature that assessed the cost of disinfection with QACs in any setting.

There was weak evidence of no benefit from five laboratory studies [227,234,244–246] which evaluated the effect of QACs on different types of surfaces using MNV and FCV surrogates. None of the studies reported any benefit of using QACs, regardless of the type of virus, type of surface, concentration used, or whether or not organic soiling was present.

Alcohols

There was very weak evidence from one outbreak study [31] which used alcohol wipes (no details reported) in combination with NaCl- during an outbreak in a healthcare setting. These wipes were introduced in response to a continuing outbreak which was not controlled with initial interventions (there was no mention of disinfection). The authors reported that cases started to decline a couple of days later, and that the outbreak was contained within 11 days following disinfection.

No studies were found in the existing literature that assessed the effect of disinfection with alcohols in outbreaks outside the healthcare settings.

No studies were found in the existing literature that assessed the cost of disinfection with alcohols in any setting.

There was weak evidence of no effect from five laboratory studies [233,244,245,247,248] which evaluated the effect of disinfection with alcohols on MNV and FCV surrogates on different types of surfaces. One study [247], which reported effectiveness as the concentration of the disinfectant required to achieve at least 4 x $\log_{10}$ reduction of infective titre within 5

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min, reported that this was achieved with 60% ETA and 40% 1-IPA for dirty conditions (50% and 30%, respectively, for clean conditions), but was not achieved for 2-IPA. In contrast, the remaining studies did not report any effect, neither with 70% ETA [233] nor with 58-70% isopropyl alcohol [244,245,248].

Phenolic disinfectants

There was very weak evidence from one outbreak study [33] which used a phenolic disinfectant, together with other interventions, during an outbreak in a healthcare setting. The study reported that the outbreak lasted 41 days and affected 211 cases. A phenolic disinfectant (Wex-Cide®) was used as one of the initial interventions, but as the cases continued further, interventions were introduced, the disinfectant was switched to another phenolic compound (Microbac II®) and the unit was closed to admissions. After these enhanced interventions, there was only one further case and the outbreak ended 2 days later.

There was very weak evidence from one outbreak study [160] which used a phenolic disinfectant, together with other interventions, during an outbreak outside the healthcare setting. The authors reported that 0.2% parachlorometaxylenol (EnviroTru®, in combination with steam cleaning of soft furnishings and replacing a portion of a carpet) was used to disinfect an area on an aeroplane where a vomiting accident occurred. No further cases were reported, but the authors also reported that no cases occurred shortly before disinfection. As such, it is possible that norovirus was removed before disinfection took place.

No studies were found in the existing literature that assessed the cost of disinfection with phenolic disinfectants in any setting.

There was very weak evidence of no effect from one laboratory study [245] which evaluated the effect of disinfection with a phenolic agent using inactivation of FCV as a surrogate for HNV. The study used Microbac II® (4.75% o-benzyl p-chlorophenol + 4.75% o-phenylphenol) on different types of fabrics and carpets, and found that, except for 100% polyester fabric with Microbac II® where 99% of inactivation occurred after 10 min of exposure, this disinfectant was not effective in inactivating FCV.

Hydrogen peroxide (surface and vapour)

There was very weak evidence from three outbreak reports [28,35,55] and one case series study [128] which used hydrogen peroxide, together with other interventions, during outbreaks in healthcare settings. One study [55], which described an outbreak in a psychiatric ward where it was difficult to implement some interventions due to the type of patients present (i.e. isolation rooms were not always available because they had to be used for some patients with challenging behaviour), reported that switching from QAC disinfection to accelerated hydrogen peroxide surface disinfectant (Virox®, concentration not stated) was beneficial and contributed to outbreak resolution. The outbreak involved 25 cases and lasted 11 days, but there were nine cases after implementation of the control measures and the outbreak was resolved after 5 days. In another study [28], control measures introduced on the first day were able to contain an outbreak quickly, with only three cases affected over 2 days. Control measures included disinfecting all surfaces and equipment with hydrogen peroxide wipes, and this, along with other measures, contributed to quick resolution of the outbreak. The last outbreak report [35] described control measures which included either the use of 1% aldehyde or 0.1% chlorine-free bleach (peroxide), neither of which seemed to influence the course of an outbreak. Despite the control measures being in place from the first day, the authors reported that the outbreak continued for a further 21 days and affected a further 59 cases. Finally, one case series study [128] described a chronic index patient who was admitted to a ward on multiple occasions. For 10 months, during which time the index patient was sometimes present due to multiple admissions, cases of norovirus occurred on a ward. Additionally, when the patient was discharged, patients who occupied the room after the index case also acquired norovirus despite extensive disinfection. The protocol of disinfection included thorough disinfection of surfaces with NaCl-, steam cleaning and 12% hydrogen peroxide mist. Despite these measures, environmental swabs still detected norovirus in the room. It was reported that norovirus was only eradicated from the room after the protocol for disinfection was repeated and UV light was added.

No studies were found in the existing literature that assessed the effectiveness of using hydrogen peroxide outside healthcare settings.

No studies were found in the existing literature that assessed the cost of disinfection with peroxide in any setting.

There was very weak evidence from seven laboratory studies [227,231,237,241,249–251] which evaluated the effect of disinfection with hydrogen peroxide using HNV [227,241,249], as well as MNV and FCV surrogates [231,237,241,249–251]. One study [227], which used 1.4% hydrogen peroxide applied for 1 min as a surface disinfectant to plastic, leather and seatbelt sample surfaces, did not remove HNV sufficiently, regardless of whether or not organic load was present. Another study [237] reported that application of 4.25% accelerated hydrogen peroxide to glass, polyester or cotton for 5 min resulted in a sufficient reduction in infectious FCV but not MNV. Additionally, disinfection did not seem to show an effect on reduction of the number of viral copies, which, the authors concluded, suggests that molecular-based tests may not be suitable for assessing the effectiveness of a disinfectant as they may detect inactive viral particles. In line with these findings, another study [231], which used accelerated hydrogen peroxide applied to stainless steel surfaces for up to 10 min, reported that 5 min was required to inactivate FCV without organic soiling at a concentration of 1750 ppm. When organic soiling was present, the concentration needed to be increased to at least 3500 ppm for 10 min of disinfection, or 7000 ppm for 5 min. However, to inactivate MNV, concentrations of 35,000 ppm were required for 10 min of exposure, and the authors reported that there was a potential cytotoxic effect was observed in murine and feline cells at this concentration. In one study [241] which used HPV, 5 min of fogging at a concentration of 12.4% HPV resulted in sufficient deactivation of FCV [4.3 x $\log_{10}$ reduction in plaque-forming unit (PFU) infectious virus] but did not remove HNV GI and GII sufficiently (2.5 and 2.7 $\log_{10}$ reduction in number of copies, respectively). Lowering the concentration of HPV resulted in less inactivation or a reduction of the number of copies (FCV and HNV, respectively). However, another study [249] which used HPV reaching 860 ppm reported that disinfection resulted in a 4.5–5.0 x $\log_{10}$ reduction of viable MNV, but an assessment of the reduction of the number of viral copies using two different PCR assays only demonstrated 1.7

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and 0.4 x $\log_{10}$ reductions. The mean reduction in HNV was 0.4 x $\log_{10}$, and the authors concluded that the results may also be affected by detecting deactivated virus. In another experiment [250], FCV was eliminated completely after 15 min of exposure to 30% HPV on glass, vinyl, ceramic and PVC, but 20 min of exposure was required to achieve a 4 x $\log_{10}$ reduction on stainless steel, and complete elimination was not achieved. Finally, one simulation study [252] used FCV and MNV as surrogates in assessing the effectiveness of HPV (474—505 ppm reached with a 15-min dwell cycle) on different surfaces in a non-occupied single hospital room and the attached bathroom. Plastic coupons were placed in different areas, some of which were high-touch surfaces and some were high surfaces which were difficult to clean. The study reported that no viable MNV or FCV (defined as <1 $\log_{TCID50}$/100 μL) was detected on any surfaces after the disinfection cycle was completed. The authors also reported that the time required from dwelling until the room was safe to enter was 3 h.

Aldehydes

There was very weak evidence from one outbreak report [35] which evaluated the use of aldehydes during outbreaks in healthcare settings. The report described the control measures, which included the use of 1% aldehyde or 0.1% chlorine-free bleach (peroxide), which did not seem to influence the course of the outbreak. Despite the control measures being in place from the first day, the authors reported that the outbreak continued for a further 21 days and affected a further 59 cases.

No studies were found in the existing literature that assessed the effect of disinfection with aldehydes in outbreaks outside healthcare settings.

No studies were found in the existing literature that assessed the cost of disinfection with aldehydes in any setting.

There was very weak evidence of no effect from four laboratory studies [233,245,247,248] which evaluated the effect of disinfection with aldehydes on MNV [233,247] and FCV [233,245] surrogates on stainless steel [247], formica [233], and different types of fabrics and carpets [245]. One study [247], which reported effectiveness as the concentration of the disinfectant required to achieve at least 4 x $\log_{10}$ reduction of infective titre within 5 min, reported that this was achieved with 60% ETA and 40% 1-IPA for dirty conditions (50% and 30%, respectively, for clean conditions), but was not achieved for 2-IPA. In contrast, the remaining studies did not report any effect, neither with 70% ETA [233] nor with 58—70% isopropyl alcohol [245,247,248]. At a 1% concentration of glutaraldehyde, it was possible to reduce the number of FCV viral copies sufficiently in 30 s and 1 min, but for MNV, a 2% concentration was required [233]. To achieve at least 4 x $\log_{10}$ reduction of infective titre of MNV, 2500 ppm of glutaraldehyde with a contact time of 5 min was required [247]. Glutaraldehyde at a concentration of 2.6% was successful in inactivating at least 3 x $\log_{10}$ of infectious FCV within 10 min [245]; however, this concentration may be beyond the safety level threshold, which is considered to be 2%.

Ultraviolet light

There was very weak evidence from one case series study [128] which evaluated the use of UV light disinfection in healthcare settings. The study described a chronic index patient who was admitted to a ward on multiple occasions. During these admissions, when the index patient was present on a ward in one of the isolation rooms, cases of norovirus occurred, and when a new patient was placed in a room after the index patient was discharged, they also acquired norovirus. These infections occurred even after extensive disinfection with NaCl- (2000 ppm) and HPV was undertaken. The author reported that only when the room was cleaned thoroughly, and disinfected with NaCl- and HPV, followed by UV light disinfection, did environmental sampling show that norovirus was eradicated from the room and no further cases occurred.

No studies were found in the existing literature that assessed the effect of UV light disinfection in outbreaks outside healthcare settings.

No studies were found in the existing literature that assessed the cost of UV disinfection in any setting.

There was very weak evidence of no effect from one laboratory study [226] which evaluated the effect of disinfection using a manual UVC device in comparison with 1% NaCl-. The device was held approximately 1 cm from the surface, and using a wavelength of 245 nm for 5 min of exposure, the NaCl- contact time was 10 min. The study reported that NaCl- was able to remove HNV from all sampled vinyl and granite surfaces, while 7/13 (54%) of the surfaces which were disinfected by UVC remained contaminated. The device performed better for disinfection of vinyl surfaces, with a mean number of 28 HNV copies per sample on vinyl compared with 278 copies on granite.

Steam

There was very weak evidence from one prospective cohort study [221] which compared the effectiveness of using microfibre and steam technology with NaCl- in outbreak situations in a hospital. This study reported that the transmission of cases in two units was not due to environmental contamination and, as a result, concluded that steam and NaCl- are equally effective in minimizing environmental spread [14/32 (44%) cases in the unit using NaCl- compared with 22/32 (69%) in the unit using steam (*P*-value not reported but not significant). In both units, the outbreak lasted 5 days. In addition, the authors reported that microfibre and steam were more acceptable to staff and visitors, required less labour and used less water than NaCl-.

No studies were found in the existing literature that assessed the effect of steam disinfection in outbreaks outside healthcare settings.

No studies were found in the existing literature that assessed the cost of UV disinfection in any setting.

There was very weak evidence from one laboratory study [226] which evaluated the effect of disinfection using steam technology on glass, as well as wool and nylon carpets. The study reported that steam removed FCV successfully from glass (>4.93 PFU $\log_{10}$ reduction) in 10 s. However, exposure to steam, even at the highest exposure time of 90 s, did not result in sufficient removal of FCV from wool and nylon carpets. The authors reported that minor abrasion was visible on a wool carpet immediately and 24 h after disinfection.

No disinfection

There was weak evidence from one outbreak report [24] which did not use any disinfectants during an outbreak in a healthcare setting. The study reported that the outbreak affected 145 cases and lasted 63 days, despite control measures being implemented on day 4 of the outbreak. The authors

reported that the reason for the prolonged duration of the outbreak was non-compliance with interventions, and it was noted that, due to staff shortages, residents cleaned their own rooms, but the detergents used did not have virucidal properties and were not approved by EPA for decontamination in healthcare settings.

There was weak evidence from two outbreak reports [59,124] which did not use any disinfectants during outbreaks outside healthcare settings. One of these outbreaks [124], which occurred in a hotel, affected over 1000 cases and lasted over 26 weeks. The authors reported that disinfectants were not used because there was a concern that these would damage the carpets and soft furnishings. Cases continued for 14 weeks, at which point the hotel closed and deep cleaning was performed (still without disinfectants). It was reported that, after re-opening, cases increased rapidly and started to diminish a couple of weeks later. Another outbreak [59], which also occurred in a hotel, was initiated by a common food source, but secondary cases from person-to-person and environmental sources followed. It was reported that no disinfection was in place for the first 9 days. The hotel closed for disinfection (details not provided), after which it was reported that no further cases occurred.

Other disinfecting agents and technologies

There was further evidence from laboratory studies which used other disinfecting agents and technologies for removal or inactivation of HNV, or MNV and FCV as its surrogates. These included peracetic acid [244], ozone [253,254], silver dihydrogen citrate (SDS) or levulinic acid (LEV) in combination or alone [230,252,256], trisodium phosphate [233] and T36 (70% ETA + 0.28% phenylphenol, 0.01% CHG + 0.20% BAC) [231] disinfectants. The studies also assessed Serquet® wipes (singlet-oxygen-producing photosensitizer) [257], copper surfaces [258,260] and silver-impregnated cotton [259]. These studies reported that peracetic acid (1000 ppm) [244], ozone [253], SDS/LEV [230,256], trisodium phosphate at a concentration of at least 2% (FCV but not MNV) [233], $T^3$6 [231] and copper surfaces [255,258] were somewhat effective in removing or inactivating HNV and its surrogates. Other studies reported that ozone with organic soiling [254], SDS or LEV alone [252,255,256], Serquet wipes [257] and silver-impregnated cotton were not effective. These, however, were small, isolated studies which were only performed in laboratory settings. Epidemiological studies would be needed to assess their effectiveness and feasibility in outbreak situations. Additionally, one study assessed the ability of different types of cloth to remove MNV and FCV from acrylic and stainless steel surfaces [261]. None of these cloths were able to remove MNV and FCV completely from the surfaces, but two types of cloth with cotton (70%) and cellulose, as well as microfibre cloths, removed significantly more virus than non-woven and terry cotton cloths.

Fabrics

Sodium hypochlorite (NaCl-)

There was very weak evidence from one outbreak study [31] which reported using NaCl- on soft furnishings during an outbreak in hospital. This was a large outbreak which affected 164 cases, lasting 18 days. The authors reported that the initial interventions were not effective and that cases continued at the same rate. As part of enhanced control measures, thorough disinfection was carried out and the reported disinfectant was 2% (2000 ppm) NaCl-, which was used on all surfaces including carpets, curtains and walls. Following introduction of the enhanced control measures, the incidence of new cases decreased. The outbreak continued for a further 11 days, affecting 60 cases. The authors did not comment on whether NaCl- damaged or influenced the appearance of any of the soft furnishings.

No studies were found in the existing literature that assessed the effectiveness of using NaCl- for disinfecting soft furnishings during norovirus outbreaks outside healthcare settings.

There was weak evidence from two laboratory and simulation studies [227,237] which reported the effect of NaCl- disinfection on different types of fabric. One study [227] obtained samples of frequently touched surfaces on an aeroplane, which included a leather seat and a fabric portion of the seatbelt. Samples were cut into small coupons and were inoculated with HNV with or without organic load (simulated gastric fluid to mimic vomitus). The authors reported that 0.65% NaCl- applied for 1 min was effective at removing HNV from leather, but not the seatbelt fabric, when organic soiling was not present. However, NaCl- was not effective in the presence of organic load. Another study [237] used polyester and cotton fabric samples which were contaminated with FCV and MNV, and treated with 5% (5000 ppm) NaCl- for 5 min. The authors reported that complete inactivation (reported as mean $\log_{10}$ reduction in the number of viral copies using a plaque assay) was achieved for both viruses and on both fabric types. Neither of the studies reported whether NaCl- damaged or influenced the appearance of the fabrics.

Quaternary ammonium compounds

No studies were found in the existing literature that assessed the effectiveness of using QACs for disinfecting soft furnishings during norovirus outbreaks in any setting.

There was weak evidence from two laboratory and simulation studies [227,245] which reported the effect of QACs for inactivation of HNV or its surrogates on different types of fabric. One study [227] obtained samples of frequently touched surfaces on an aeroplane, which included a leather seat and a fabric portion of the seatbelt. Application of broad-spectrum QACs (0.105% dimethyl benzyl ammonium chlorides + 0.105% dimethyl ethyl benzyl ammonium chlorides) for 10 min did not result in removal of HNV from these samples. The presence of organic load did not influence these results. Another study [245] which assessed the effectiveness of QACs (10% sodium bicarbonate + 10% dimethyl benzyl ammonium chloride) on FCV inoculated on to different types of fabrics and carpets reported that the disinfectant was not able to inactivate the virus sufficiently (<2 $\log_{10}$ inactivation). Application time (1, 5 and 10 min) did not influence the results, and a longer application time resulted in less virus being inactivated for some types of fabric.

Alcohols

No studies were found in the existing literature that assessed the effectiveness of using alcohol-based disinfectants for disinfecting soft furnishings during norovirus outbreaks in any setting.

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There was very weak evidence from one laboratory study [245] which assessed the effectiveness of 70% IPA on FCV inoculated on to different types of fabrics and carpets. This study reported that, except on a 100% cotton fabric where more than 2 $\log_{10}$ inactivation was achieved after 5 or 10 min of exposure, IPA was not effective in inactivating the virus. These results were similar for different types of fabric, and longer application times did not always result in more virus being inactivated.

Phenolic disinfectants

No studies were found in the existing literature that assessed the effectiveness of using phenolic compounds for disinfecting soft furnishings during norovirus outbreaks in any setting.

There was very weak evidence from one laboratory study [245] which assessed the effectiveness of phenolic compounds (Microbac-II: 4.75% o-benzyl p-chlorophenol + 4.75% o-phenylphenol) on FCV inoculated on to different types of fabrics and carpets. This study reported that the disinfectant was not effective. With the exception of polyester fabric, where 99.9% inactivation of the virus was achieved, Microbac-II resulted in less than 2 $\log_{10}$ inactivation of FCV regardless of the type of fabric or the application time.

Hydrogen peroxide (surface and vapour)

No studies were found in the existing literature that assessed the effectiveness of using hydrogen peroxide for disinfecting soft furnishings during norovirus outbreaks in any setting.

There was weak evidence from two laboratory studies [227,237] which reported the effect of NaCl- disinfection on different types of fabric. One study [227] obtained samples of frequently touched surfaces on an aeroplane, which included a leather seat and a fabric portion of the seatbelt. Samples were cut into small coupons and were inoculated with HNV with or without organic load (simulated gastric fluid to mimic vomitus). The authors reported that application of 1.4% hydrogen peroxide for 1 min had no effect, regardless of whether organic soiling was present. Another study [237] used polyester and cotton fabric samples which were contaminated with FCV and MNV, and fogged with 4.25% of accelerated hydrogen peroxide NaCl- for 5 min. The authors reported that this completely inactivated FCV on polyester and cotton (5.1 and 3.1 x $\log_{10}$, respectively), but had no effect on MNV inoculated on either type of fabric (0.57 and 0.17 x $\log_{10}$, respectively).

Aldehydes

No studies were found in the existing literature that assessed the effectiveness of using aldehydes for disinfecting soft furnishings during norovirus outbreaks in any setting.

There was very weak evidence from one laboratory study [245] which assessed the effectiveness of metricide (2.6% glutaraldehyde) on FCV inoculated on to different types of fabrics and carpets. The study reported that, except on polyester and olein/nylon which required at least 5 and 10 min of contact time, respectively, glutaraldehyde inactivated 2 x $\log_{10}$ FCV on all types of fabric within 1 min.

Steam

There was very weak evidence from one outbreak study [19] which reported using steam on soft furnishings during an outbreak in hospital. This study described two outbreaks which occurred in one institution within 18 months of each other. The study reported that, during the first outbreak, the ward staff were more complacent and the control measures were not fully implemented. The authors gave an example where spilled faecal matter was not cleaned up from the carpet for 72 h. In the second outbreak, staff were reported to be more prepared, and were able to introduce some control measures without input from the infection control team. Some additional control measures, including immediate steam cleaning of carpets, were introduced in the second outbreak. The authors reported that, despite similar attack rates in patients (15 cases in the first outbreak and 12 cases in the second outbreak) and similar durations of both outbreaks (14 and 16 days, respectively), these additional interventions resulted in shorter ward closures (11 and 6 days, respectively) and a lower incidence of infection in staff (25 and 12 cases, respectively).

There was very weak evidence from two outbreak studies [44,160] which reported using steam on soft furnishings during a norovirus outbreak outside healthcare settings. The first outbreak [44] occurred in a hotel following a wedding reception, during which the index case vomited at the dinner table and in the toilet nearby. The outbreak, which lasted 5 days, affected a total of 98 cases, the majority of whom were present at the wedding. However, there was evidence of transmission from the fomites, as some staff and hotel guests who did not have any contact with the wedding guests also became ill. Steam cleaning of all soft furnishings was introduced as part of the control measures, and it was reported that, after implementation of the interventions, the outbreak only lasted 1 more day and affected three cases. Another outbreak [160] occurred on an aeroplane where at least five passengers and 29 staff became infected. Interviews with the crew identified a passenger who vomited and soiled the carpet next to their seat. Vomitus was cleared and disposed of in the waste bin in a toilet. It was determined that there were nine flights after the vomiting incident, with attack rates in staff being highest in the first flight, declining gradually with time, with no staff being affected on the last flight. As it was determined that person-to-person transmission was not possible, as cases did not meet each other, fomites were implicated as a source of infection. As part of the control measures, the aeroplane was disinfected by steam-cleaning the carpet. There were no further reports of infected cases, although the effectiveness of disinfection cannot be established definitely as there were no reported cases on the last flight before disinfection took place.

There was very weak evidence from one laboratory study [252] which evaluated the effect of disinfection using steam technology on wool and nylon carpets. Exposure to steam, even at the highest exposure time of 90 s, did not result in complete removal of FCV from the carpets, but removed 3.80 and 3.68 x $\log_{10}$ FCV copies from wool and nylon, respectively. The authors reported that minor abrasion was visible on a wool carpet immediately and 24 h after disinfection. The authors also reported that, immediately after disinfection took place, the carpet appeared wet and had some minor abrasions. These abrasions remained 1 h and 24 h after the carpet was steamed.

No disinfection

There was very weak evidence from two outbreak studies [56,262] which did not undertake any disinfection of soft furnishings during outbreaks in healthcare setting. The first

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outbreak [56], affecting 29 cases and lasting 15 days, was reported to be due to widespread environmental contamination. Cleaning the carpets with hot water and no disinfectants was part of the control measures introduced, and the authors reported that these were successful in controlling and eventually terminating the outbreak. However, the authors did not make any specific comments about whether the areas were decontaminated adequately and whether hot water was sufficient to remove the virus from the carpets. The second study [262] reported two cases of delayed transmission from fomites following an outbreak which occurred in a hospital. The authors reported that two carpet fitters, who were employed to remove the old carpet in a side room, became ill 36 and 48 h later. The fitters had no known exposure to norovirus, but the investigations revealed that a symptomatic case was diagnosed with norovirus 16 days prior, and that the carpet was only dry vacuumed 12 days before the removal. It was reported that the carpet was difficult to remove due to an adhesive, and the fitters needed to cut it into pieces and pull hard in order to detach it from the floor.

There was very weak evidence from two outbreak reports [124,224] which did not use any disinfectants during outbreaks outside the healthcare setting. One of these outbreaks [224] occurred in a concert hall shortly after the index case vomited in the male toilet and the carpeted walkway. It was reported that an emergency spillage compound was used to remove the vomitus, but no disinfection took place. The carpet was also vacuumed, but not until after a second concert which occurred the following day. There was no person-to-person contact, but further cases occurred among attendees of the second concert. The authors reported that males could have been infected from surfaces in the male toilet where the index case vomited, but females could only be infected from the walkway, thus demonstrating that the contaminated carpet was the source of infection for at least a proportion of the affected cases. The second outbreak [124], which occurred in a hotel, affected over 1000 cases and lasted over 26 weeks. The authors reported that the initial control measures (avoiding contact between leaving and arriving guests, immediate cleaning) were not effective and the hotel closed for thorough cleaning. Disinfection was not used as there was a concern that disinfectants would damage the carpets and soft furnishings; as such, carpets were shampooed and vacuumed instead. It was reported that cases increased rapidly after re-opening, but declined gradually over the next few weeks. The outbreak lasted a further 14 weeks after re-opening.

Other disinfecting agents and technologies

There was further evidence from three laboratory studies which used other disinfecting agents and technologies for removal or inactivation of HNV or its surrogates [239,252,253]. It was reported that SDS [252] was more effective in removing FCV from a nylon carpet (3.62 x $\log_{10}$ viral copies) than a wool carpet (1.82 x $\log_{10}$ viral copies), but did not achieve complete inactivation. The authors also reported that white suds and film were visible immediately after the application of SDS, but these disappeared after 1 h and there was no evidence of damage to the carpets 24 h later. Another study [253] reported that cotton and carpet samples treated with ozone contained $3x10^{-5}$ and $4x10^{-5}$ fewer PFU copies, respectively, compared with untreated controls. The last study [259] reported that silver-impregnated cotton fabric inactivated over 2.72 $\log_{10}$ copies of MNV after 24 h, while the virus remained almost intact on cotton without silver (0.18 $\log_{10}$ reduction).

The Working Party reviewed the above evidence and concluded that a clear benefit of hypochlorite has not been demonstrated. However, it suggests that using hypochlorite is likely to be better than using no disinfection at all. On the other hand, the evidence for other disinfectants is very weak, and suggests no clear benefit. Therefore, based on the evidence published to date, hypochlorite appears to be the most viable option for disinfection during norovirus outbreaks in different settings. It needs to be emphasized that, when using disinfectants, the users need to comply with the recommended concentrations and contact times to reduce viral contamination, but they also need to be aware that complete eradication may not have been achieved. The Working Party has no reason to challenge the previous recommendation [1] that 0.1% (1000 ppm) hypochlorite should be used for disinfection. The Working Party also concluded that appropriate cleaning and the removal of any organic soiling before disinfection takes place is essential in eradicating norovirus from the environmental surfaces. Thus, focus should be on staff education and training to ensure that appropriate cleaning standards are met. The Working Party recommends that hospitals and other health and social care providers in the UK refer to National Standards of Healthcare Cleanliness [263] for achieving appropriate cleanliness of the environment before disinfection takes place. Other providers should refer to their own national guidelines.

The benefit of automated room decontamination devices, such as those emitting UV light or dispersing HPV, is still not established for norovirus. The Working Party do not recommend the routine use of these technologies during norovirus outbreaks, but they do acknowledge that they may be useful in some situations, such as when there is ongoing transmission despite standard IPC measures already being in place.

For the laboratory studies, apart from sitting very low in the hierarchy of the evidence, the biggest limitation is the use of surrogates such as FCV and MNV. It is still not determined how well these surrogates represent HNV and, as such, whether the results can be extrapolated into real-world settings. As a result, the Working Party concluded that further studies in this area will have no benefit until culturable HNV become available, and thus suggest that the efforts should instead focus on identifying appropriate culture methods for HNV.

In regard to fabrics, current evidence, although weak, suggests that none of the disinfecting agents are beneficial. As such, the Working Party recommends that, wherever possible, these should be avoided, and appropriate, easy-to-clean alternatives should be considered (e.g. vinyl covers).

Recommendations

17.1: Ensure that appropriate cleaning, including the removal of organic soiling, precedes disinfection.

17.2: Ensure that all staff involved in environmental cleaning are trained to achieve appropriate cleaning standards.

Good practice points

GPP 17.1: Use 0.1% (1000 ppm) hypochlorite for disinfection of all appropriate surfaces during norovirus outbreaks.

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GPP 17.2: Consider using automated room decontamination devices for norovirus outbreaks when, despite the standard IPC measures being in place, there is evidence of ongoing transmission from the environment.

GPP 17.3: Avoid soft furnishings and use wipeable materials that are non-permeable and easy to decontaminate (e.g. vinyl).

How should terminal cleaning be conducted?

Terminal cleaning usually refers to a process whereby the entire room is cleaned after use. This process minimizes the risk of transmission of infectious diseases from fomites. Methods can vary, but terminal cleaning often involves disinfection of all surfaces and discarding all disposable items in the room. However, during a norovirus outbreak, this term can be used in different contexts. It can relate to cleaning and decontamination of individual rooms after individuals are discharged, but it can also be used for decontamination of entire units or facilities after an outbreak has ended. While terminal cleaning may be seen as good practice, there may be some practical issues which can prevent this strategy from being implemented. For example, this process is time-consuming, and it may not be feasible when bed pressures require the rooms or units to be available as soon as possible. Terminal cleaning can also be costly, especially if some items are discarded and replaced. It is currently not clear whether terminal cleaning offers any benefits and, if so, how, when and by whom it should be performed. It is also not known whether there are any consequences when it is not possible to perform terminal cleaning during outbreaks (e.g. whether there is a risk that this could result in further cases or outbreak recurrence). Previous UK guidelines [1] did not address the issue of terminal cleaning and did not provide any recommendations on how this should be achieved.

There was weak evidence of benefit from five outbreak studies [19,25,26,29,31] which assessed the effectiveness of terminal cleaning during outbreaks in healthcare settings. The studies reported that the number of cases affected varied from 10 to 355 (median 50 cases) and lasted from 11 days to over 2 months (median 17 days). These studies reported terminal cleaning of either individual rooms after discharge/recovery [19,25,26] or entire wards after the outbreak ended [26,29,31], and all were introduced as part of different measures to control an outbreak. After introducing terminal cleaning, among other interventions, the number of cases was between one and 98 (median 34 cases) and the outbreaks lasted a further 6–14 days (median 11 days). All studies reported a benefit of terminal cleaning. One of these studies [25] reported an outbreak which lasted 24 days and involved 10 cases. The initial control measures stopped the transmission, but new cases recurred once the ward was open. These cases were transfers from another unit, and were considered to be a re-introduction rather than recurrence of the outbreak. Nevertheless, the authors reported that further measures were introduced, which included increasing the concentration of a disinfectant, cleaning entire rooms (including changing all linen and curtains), and assessing the quality of the terminal clean using an ATP measuring device. After these measures, one case occurred; as such, terminal cleaning was successful in preventing a second outbreak. Another study [19] reported two outbreaks which occurred in one hospital within 18 months of each other. The authors reported that each outbreak was contained within one unit. Lessons were learnt in the first outbreak and, as a result, control measures were introduced more rapidly in the second outbreak. One of these interventions was terminal cleaning after the affected patient was discharged or 72 h after recovery. Terminal cleaning involved using 1000 ppm NaCl-, steaming carpets and changing curtains. The authors reported that the interventions did not have an effect on the number of patients affected or the duration of the outbreak, but fewer staff were affected and the measures resulted in a shorter duration of ward closure. Another study [26] described an outbreak which mainly affected coronary care and psychiatry units. The authors reported that, despite initial control measures, cases continued, and further measures were introduced 3 days later. Among the enhanced control measures, the coronary care unit was closed and disinfected thoroughly. This involved closing the unit for 24 h, discarding all medical supplies and fabric items, and disinfecting all surfaces with NaCl- twice by two consecutive teams. In other units, all rooms were terminally cleaned after patient discharges, and this involved thorough disinfection of entire rooms, floors and patient lockers, and discarding any supplies. Following this, it was reported that there were only two further cases on this unit, but the cases in psychiatric units continued. Another study [29] reported that the entire ward was terminally cleaned (details not provided) after the outbreak ended, and that there was no subsequent recurrence of the outbreak. The last study [31] reported that initial measures did not result in outbreak resolution, and the additional measures were put in place 3 days after the initial measures. This, among other control measures, included disinfection of an entire hospital and terminally cleaning the wards once they were symptom-free for 4 days. Terminal cleaning included thorough disinfection with NaCl-, including carpets, curtains and all equipment. The authors reported that cases continued for a further 11 days but at a lower rate, and no recurrences or second waves were reported.

There was weak evidence from one outbreak report [45] which assessed the effectiveness of terminal cleaning during an outbreak outside the healthcare setting. The outbreak occurred on a cruise ship, and extensive disinfection with NaCl- and chlorine dioxide fogging was in place throughout the duration of the outbreak. Cases continued until the ship reached port, when all passengers disembarked and no entry was allowed for 24 h. During this time, the ship was terminally cleaned (details not provided), and the authors did not report any further cases after cleaning. Additionally, one laboratory report [225] demonstrated how contamination should be removed. The study used different protocols for wiping melamine surfaces with either detergent alone or disinfecting with NaCl-. The results demonstrated that following wiping with detergent alone, all surfaces (28/28, 100%) remained contaminated, while adding NaCl- resulted in only 25% of surfaces remaining contaminated (7/28). However, when the protocol involved wiping with detergent before disinfection to remove organic soiling, this resulted in removal of the viruses from all surfaces (0/14, 0% contaminated surfaces).

There was weak evidence from one outbreak report [26] which assessed the cost of terminal cleaning during an outbreak in a healthcare setting. The outbreak affected 355 cases and lasted over 2 months. The authors conducted a terminal clean, involving thorough disinfection of patient rooms, floors and lockers, and discarding any supplies. Additionally, one

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entire unit was terminally cleaned, with all supplies and fabric items discarded in the process. The full cost of cleaning was $96,961 (approximately £74,000), which included terminal and enhanced cleaning during the outbreak. The authors also reported that the cost of the replacement of supplies was $53,075 (approximately £40,000).

The Working Party discussed the above evidence and concluded that, despite the current weak evidence of the benefit of terminal cleaning, this should be part of IPC measures for controlling norovirus outbreaks. They also acknowledged that this is current practice in many institutions, and that the limited evidence may be due to publication bias or the failure of outbreak studies to report that this control measure was used. There is little information as to how this should occur, and the Working Party agreed that current local policies should be followed. The most important decision relates to the timing of terminal cleaning. Terminal cleaning is costly because it is time- and resource-consuming. Therefore, to achieve the best results, it needs to take place shortly after patients' symptoms cease, but within a sufficiently long period to ensure that no further transmission occurs. For this reason, the Working Party concluded that the optimal time to balance these two factors is different for different types of rooms and areas within the unit. For post-symptomatic patients occupying single rooms, a minimum of 48 h is necessary before terminal cleaning takes place, although this period may be longer if recommended by the IPC team (e.g. if there is a suspicion that the person may be a chronic shedder). For shared patient areas and multi-occupancy patient areas, further consideration needs to be given to the risk that transmission may have occurred, and that some remaining individuals may be pre-symptomatic. To allow for the incubation period in pre-symptomatic cases, the Working Party concluded that, in these areas, terminal cleaning needs to be undertaken 72 h after the symptoms last occurred. Where all patients have been discharged (i.e. empty areas), terminal cleaning can take place immediately.

Recommendations

18.1: Conduct terminal cleaning as per local policy.

Good practice points

GPP 18.1: For occupied single rooms, delay terminal cleaning until at least 48 h after the patient's symptoms of norovirus have resolved. Consult the IPC team to establish if there is a need for this period to be extended.

GPP 18.2: For occupied, shared patient areas or multi-occupancy rooms, undertake terminal cleaning a minimum of 72 h after symptoms in the last case of norovirus have resolved.

How should cleaning equipment be handled after being used in areas affected by norovirus?

Cleaning equipment can become contaminated after contact with soiled surfaces. If cleaning equipment is not changed or decontaminated, this increases the possibility of norovirus transfer from one surface to another, and may therefore increase the risk of transmission to unaffected individuals. Previous guidelines [1] recommended that disposable materials are used whenever possible, and that if re-usable cleaning equipment is used, it should be dedicated to clean affected areas only and should be decontaminated after each use. This approach is widely accepted as good practice, but the evidence from published literature at the time these guidelines were developed was lacking. It is therefore still unclear whether re-using cleaning materials is associated with increased risk of norovirus transmission, and whether using disposable cleaning equipment, decontaminating re-usable equipment or dedicating the equipment to specific areas is clinically or cost effective.

There was weak evidence from one cross-sectional study [21], one prospective cohort study [221] and two outbreak studies [26,40] which assessed the effectiveness of changing the cleaning equipment during outbreaks, and one outbreak study [222] which reported what happens when the equipment is not changed. The cross-sectional study [21] which compared the risk of infection in residents in nursing homes which used new cleaning materials with residents in nursing homes which did not use new cleaning materials reported no benefit; the risk was higher for the nursing homes which used new cleaning materials for each room (OR 1.94, 95% CI 1.20–3.15) as well as for nursing homes which used new cleaning materials for every toilet (OR 1.89, 95% CI 1.23–2.90). One prospective cohort study [221], which compared the use of microfibre cloths changed between each patient and combined with steam technology for disinfection with the use of traditional cleaning with disinfection, reported that neither method was inferior during the outbreaks, and both outbreaks were contained within one unit each. The authors reported that there were 22 cases in the microfibre group and 14 cases in the traditional cleaning group (*P*-value not provided but not significant), and that the duration of the outbreaks was similar (7 days vs 9 days in the microfibre and traditional cleaning groups, respectively). In one outbreak [40], which affected 101 cases and lasted 44 days, the authors reported that using a mop head only once for cleaning vomit and faecal spills was successful in controlling outbreaks on different units. In another outbreak [26], which affected 355 cases and lasted over 2 months, introducing interventions including changing the disinfection solutions and mop heads after cleaning the floors of three patient rooms, did not seem to have an effect on the course of the outbreak. In both outbreaks, cases were reported to occur in more than one unit; however, these occurred before the outbreak was recognized and the interventions were in place. The last study [222] described how a cleaner, who had a faecal incident in a nursing home where he worked, triggered an outbreak after he continued to use the same mop. The study reported that after cleaning the faecal contamination from the floor, he continued to use the same mop to clean other floors in the nursing home. This preceded an emergency evacuation training which was attended by most staff later that day. Subsequently, 86 cases were affected in an outbreak which lasted 10 days. Most staff cases occurred following the training, but some secondary person-to-person spread to patients and other staff was also evident. This outbreak affected a further 22 cases in other institutions, although this was not associated with use of the contaminated equipment.

There was weak evidence from one outbreak report [59] which reported an effect of re-using cleaning equipment during a norovirus outbreak outside the healthcare setting. The outbreak, which occurred in a large hotel, affected 116 cases and lasted approximately 14 days. It was reported that the outbreak was initiated by infected food handlers, but continued

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despite these staff being excluded from work. One of the factors, which the authors reported contributed to the outbreak progression, was using the same cleaning materials and gloves to clean all rooms.

No studies were found in the existing literature that assessed the cost of using new equipment for cleaning during the outbreaks in any setting.

There was weak evidence from three laboratory studies [225,247,261] which assessed the effect of re-using cleaning equipment on surface contamination. One study [225] used five different protocols to evaluate the effect of cleaning or disinfecting with NaCl- on melamine surfaces. Alongside the effectiveness of the disinfection, the authors reported that they also re-used the cloth, which was used to wipe the surface after disinfection, to wipe a new melamine surface. The studies reported that in situations where HNV was eliminated (N=35), the virus was not transferred to a new surface, but in 34/35 (97%) scenarios where HNV remained on the surface, re-using the cloth resulted in cross-contamination to the new surface. In another study [247], which comapred the effectiveness of Serquet® wipes (coated in technology that produces singlet oxygen when exposed to visible light) with uncoated similar wipes and viscose wipes on stainless steel surfaces, part of the experiment involved re-using the wipes to assess the effect of cross-contamination. The study reported that between 0.2% and 0.6% of viral copies were transferred to a new surface, and there was no difference in the transfer rate between the type of wipe or the type of virus tested (HNV GI and GII and MNV). The last study [261] assessed the rate at which five different types of cleaning cloths can transfer FCV from one surface to another. The study reported that two types of cotton/cellulose cloth and a microfibre cloth transferred fewer virus copies from one acrylic surface to another when compared with a non-woven cloth and a terry cotton cloth (3.4 and 8.5 $\log_{10}$ copies vs 330 and 830 $\log_{10}$ copies, respectively; $P<0.0001$). Similar findings were obtained for stainless steel surfaces, with the cellulose cotton cloth transferring significantly fewer virus copies than the non-woven cloth (data not provided; $P<0.0001$) and the terry cloth (data not provided; $P=0.0009$), and the microfibre cloth transferring significantly fewer virus copies than the non-woven cloth (data not provided; $P=0.0110$).

The Working Party considered the above evidence and concluded that, despite only few, low-quality studies being available on this subject, prudence dictates that the practice of re-using contaminated equipment runs the risk of cross-contamination from one area to another. The laboratory studies included in this evidence further suggest that the risk may differ depending on the nature of the cleaning equipment; however, the risk cannot be eliminated completely if the cleaning equipment is re-used. Therefore, despite the limited evidence, the Working Party agreed that it was sensible to recommend that cleaning equipment should not be re-used for cleaning non-contaminated areas. As with the above conclusions about the quality of cleaning, staff need to receive appropriate training to ensure that this practice does not take place.

Recommendations

19.1: Ensure that appropriate decontamination is performed on any re-usable cleaning equipment following the cleaning of contaminated areas.

Good practice points

GPP 19.1: Provide training to staff to ensure that an appropriate sequence of cleaning takes place, and that the equipment is changed when required.

What is the clinical and cost effectiveness of enhanced routine cleaning during a norovirus outbreak?

It is a common practice during norovirus outbreaks to introduce additional cleaning routines to prevent possible transmission from fomites. Previous guidelines [1] recommended that the affected facilities should intensify cleaning, and the toilets used by affected patients must be included in this process. However, it is still not clear whether enhanced cleaning offers any clinical benefit which outweighs the cost of additional resources to perform it. It is also not known how often cleaning should occur, and which areas need to be cleaned and disinfected more often. There is also a concern that reliance on enhanced cleaning may prevent an introduction of more conventional methods to control an outbreak (i.e. isolating infected individuals), and provide the facilities with a false sense of security that the risk of transmission is minimized.

Increased frequency of cleaning

There was weak evidence from eight outbreak studies [22,25,26,28,34,37,56,112] which reported increasing the frequency of cleaning, together with other outbreak measures, to control an outbreak in healthcare settings. The studies reported between three and 355 cases (median 15 cases) and lasted from 5 days to over 2 months (median 16 days). Increased frequency of cleaning, together with other outbreak measures, was reported to contribute to outbreak resolution in six studies [22,28,34,37,56,112]. After the interventions, based on six [22,25,28,34,37,56] and five studies [22,25,28,34,56], respectively, the number of cases was between one and 37 (median four cases) and the outbreak lasted for a further 3–19 days (median 8.5 days). One of the two studies [25] which did not report a benefit mentioned that initial control measures (including enhanced cleaning) were not successful in controlling the outbreak, the recurrent cases were a result of re-introduction from another unit, and further measures which controlled the outbreak included monitoring the quality of cleaning using an ATP device. Another study [26] mentioned that the increased frequency of cleaning, along with other interventions, had no effect on the course of the outbreak, which was controlled only after thorough terminal cleaning of one unit and when contact between the patients on the other unit was restricted.

There was weak evidence from four outbreak studies [45,46,117,183] which reported increasing the frequency of cleaning, together with other outbreak measures, to control outbreaks outside healthcare settings. The outbreaks involved between 196 and over 800 cases (median 486 cases) and lasted between 12 and 20 days (median 15 days, based on three studies [45,46,117]). Only one study reported the number of cases after the intervention (137 cases [45]), and two studies reported the duration of the outbreak after the intervention (7 [45] and 15 [46] days). Only in one of these studies [46] did the increased frequency of cleaning, along with other interventions, positively impact the course of the outbreak, with the authors reporting that cases continued for a further 15

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days, but at a much lower rate. The remaining three studies which did not report any benefit reported that the source of contamination was the resort water, which needed to be disinfected to terminate the outbreak [117,183], and the outbreak on a cruise ship only ended when the ship was terminally disinfected after all passengers disembarked [45].

There was weak evidence from one outbreak report [26] which assessed the cost of increased frequency of cleaning during an outbreak in healthcare settings. The outbreak affected 355 cases and lasted over 2 months. The entire cleaning cost was $96,961 (approximately £74,000), which included terminal and enhanced cleaning during the outbreak.

No studies were found in the existing literature that assessed the cost of increased frequency of cleaning outside healthcare settings.

Rapidly mobilized team to eliminate contamination

There was weak evidence from one cross-sectional study [21] and one outbreak report [14] which reported the effect of a rapidly mobilized team (domestic or healthcare staff) following a vomiting or faecal incident in healthcare settings. One study [21] reported a possible benefit of the rapidly mobilized team to clear the contamination following a vomiting or faecal accident. In nursing homes which disinfected the source of contamination immediately, the OR for the incidence of norovirus infection among residents was lower compared with nursing homes which did not (OR 0.60, 95% CI 0.41—0.88), although this intervention did not seem to have an effect on staff (OR 0.64, 95% CI 0.41—1.02). The outbreak report [14] described an outbreak which affected multiple wards in a hospital which lasted 54 days and involved 173 cases. The authors reported that, among other interventions, the domestic staff were ready to clean up vomit and faeces and perform deep-cleaning promptly, the entire hospital was cleaned and disinfected, and these two interventions worked particularly well in controlling an outbreak. The authors reported that the additional cost of cleaning and disinfection (including enhanced cleaning) was £3500.

There was weak evidence from one outbreak report [124] which reported the effect of a rapidly mobilized domestic team following a vomiting or faecal incident. This outbreak, which occurred in a large hotel, affected more than 1000 cases and lasted over 26 weeks. The authors reported that, as part of the bundle of interventions, rapid mobilization of the cleaning staff following any contamination events was introduced. The study did not report the benefit of these strategies, and cases continued following the introduction of control measures. One reason for this was that the hotel did not introduce disinfection as there was a concern that this would damage the carpets and soft furnishing.

No studies were found in the existing literature that assessed the cost of mobilizing the cleaning team outside healthcare settings.

Focused (more thorough and more frequent) cleaning of certain areas

There was weak evidence from one cross-sectional study [21] and 10 outbreak studies [14,19,20,22,28,29,31,58,114,123] which used focused cleaning of some areas during outbreaks in healthcare settings. One cross-sectional study [21] reported a possible benefit of cleaning the toilets three times a day, with a significant effect observed for the incidence of norovirus in staff (OR 0.55, 95% CI 0.37—0.82) but not in residents (OR 0.71, 95% CI 0.50—1.00). Disinfection of toileting equipment (study referred to 'chamber pots') and cleaning and disinfection of the bathroom after use was also reported to have a significant effect on staff infections (OR 0.62, 95% CI 0.40—0.96), but was associated with more infections in residents (OR 1.52, 95% CI 1.03—2.25). Cleaning and disinfection of bathrooms after use had no effect (OR 0.70, 95% CI 0.49—1.00 for residents; not reported for staff). The 10 outbreak studies involved between three and 173 cases (median 52 cases) and lasted between 5 and 82 days (median 17 days). From these 10 outbreak studies, eight found this intervention beneficial when implemented alongside other control measures [14,19,20,22,28,29,114,123]. After the implementation of these interventions, outbreaks affected a further one to 98 cases (median 24 cases) and lasted between 3 and 18 days (median 10 days). One [58] of the two studies which did not report a benefit stated that it was difficult to associate the implemented control measures with the reduced number of cases because they were introduced at the peak, and it was likely that the number of cases would have declined regardless. The second study [31] reported that cases continued until thorough disinfection of the entire hospital took place.

No studies were found in the existing literature that assessed the effectiveness of focused cleaning of certain areas outside the healthcare setting.

No studies were found in the existing literature that assessed the cost of focused cleaning of certain areas in any setting.

Inspection followed by recleaning of insufficiently cleaned areas

There was very weak evidence from one outbreak study [25] and one environmental survey [170] which used inspection of the cleaned rooms or surfaces followed by feedback and recleaning of insufficiently cleaned areas. The outbreak study [25] reported that, following the recurrence of the cases after re-opening the ward, they introduced an intervention where an ATP measuring device was used to identify areas which were not cleaned sufficiently, and recleaning was ordered when these areas were identified. The authors reported that the recurrence was due to re-introduction of norovirus cases into the ward, rather than an ongoing outbreak. However, they did report that this strategy prevented a new outbreak from occurring. The environmental survey [170] showed a limited benefit of this strategy on wards with norovirus-positive patients. The cleaning routine included disinfection with NaCl- and an extensive list for disinfecting different types of furniture, fittings and equipment. When positive samples were found, the cleaners were asked to reclean. It was reported that cleaning got better after the first round of environmental surveillance, but declined after 3 months. The overall proportion of samples which were contaminated with norovirus was 26% for the first clean and 19% for the reclean.

No studies were found in the existing literature that assessed the effectiveness of inspection and recleaning outside healthcare settings.

No studies were found in the existing literature that assessed the cost of inspection and recleaning in any setting.

The Working Party considered the above evidence and concluded that they cannot recommend for or against this practice as part of the control measures. However, all

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members agreed that the elements of enhanced cleaning are often used as IPC measures during outbreaks and, despite the lack of evidence, they may represent the best care. Additionally, not introducing these measures may have a potential negative impact on how patients and visitors see the outbreak being managed.

Recommendations

20.1: No recommendation.

Good practice points

GPP 20.1 Introduce a higher frequency of manual cleaning and disinfection during outbreaks, with particular emphasis on high-touch areas and toilets/commodes.

GPP 20.2 Immediately clean up spills of blood or body fluids.

How should food and drinks be stored and handled in areas affected by norovirus?

Previous UK [1] and US [264] guidelines acknowledge that food and food preparation areas can serve as a common source of contamination with norovirus. The UK Food Standards Agency also advises that foods that are handled and are not subjected to further cooking are commonly implicated in foodborne norovirus infections. Sauces, sandwiches, fruits, vegetables and salads were most often cited as extrinsically contaminated sources of outbreaks of norovirus gastroenteritis. Importantly, these sources reflected the breadth of foods that can become contaminated. The UK and US guidelines have recommended the removal of all shared or communal food items for patients and staff from the clinical areas for the duration of the outbreak, and prohibit eating and drinking by staff within clinical areas. The importance of hand hygiene prior to the handling of food or drink is also a key component in the prevention of food contamination within the guidance. However, these recommendations were not based on reviewed published evidence, and it is still not known whether this practice helps to minimize transmission and whether the potential benefit outweighs the risks (e.g. in situations where individuals are severely undernourished).

There was weak evidence of benefit from one cross-sectional study [21] and two outbreak studies [108,115] which reported the removal of food during outbreaks in healthcare settings. The cross-sectional study [21] reported that nursing homes which removed any exposed food during the norovirus outbreak had a lower risk of norovirus infection for residents (OR 0.62, 95% CI 0.44—0.88) and staff (OR 0.31, 95% CI 0.19—0.50]). Of the two studies which reported outbreaks in healthcare facilities [108,115], both reported that removal of food, together with other interventions, was successful in containing the outbreaks. These outbreaks were reported to affect between 14 and 195 cases (median 26 cases) and lasted between 3 and 12 days (median 7 days). The outbreak, which was reported to affect 195 cases [115], was likely due to an infected food handler, and it was reported that most cases were infected from the common source (not identified); secondary person-to-person transmission also occurred. Neither of the two studies reported the number of cases nor the duration of the outbreaks after the interventions were implemented.

There was weak evidence from two outbreak studies [124,223] which reported the removal of food during outbreaks in non-healthcare settings. One of these studies [223], which described an outbreak due to infected food handlers in the restaurant, reported that removal of all prepared food, together with thorough cleaning of the premises and exclusion of symptomatic staff, was not successful in termination of the outbreak, and three further cases occurred until thorough disinfection was performed. The authors did not report data on the duration of the outbreak or the number of cases involved. The other study [124], which described a large outbreak in a hotel affecting over 1000 cases and lasting over 26 weeks, also reported that removing all prepared food together with other control measures was not sufficient in controlling the course of the outbreak.

No studies were found in the existing literature that assessed the effect of removing food on any unintended consequences (e.g. nutritional or hydration status) in any setting.

There was weak evidence from two outbreak studies [26,55] which reported not allowing any shared foods during an outbreak in healthcare settings. These studies were reported to affect 25 [55] and 355 [26] cases and lasted 11 days [55] and over 2 months [26]. The study which described the smaller outbreak [55] reported that removing communal foods and providing single-serve foods and individually-wrapped cutlery positively affected the course of the outbreak. Following introduction of these control measures, a further nine cases occurred and the outbreak ended within 5 days. In the larger outbreak [26], which was not recognized until week 6, this intervention, together with other measures, was not sufficient to control the course of the outbreak. The authors reported that cases continued until one unit was disinfected thoroughly and further restrictions were applied in other units.

There was weak evidence from five outbreak studies [34,44,45,59,117] which reported not allowing any shared foods or removing self-service areas during outbreaks outside healthcare settings. These outbreaks affected between 98 and over 800 cases (median 156 cases) and lasted 5—17 days (median 13.5 days, based on four studies [34,44,45,117]). Of these five studies, two studies [44,59] reported that not allowing any shared foods or removing self-service areas, together with other interventions, positively affected the course of the outbreak. In one of these outbreaks [59], initial interventions, such as excluding ill employees and educating them on the importance of hand and personal hygiene, made no difference to the outbreak outcome. The outbreak ended only after cold food which required hand preparation was removed from the menus, along with not allowing any shared foods such as crisps (chips) and popcorn, and closing for another thorough clean. The second outbreak was controlled quickly after initial control measures (i.e. only hot food allowed and removal of a self-serve buffet) were introduced. From the three studies which reported no effect [34,45,117], two studies reported that cases continued for as long as the guests were present [45,117]. In all three outbreaks, the facilities needed to be disinfected thoroughly to remove environmental contamination [34,45,117]. Following introduction of the interventions, the outbreaks affected between three and 137 cases (median 68 cases) and lasted for a further 1—12 days (median 7 days) [34,44,45].

No studies were found in the existing literature that assessed the effect of not allowing any shared foods or

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removing self-service areas on any unintended consequences (e.g. nutritional or hydration status) in any setting.

There was weak evidence from two outbreak studies [32,48] which reported allowing eating and drinking in designated areas alone during outbreaks in healthcare settings. These outbreaks affected between 22 [32] and 59 (eight asymptomatic) [48] cases and lasted 5 [32] and 9 [48] days. Both studies reported that introducing this intervention, together with other control measures, contributed to termination of the outbreak. In one of these studies [32], staff were not allowed to eat and drink on the unit and, together with excluding symptomatic staff, with disinfection and contact precautions in place, it was reported that the outbreak ended after 3 days, during which time there were five more cases. The second study [48] introduced serving of meals in residents' rooms, together with other interventions, and the authors reported that the outbreak resolved within 7 days, during which time a further 37 cases were affected.

The Working Party discussed the evidence and concluded that it is currently not possible to determine whether the benefit of removing food outweighs the potential risk of negatively affecting the hydration and nutritional status of more vulnerable individuals. Subsequently, the Working Party decided to make no recommendation on this matter. However, the Working Party recognized that pragmatic actions, which are not based on evidence, can be taken to balance the risk of norovirus transmission with less severe consequences on nutrition and hydration status. Depending on the setting and the type of individuals, these may include covering the exposed food or providing it individually wrapped, and removing food and drinks which are known to have been contaminated.

Recommendations

21.1 No recommendation.

Good practice points

GPP 21.1 To reduce potential transmission, offer food which is covered, individually wrapped or placed in closed drawers/cupboards.

GPP 21.2 Remove all exposed and communal food and utensils.

GPP 21.3 In addition to regular replacement and disinfection of crockery/glasses/utensils, replace all drinks and drinking vessels which have been exposed to contamination (i.e. uncontained vomiting and diarrhoea) immediately.

GPP 21.4 Ensure that appropriate support is offered to maintain nutrition and hydration status.

How should communal items/equipment be handled in areas affected by norovirus?

Care equipment which can be further described as re-usable non-invasive equipment can be easily contaminated with bodily fluids and infectious agents such as norovirus. These infectious agents can then be transferred during care delivery. When equipment is not cleaned between patient use, transmission of norovirus can occur. Therefore, to reduce the risk to patients and staff, it is important to ensure that cleaning and decontamination processes for communal items and equipment are adhered to and completed according to local protocols and national guidance [263,265]. Examples of equipment that may be shared between patients include commodes, hoists, pulse oximeters, drip stands and blood pressure monitors. Other communal items, such as mobile computers, can also be contaminated and require frequent cleaning during norovirus outbreaks. Cleaning and decontamination of communal items by the use of physical and/or chemical means aims to remove, inactivate or destroy the pathogens so that the items are rendered safe for use for the next patient. This must be done in accordance with manufacturers' instructions and have evidence of efficacy in activity against norovirus. Previous UK [1] and Centers for Disease Control and Prevention guidelines [264] recommended increasing the frequency of cleaning and decontamination of communal items, utilizing single-patient use equipment wherever possible, and decontaminating all other equipment immediately after use.

There was weak evidence of benefit from four outbreak studies [19,31,40,123] and one environmental survey [170] which reported the effect of disinfecting shared equipment during the outbreaks [19,31,40,123], or in non-outbreak situations when patients with norovirus were present [170] in healthcare facilities. Four studies, which described a total of eight outbreaks affecting 13—164 cases (median 58 cases) and lasting 15—44 days (median 19 days), reported that disinfecting the shared equipment, together with other interventions, contributed to outbreak resolution. In one large outbreak [40] in a LTCF, interventions were introduced late and only after new norovirus cases occurred on a third unit. The authors reported that, together with other control measures, wiping all equipment used by allied health professionals with hot water contributed to outbreak resolution. Another study [19] described two outbreaks which occurred in the same institution, and reported that additional control measures during the second outbreak, which included disinfecting all shared equipment with 1000 ppm NaCl-, had a positive effect on its progression. While the number of affected patients and the duration were similar in both outbreaks, the authors reported that these additional measures resulted in fewer staff being affected and a shorter duration of ward closures. The total number of cases and the duration of the outbreaks after control measures were introduced were also similar in both outbreaks (27 vs 27 cases and 11 vs 13 days in the first and second outbreaks, respectively). In another outbreak [31], initial control measures had no impact on the course of the outbreak, and only when enhanced interventions were introduced did the number of cases start to decrease. As part of the enhanced measures, all wards which had no new cases for 4 days disinfected all shared equipment and surfaces with 2% NaCl- to ensure that no new transmissions occurred. A further 60 cases occurred in the hospital, but the authors reported that none occurred in the wards which were disinfected, and the outbreak was contained in the entire hospital within 11 days. The last study [123] reported on four different outbreaks which occurred in the same institution over 2 years. The authors reported that the first outbreak enabled them to identify successful control measures which were then used in controlling subsequent outbreaks. These control measures, which included disinfecting all shared equipment with 500 ppm NaCl- every 8 h, resulted in fewer cases being affected in the subsequent outbreaks (82 cases in

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the first outbreak, and 31, 58 and 13 cases in the second, third and fourth outbreaks, respectively). Lastly, the environmental survey [170], which was carried out in the hospital wards where patients with norovirus were present, reported the results of disinfecting all shared equipment, surfaces and fixtures with 1000 ppm NaCl- (10,000 ppm if soiled with body fluids). The authors reported that, overall, 40% (36/91) of the equipment remained contaminated following disinfection. Recleaning resulted in less contamination (4/32, 13%), although the thermometer, notes trolley and computer keyboard were identified as potential hotspots for fomites as these were not cleaned appropriately. The authors also reported that cleaning performance improved at the start of the intervention, but deteriorated over the next 3 months.

There was weak evidence of benefit from one outbreak study [41] which described the effect of disinfecting shared equipment during a norovirus outbreak outside the healthcare setting. This outbreak, which occurred in a school, affected 103 cases and lasted 14 days. The initial outbreak measures, which included disinfection of all surfaces with NaCl- and encouraging hand hygiene, did not result in outbreak resolution. The authors reported that cases continued despite these interventions being in place, and one of the risk factors for the later cases was a classroom with shared computers. Following this finding, environmental sampling identified one computer keyboard and mouse which were contaminated with norovirus, and disinfection of these with 1:50 NaCl- solution resulted in only four further cases within 2 days, after which the outbreak ended.

There was weak evidence from one outbreak study [22] which described the effect of withdrawing access to shared equipment during the norovirus outbreak in a healthcare setting. The outbreak affected 11 patients and lasted 5 days. The authors reported that following the introduction of control measures, which included removing all toys and magazines, there were only three further cases in the next 3 days, after which time the outbreak ended. The authors also reported that there were no re-occurrences or a second wave.

There was weak evidence from two outbreak studies [44,48] which described the effect of withdrawing access to shared equipment during the norovirus outbreaks outside the healthcare setting. One of these studies [44], which described an outbreak in a hotel affecting 98 cases (wedding guests, staff and hotel guests) and lasting 5 days, reported a benefit of closing all facilities with access to shared equipment, together with other measures, in containing the outbreak. The authors reported that following introduction of these control measures, there were a further three cases the next day, after which time the outbreak ended. The other study [48],which described a large outbreak in a military camp affecting 156 cases and lasting 17 days, reported that withdrawal of all shared equipment, together with other control measures, had no effect on the outbreak progress and new cases occurred at a similar rate. The authors reported that the outbreak was resolved only after the entire facility was disinfected with NaCl-.

There was weak evidence of benefit from three outbreak studies [26,28,37] which described the effect of disinfecting shared equipment and discarding or removing access to equipment which could not be disinfected during norovirus outbreaks in healthcare settings. All three studies reported a benefit of using this strategy in containing the outbreaks. One of these studies [26], which affected 355 cases and lasted over 2 months, reported that disinfection of all surfaces and equipment with NaCl- and discarding all supplies resulted in outbreak resolution on one unit. On other units, where this strategy was not implemented, cases continued until further control measures were put in place. The authors reported that the total cost of replacing the supplies and other shared equipment was $53,075 (approximately £41,000). Another study [28] reported that the outbreak was contained quickly after control measures were put in place on the first day following the recognition of two cases with norovirus-like symptoms. One of the control measures was to disinfect all surfaces and shared items with hydrogen peroxide wipes and to remove all items (e.g. books and games) on which these wipes could not be used. The authors reported that introduction of these interventions resulted in only one further case the following day, who was reported to have been discharged already and recovered at home. The last study [37] described an outbreak in a paediatric oncology unit which affected 14 patients and lasted 23 days. It was reported that 25 staff members also had symptoms compatible with norovirus infection, although the majority of these staff were not tested. The authors reported that the introduction of control measures, which included closing the playroom where all shared toys were kept and disinfecting the toys with NaCl-, resulted in outbreak resolution, with only four patient cases occurring after the control measures were in place. No further waves of infection occurred, despite evidence that there were at least two chronic shedders present on the unit.

No studies were found in the existing literature that assessed the effect of disinfecting shared equipment and discarding or removing access to the equipment which could not be disinfected during norovirus outbreaks outside the healthcare setting.

There was one additional study [266] which was excluded because it did not report data specific to norovirus. However, the study reported sampling the self-serve hot beverage trolley, which has become a popular addition in hospitals to improve patient hydration. The authors reported that they used an ATP measuring device to assess the contamination of different types of equipment found on one of these trolleys. Based on the results (heavy contamination of various items, no data provided), the authors recommended that the trolleys and all included equipment should be disinfected more often than once daily and, if norovirus is present on a ward, all trolley equipment should be removed.

The Working Party agreed that, during norovirus outbreaks, shared equipment is likely to become contaminated. Despite weak evidence for any of the strategies, the Working Party agreed that it was good practice to ensure that shared equipment should either be decontaminated or removed and then discarded. Shared equipment that needs to be decontaminated includes medical and care devices (e.g. commodes, blood pressure monitors), other equipment used to support care (e.g. computer keyboards), as well as other items not related to care that are used by patients (e.g. toys, beverage trolleys, snack stations, patient kitchens etc.).

Recommendations

22.1: No recommendation.

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Good practice points

GPP 22.1: Ensure that any shared (communal) re-usable items are decontaminated as per manufacturers' instructions and local policy.

GPP 22.3: Where manufacturers' instructions do not provide sufficient detail on equipment decontamination, use local guidelines or contact the infection control team for advice.

GPP 22.4: Ensure that appropriate decontamination notification/certification is addressed where equipment requires transfer for maintenance.

GPP 22.5: Be aware that disinfectants may cause damage to some equipment, and ensure this issue is addressed in local cleaning guidelines.

GPP 22.6: For equipment that is not readily decontaminated, provide single-use items which can be removed easily, discarded and replaced.

GPP 22.7: To ensure that shared items are decontaminated easily, perform a risk assessment at the time of procurement.

How should used and/or infectious linen be handled to avoid norovirus transmission?

The provision of clean linen may be overlooked in norovirus outbreaks but may be important in preventing transmission. Incorrect handling, processing and storage of linen could, at least in theory, drive the transmission of norovirus. The virus could be transferred to uncontaminated items or staff hands when linen is soiled, and there is some concern that the virus could be incompletely removed or inactivated during the process of washing. If this does occur, items which were washed or stored with soiled linen could also become contaminated. Laundry is typically managed and segregated to avoid any potential risk of infection, and guidance on how linen should be handled is available [267]. Previous guidelines [1] did not make any specific recommendations based on the evidence, but stated that the relevant Health Technical Memorandum document should be followed for advice on laundry. This document [267], however, does not mention whether enhanced control measures are required during norovirus outbreaks.

There was weak evidence of benefit from one cross-sectional study [21] and two outbreak studies [19,30] which assessed the effect of how laundry was handled during norovirus outbreaks in healthcare settings. One cross-sectional study [21] reported that the risk of acquiring an infection was lower for residents in nursing homes with a policy to close laundry bags carefully during norovirus outbreaks compared with residents in nursing homes without this policy in place (OR 0.65, 95% CI 0.45—0.92), although this risk was not lower for staff (OR 0.71, 95% CI 0.50—1.00). One outbreak study [19] described two outbreaks in the same institution, and reported that enhanced control measures were introduced in the second outbreak, including taking linen carriers to the bedside, using hot-water-soluble bags for handling contaminated linen, and using labels to identify contaminated linen bags. The study reported that, despite the similar duration and number of patients affected, fewer staff were affected in the second outbreak, and the ward was able to open earlier than after the first outbreak. The second outbreak study [30], which affected 92 cases and lasted 24 days (all in units caring for older patients), reported that the interventions introduced did not seem to affect the course of the outbreak for the affected four units (51 cases and 16 days after introduction of the interventions), but the outbreak did not spread to other areas of the hospital.

There was very weak evidence of benefit from one outbreak study [44] which assessed the effect of how laundry was handled during a norovirus outbreak outside a healthcare setting. This study described a large outbreak in a hotel affecting 98 cases (wedding guests, staff and hotel guests) and lasting 5 days. The authors reported that, among other interventions, all laundry was washed at a temperature of at least 60°C, and these interventions resulted in the outbreak being contained, with only three further cases occurring the following day.

No studies were found in the existing literature that assessed the effect of how laundry was handled on cost during norovirus outbreaks in any setting.

The Working Party agreed that, despite little evidence, laundry is an important part of IPC. Based on the available literature, no recommendations can be made, but the Working Party agreed that all facilities need to follow current national guidelines for how laundry should be handled, and made no recommendations specific to norovirus.

Recommendations

23.1: No recommendation.

Good practice points

GPP 23.1: Ensure that all laundry is handled and segregated according to national guidance.

What is the clinical and cost effectiveness of excluding staff affected by norovirus from work? When should these staff be allowed to return to work and how should their return be managed to ensure patient safety?

Staff often provide care for a number of patients and move between different patient environments, meaning they can act as sources of norovirus transmission. Ongoing, although reduced, viral excretion beyond the acute phase means that staff members who return too early may infect others. In order to reduce the risk of transmission of norovirus, previous guidelines [1] recommended that symptomatic members of staff in health and social care facilities are typically excluded from work until symptom-free, with no loose stools for 48 h. Due to the high infectivity of norovirus in the acute stage, this is an important control strategy. However, exclusions may place additional burden on remaining staff and potentially increase the risks associated with reduced staffing.

There was weak evidence from one case—control study [127] which investigated the effect of exclusion policies for staff on the risk of norovirus outbreaks in healthcare settings. The study, which was undertaken in LTCFs, reported that the risk of experiencing a norovirus outbreak was not significantly different between facilities which had an exclusion policy compared with those which did not (RR 0.26, 95% CI 0.04—1.66). There was also no difference when comparing

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facilities which offered paid sick leave for staff and those which did not (RR 3.32, 95% CI 0.90—12.22).

There was inconsistent evidence from one cross-sectional study [21] and two outbreak studies [34,114] which reported excluding symptomatic staff working in healthcare settings until symptom resolution. The cross-sectional study [21] reported that this exclusion policy implemented in nursing homes had a positive effect on the incidence of norovirus infection in residents (OR 0.60, 95% CI 0.39—0.92; *P*-value not reported) but not in staff (OR 2.42, 95% CI 1.45—4.04; *P*-value not reported). Of the two outbreak studies which introduced this policy, one study [34] reported the benefit of excluding staff until symptom resolution. This outbreak, which occurred in a nursing home, involved 51 cases and lasted 9 days. Following the introduction of control measures, which included policies for symptomatic staff to be excluded from work, the outbreak lasted for a further 7 days and affected 37 cases, although the authors stated that the rate at which the cases occurred had slowed. The study which did not show a benefit of excluding staff until they recovered [114] described a large outbreak in a hospital. This outbreak affected 97 cases and lasted 29 days, and the authors reported that it spread to other units despite the interventions. The studies did not report whether or not a post-symptomatic staff member who returned to work was responsible for infecting others.

There was very weak evidence from one outbreak study [37] which reported excluding symptomatic staff working in healthcare settings for 24 h until symptom resolution. This outbreak affected 14 cases and lasted 23 days. The authors reported that a staff exclusion policy, together with other control measures, was beneficial. It was reported that four further cases become infected and the outbreak ended soon after control measures were in place, although the authors also stated that they had at least two chronically infected individuals who continued to shed the virus for a prolonged period of time. The study did not report whether or not a post-symptomatic staff member who returned to work was responsible for infecting others.

There was moderate evidence from one cross-sectional study [21] and 18 outbreak studies [14,19,20,29—33,39,40,55,57,108,111,113,125,146,268] which reported excluding symptomatic staff working in healthcare settings for 48 h until symptom resolution. The cross-sectional study [21] reported that this exclusion policy implemented in nursing homes had a positive effect on the incidence of norovirus infection in residents (OR 0.43, 95% CI 0.28—0.67; *P*-value not reported) but not in staff (OR 1.48, 95% CI 0.88—2.50; *P*-value not reported). The 18 outbreak studies [14,19,20,29—33,39,40,55,57,108,111,113,125,146,268] described a total of 22 outbreaks which affected 14—281 cases (median 62 cases) and lasted between 3 and 54 days (median 15 days, based on 15 studies reporting 19 outbreaks [14,19,20,29—33,39,40,55,57,108,111,125]). Eleven of these studies (61%) reported a benefit of using staff exclusion for 48 h after symptom resolution as part of the control measures. None of the studies which did not report a benefit of staff exclusion stated explicitly that a 48-h period was not sufficient. Two of these studies reported that further control measures were required [31,33], one study mentioned that the interventions did not seem to have an effect on the course of the outbreak but might have prevented the spread of the outbreak to other units [30], one study stated that new cases occurred despite two groups of patients having no contact with each other [268], one study reported that an outbreak continued because of an epidemic in the community and new cases arriving at hospital continuously [14], and two studies stated that, despite having policies in place, staff returned to work before 48 h after symptom resolution [111,113]. One of the studies [19] which reported the benefit of this strategy when combined with other control measures also reported that they offered enhanced sick pay to encourage compliance. However, they did not report whether increasing pay had any effect on compliance. Two studies reported logistic issues when introducing this policy. One study [146] reported that nursing staff were easily replaced, but medical staff and allied professionals were not, which resulted in problems with staffing levels. Another study [108] reported that staff were not always eligible for sick leave, and that the management were concerned about staffing levels. However, concerns regarding staffing levels were resolved quickly as the wards were also closed to new admissions, and therefore the staffing requirements were reduced. There was also one study which estimated that the cost of staff exclusion was approximately £11,000 for the affected 30 healthcare workers, although they did not state whether this strategy was cost effective or not.

There was very weak evidence from one outbreak study [122] which reported excluding symptomatic staff working in healthcare settings until they were symptom free, but for at least 48 h. This outbreak, which occurred in a hospital, affected 77 cases and lasted 37 days. The authors reported that this staff exclusion policy, although somewhat successful, was not beneficial. It was reported that some healthcare workers returned to work earlier than 48 h after symptom resolution because of severe staff shortages. This was accepted by the management, as otherwise the care of patients would have been seriously jeopardized. The authors did not report whether or not these staff infected others upon their return.

There was weak evidence from eight outbreak studies [24,26,36,38,56,112,123,126] which reported excluding symptomatic staff working in healthcare settings for 72 h after symptom resolution. The studies described a total of 11 outbreaks which affected 13—394 cases (median 42 cases) lasting between 8 days and 2 months (median 19 days). Four of these studies (50%) [36,112,123,126] reported a benefit of using staff exclusion for 72 h after symptom resolution as part of the control measures. None of the studies which did not report a benefit stated explicitly that this period was not sufficient in preventing transmission to others. Two studies [26,56] reported that the outbreak continued due to extensive environmental contamination, and that the outbreak was resolved only after thorough environmental cleaning and disinfection. Another study [38] reported that the control measures, which included a staff exclusion policy, were not initially successful but they slowed down the rate at which new cases occurred. The last study [24], which stated that the outbreak continued for further 59 days, reported that the reason for the prolonged duration was staff being non-compliant with the interventions. One of these was the staff exclusion policy, and it was reported that staff were not able to stay at home for 72 h after symptom resolution due to staff shortages.

There was weak evidence from one cross-sectional study [21] which reported implementation of a policy where recovered staff were caring only for symptomatic cases. This study reported that this policy, implemented in nursing homes, had

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no benefit on the incidence of norovirus infection in residents (OR 2.17, 95% CI 1.19—3.99; *P*-value not reported) or staff (OR 4.63, 95% CI 1.99—10.73; *P*-value not reported).

There was very weak evidence from one outbreak study [59] which reported excluding symptomatic staff working outside a healthcare setting until 24 h after symptom resolution. The outbreak, which occurred in a hotel, affected 116 cases and lasted 19 days. The authors reported that the hotel had an existing policy which required staff to stay at home until symptom resolution. However, staff did not comply with this policy because they did not want to miss work. The hotel introduced another policy which required staff to stay at home for 24 h after symptom resolution, but the authors reported that, despite being told repeatedly, staff were still non-compliant. It was reported that staff were more compliant after sick pay was introduced, and this strategy, combined with other control measures, eventually contributed to outbreak resolution.

There was very weak evidence from two outbreak studies [44,269] which reported excluding symptomatic staff working outside healthcare settings until 48 h after symptom resolution. One of these studies [44] reported this strategy to be beneficial. This was an outbreak in which most cases were affected following a common exposure to a vomiting index case, but it was reported that secondary person-to-person spread also occurred. The outbreak lasted 5 days and affected a total of 98 cases, including food handlers. The authors reported that following the introduction of control measures, which included a policy for staff to stay at home for 48 h after symptom resolution, there were only three further cases and the outbreak ended 1 day later. In the second outbreak [269], which occurred on a cruise ship affecting 196 cases and lasting 12 days, staff exclusion for 48 h, together with other control measures, was not successful. The authors reported that the outbreak resolved 7 days later, when the ship arrived at the port, all passengers disembarked and the ship was disinfected thoroughly. The authors did not specifically report whether or not symptomatic or recovered staff were responsible for the transmission of norovirus to others.

There was very weak evidence from one outbreak study [41] which reported excluding symptomatic staff working outside a healthcare setting until 72 h after symptom resolution. This was a small outbreak in a restaurant which affected three cases. The authors reported that no further cases were reported following staff exclusion for 72 h after symptom resolution, discarding food and disinfecting the entire premises.

There was very weak evidence from one outbreak study [118] which reported excluding symptomatic staff working outside a healthcare setting until they received clearance from the doctor. This outbreak occurred following three different events at a function centre following exposure to food prepared by a symptomatic food handler. It was reported that at least 77 people were affected by this outbreak. The authors reported that the function centre closed and all symptomatic staff were excluded from work until they obtained clearance. Following these interventions, no further cases were reported.

There was very weak evidence from one outbreak study [46] which reported excluding symptomatic staff working outside the healthcare setting until they received a negative norovirus test, taken more than 72 h after symptom onset. The authors reported that following the introduction of this policy, together with other control measures, cases continued for a further 15 days but at a much lower rate.

The Working Party agreed that there is currently weak evidence that excluding symptomatic staff with norovirus infection reduces the number of affected people in some outbreaks. Based on the knowledge that most individuals shed the virus for approximately 48 h after symptoms, this strategy would be considered good practice. However, the Working Party also recognized that this may not always be possible in some outbreaks or settings. For example, the literature pointed out the difficulties meeting staffing levels when doctors and allied health professionals were excluded. Therefore, the Working Party recommended that the standard procedures should support the policy where staff are excluded for 48 h after symptoms have resolved. However, in outbreaks when this is not possible (i.e. when it is not possible to replace skilled members of staff), this policy can be withdrawn if the absence of these staff can put individuals at risk. In these situations, a local risk assessment needs to be made that takes into account skills and staffing levels before allowing staff to return within 48 h.

Recommendations

24.1: Consider excluding symptomatic staff with norovirus infection for a minimum of 48 h after symptom resolution.

Good practice points

GPP 24.1: In outbreaks where staff exclusion policy is not feasible (i.e. when it is not possible to replace skilled members of staff), conduct a local risk assessment that takes into account skills and staffing levels before allowing staff to return within 48 h of symptomatic norovirus infection.

What approaches to the management of transfer of individuals infected with norovirus are most practical and effective at minimizing the risk to others?

Due to the high infectivity of a patient during the acute stage of infection with norovirus, the most reliable precaution against onwards transmission in another unit is to avoid the transfer of patients with infection or those exposed to infectious patients. Previous guidelines [1] recommended that, should clinical need necessitate transfer of an infected or an exposed, asymptomatic individual, a risk assessment should be undertaken, and the receiving staff and transport staff should be informed of the patient's norovirus infection. This would allow them to ensure that appropriate placement of the patient and infection control precautions can be put in place.

There was moderate evidence from one cross-sectional study [21] and 14 outbreak studies [19,20,26,27,29,30,37,38,56,108,111,115,121,146] which assessed the effectiveness of avoiding patient transfers during norovirus outbreaks in healthcare settings. The cross-sectional study [21], which assessed the effectiveness of different control measures in nursing homes affected by norovirus outbreaks, reported that there was no significant difference in the incidence of either residents or staff becoming infected during the outbreaks (OR 1.33, 95% CI 0.90—1.95, *P*=NS for residents; OR 1.47, 95% CI 0.87—2.48, *P*=NS for staff). The outbreak studies, which described a total of 17 outbreaks, reported different approaches to transfers, all of which involved avoiding internal

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transfers within the facility. These included a blanket approach of avoiding transfers of any patients anywhere in the facility [19,108,115,146], avoiding transfer of symptomatic patients [26,27,56], avoiding transfers from affected areas [20,29,30,37,121], and avoiding transfers to and from affected areas [38,111]. Two studies also mentioned that the transfer of symptomatic patients was only allowed in emergency situations and under strict contact precautions [26], or only with permission from epidemiologists. Two studies also mentioned that transfer to another facility was avoided [108,146]. These outbreak studies affected between 14 and 355 cases (median 29 cases), lasting 3 days to over 2 months (median 15 days, based on 13 studies reporting 16 outbreaks [19,20,26,27,29,30,37,38,56,108,111,115,121]). In total, 10 of these studies (72%) reported that avoiding transfers, together with other control measures, was beneficial in terminating an outbreak. Additionally, four of these studies [19,29,108,115] specifically reported that the outbreak was controlled within one unit. The remaining studies did not mention whether cases occurred in other parts of the facility or in another facility after transfer restrictions were implemented. Following introduction of the control measures, the studies reported that the outbreaks affected a further two to 51 cases (median 10 cases, based on six studies reporting seven outbreaks [19,20,29,30,37,56]) and lasted a further 2–16 days (median 10 days, based on six studies reporting seven outbreaks [19,20,29,30,38,56]).

No studies were found in the existing literature that assessed the effectiveness of avoiding transfers outside healthcare settings.

There was very weak evidence from one outbreak study [34] which assessed the effectiveness of informing a receiving institution of an ongoing norovirus outbreak during transfers between healthcare settings. This outbreak, which occurred in a nursing home, affected 59 cases and lasted 9 days. The authors reported that the receiving hospital experienced one case of norovirus infection in a healthcare worker who cared for one of the nursing home residents. No patients were affected, and transfers did not result in an outbreak occurring in the receiving hospital.

No studies were found in the existing literature that assessed the effectiveness of informing the institutions of an ongoing outbreak in facilities outside healthcare settings.

The Working Party reviewed the above evidence and concluded that patient/resident/individual transfers should be avoided if possible. Any transfers which are deemed to be clinically necessary should take place as planned; however, they need to involve good communication with the receiving team so that appropriate precautions can be implemented.

Recommendations

25.1: Avoid transfers to/from affected areas during norovirus outbreaks. This includes transfers within and between facilities.

Good practice points

GPP 25.1: Use a local risk assessment to determine whether the transfer of the individual is clinically necessary.

GPP 25.2: Where a transfer is clinically necessary, inform the receiving institution/department that the patient is infected with norovirus so that appropriate precautions can be taken.

GPP 25.3: Where transfer is necessary, and where appropriate (e.g. for urgent radiology), consider placing patients last on the list in order to minimize opportunities to transmit norovirus to others.

GPP 25.4: Ensure that appropriate cleaning takes place post transfer.

When should a patient affected by norovirus be discharged home or to another facility?

Discharge of a patient with norovirus infection poses a risk of onwards transmission amongst patients and staff in the new location. The acute phase of norovirus infection is highly infectious, but if clinically appropriate, patients are typically discharged to their own home during any stage of illness. Discharge of patients with norovirus infection to facilities other than the patient's home tends to be avoided. Previous guidelines [1] distinguished between three scenarios to facilitate discharge of patients with norovirus infection where feasible whilst minimizing the risk to others. Discharge to a nursing or residential home which is not known to be part of an outbreak should be avoided. If the nursing/residential home is known to be part of an outbreak, discharge may go ahead provided the patient's care needs can be met. Transfer to other community care facilities and other hospitals should also be avoided until the patient has been asymptomatic for 48 h.

There was very weak evidence from five outbreak studies [19,25,29–31] which reported using different approaches to discharging patients during norovirus outbreaks in healthcare settings. The studies described discharging all symptomatic patients and their contacts early if possible [25], discharging patients 48–72 h after symptom resolution [19,29,30], and a blanket approach of no patients being discharged from the unit until the outbreak ended [31]. None of these studies reported whether or not there were any benefits of this approach for the facility in which an outbreak occurred, nor for the receiving facility.

No studies were found in the existing literature that assessed the effectiveness of avoiding discharges outside healthcare settings.

The Working Party agreed that, despite very little evidence, discharge to another facility should not take place for 48 h after symptom resolution for all individuals affected by norovirus. As with transfers, the Working Party recognized that this may not always be possible, and that a clinical need may arise when individuals need to be discharged to another care facility earlier. This includes discharge to any new healthcare setting (e.g. new residential home placement, rehabilitation hospital or community bed). The decision for discharge earlier than 48 h after symptom resolution needs to be balanced carefully and, if the discharge is considered necessary, the receiving facility needs to be informed so that appropriate arrangements can be made. When the individual is going to be discharged to a non-residential care setting, the Working Party agreed that there is no reason to delay this

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process if a patient is otherwise medically stable (fit) for discharge, and when there is no clinically vulnerable person in the same household. In situations where the patient is assessed in an A&E or ambulatory assessment unit and deemed not to need hospital admission, the Working Party agreed that this is considered a non-admission and not a discharge. In these situations, returning the individual to a long-term residential facility should still be considered appropriate (as norovirus was likely acquired in the patient's own residential institution), especially if there is a known outbreak at that institution. This is in line with Good Practice Point 3.1, which recommends that admission should be avoided to reduce the chances of hospital-based outbreaks.

Recommendations

26.1: No recommendation.

Good practice points

GPP 26.1: If a patient is medically stable (fit), discharge them home only when there is no clinically vulnerable person in the same household.

GPP 26.2: Unless the individual risk assessment dictates otherwise, avoid discharging individuals with known or suspected norovirus infection to another facility until 48 h have elapsed since the last episode of diarrhoea or vomiting.

GPP 26.3: If the patient with norovirus infection is discharged to another facility sooner than 48 h after symptoms cease, inform the receiving facilities so that appropriate arrangements can be made.

GPP 26.4: If receiving discharged patients with confirmed or suspected norovirus infection from other facilities, ensure that appropriate arrangements are in place so that norovirus is not transmitted to others (e.g. isolation is recommended for at least 24 h for asymptomatic/suspected patients and 48 h after the symptoms have resolved for infected/confirmed patients).

What is the clinical effectiveness of different medications given to alleviate the symptoms of norovirus infection?

Norovirus infection is usually self-limited and therefore typically treated with supportive measures, such as prevention of dehydration, electrolyte disturbance and malnutrition which can be seen in severe cases. No effective vaccines or antimicrobial drugs are currently licensed for use against norovirus infection. For symptom control, previous guidelines [1] did not recommend the routine use of anti-emetics due to a lack of evidence of the efficacy of these drugs in adults, and concerns regarding conflicting evidence, especially side effects, when used in children. Similarly, antimotility agents were not recommended routinely, but may be used in practice when other causes of diarrhoea have been excluded (i.e. *Clostridioides difficile*, where use may be harmful). In practice, both anti-emetics and antimotility agents are sometimes used in specific circumstances, such as if a patient is volume-depleted and cannot tolerate oral rehydration, particularly if they cannot be hospitalized. Previous guidelines [1] also expressed concern regarding the masking of infectivity of patients with the use of anti-emetic and antimotility medications.

There was weak evidence of benefit from one RCT [270] which assessed the effectiveness of antiviral medication (nitazoxanide) to reduce the duration of symptoms in patients with norovirus infection. This was a small study which included patients with either rotavirus, norovirus or astrovirus; the subset of the population with norovirus was six and seven cases in the treatment and placebo groups, respectively. The study reported that the median number of days from first dose to symptom resolution (norovirus patients alone) in the treatment group, given 500 mg nitazoxanide twice a day for 3 days, was 1.5 days (IQR 1.5—1.5), while it was 2.5 days (IQR 1.5—6.5; P=0.0295) in the group which received the same schedule with placebo. The authors did not report whether there were any differences in the severity of symptoms between the groups. There were some adverse events related to treatment, which included one case with abdominal pain and one case with headache in the nitazoxanide group, as well as one case each of abdominal pain, nausea, dyspepsia and dysuria in the placebo group. However, it is not possible to determine whether these patients were infected with norovirus.

There was moderate evidence of benefit from one RCT [271] and one cross-sectional study [272] which assessed the effectiveness of medication to regulate bowel movements on the severity [271,272] and duration [271] of norovirus symptoms. The RCT, which used bismuth subsalicylate (BSS) or placebo in volunteers inoculated with norovirus (N=17 and 15 participants, respectively, who were subsequently infected with norovirus), reported that there were no significant differences in the number of vomiting episodes, number of diarrhoeal episodes, severity of symptoms or overall duration of illness between the groups (data not reported). The only significant differences were the number of individuals with headaches and the median duration of gastrointestinal symptoms, which were both lower in the BSS group [1/7 (6%) vs 7/15 (47%), P=0.014 for headaches; 14 vs 20 h, P<0.05 for duration of symptoms in BSS and placebo groups, respectively). The cross-sectional study [272] reported that the incidence of gastroenteritis symptoms was lower in residents who had been receiving metamucil (constipation relief agent with psyllium husks containing soluble fibre with possible prebiotic effect) before and during the norovirus outbreak in a nursing home compared with residents who had not [3/11 (27%) vs 27/38 (71%), respectively; P=0.012]. The authors reported that the evidence of infection was similar in both groups of residents, and therefore the effect was not only seen in the incidence and severity of symptoms. Neither of these two studies reported whether any adverse effects were associated with treatment.

There was moderate evidence of no benefit from one RCT [273] and one non-RCT [274] which assessed the effectiveness of probiotics to reduce the duration of symptoms in patients with norovirus infection. One study used *Lactobacillus acidophilus* tablets [273] (N=28 and 35 for the intervention and placebo groups, respectively), and another study used *Lactobacillus casei* (strain Shirota)-fermented milk product [274] (N=37 and 21 in the intervention and placebo groups, respectively). Both studies reported that there was no difference in the duration of symptoms between the treatment and placebo groups. The only benefit was a shorter duration of fever over 37°C observed in one study [274], although this was not significant for fever over 38°C. The severity of symptoms and adverse events were not assessed in either of these two studies.

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There was moderate evidence of benefit from one RCT [275] which assessed the effectiveness of an immunomodulating medication (anaferon, $N=30$ in intervention and placebo groups) on the duration of norovirus symptoms. The authors reported that the durations of diarrhoea, vomiting and nausea were not significantly different between the groups (data and P-value not reported), but that the overall durations of illness and fever were lower in the anaferon group (data not reported; $P<0.001$). The authors also reported that the duration of virus shedding was shorter in the treatment group {mean 5.70 [standard deviation (SD) 0.47] days in intervention group vs mean 9.80 (SD 0.58) days in placebo group}. Adverse events were not assessed in this study.

There was very weak evidence of benefit from one cross-sectional study [272] which assessed the effectiveness of other medications on the severity of norovirus symptoms. This study compared a group of residents who received different types of medication before and during a norovirus outbreak in a nursing home. They reported that residents who received antipsychotic medication (haloperidol, chlorpromazine, thioridazine or trifluoperazine) together with anticholinergic medication (trihexyphenidyl or benztropine) had a lower incidence of gastroenteritis than residents who did not [1/7 (14%) vs 15/21 (71%), respectively; $P=0.013$], despite the evidence that the incidence of infection was similar in both groups.

The Working Party reviewed the above evidence and concluded that no therapy can currently be recommended to alleviate the symptoms of norovirus. However, it is recognized that some patients may develop secondary conditions (e.g. dehydration) due to an underlying norovirus infection. When this occurs, the Working Party highlights the need to treat these conditions early to avoid any complications.

Recommendations

27.1: No recommendation.

Good practice points

GPP 27.1: Consider appropriate treatment for secondary conditions (e.g. rehydration therapy for individuals at risk of dehydration).

What are the best strategies for preventing and managing norovirus infection in immunocompromised patients? How should patients with chronic norovirus excretion be managed?

Immunocompromised individuals are at increased risk of more prolonged, severe and even life-threatening gastroenteritis following norovirus infection. In some cases, chronic infection can develop with persistent diarrhoea and excretion of norovirus in the faeces [276]. There are currently no effective licensed vaccines or drugs available to protect against norovirus infection. Good adherence to IPC measures, especially hand hygiene and other measures described in these guidelines, is of vital importance in preventing transmission of norovirus to immunocompromised patients. No antiviral drugs or other therapeutic agents are currently available to treat norovirus infection. Supportive care with particular attention to preventing dehydration, electrolyte disturbance and malnutrition is therefore the mainstay of management, especially in immunocompromised patients where prolonged and severe gastroenteritis is more likely. The prevention and management of norovirus infection in immunocompromised patients was not examined in the previous norovirus guidelines [1]. In immunocompetent individuals, symptoms of norovirus gastroenteritis typically resolve within 24–48 h [5], but in hospitalized patients and young infants, symptoms may be more prolonged (e.g. 4–6 days) [6,277]. More chronic illness may be observed in individuals with suppressed immune responses, where persistent diarrhoea alongside detection of norovirus RNA in faeces is seen; in some cases, this can be months, and even years, after the initial infection [278,279]. These individuals present significant challenges in terms of clinical management of symptoms, as well as IPC, in health and social care settings, where there may be risk of onward transmission. There are no well-established treatments, and a multi-disciplinary approach to management is often required. The significance of persistent norovirus detection in faeces to IPC also presents a challenge, as inability to cultivate norovirus means that the duration of shedding of infectious virus is unknown, and the risk of onward transmission is unclear. The approach to patients with chronic norovirus infection was not examined in the previous norovirus guidelines [1].

Preventative measures

There was moderate evidence of no benefit from one RCT [280] which assessed the effectiveness of a neutropenic diet compared with a food-safety-based diet for preventing norovirus infection in immunocompromised patients. The study reported no significant difference in the incidence of norovirus in the group of children undergoing haematopoietic stem cell transplantation and given a neutropenic diet [2/102 (4%)] compared with the children given a food-safety-based diet [3/53 (6%); $P=1.00$].

There was very weak evidence from two outbreak studies [62,128] which assessed the effectiveness of different control measures to prevent transmission of norovirus to immunocompromised patients. The first study [62] described an outbreak which occurred in a paediatric haematology and oncology unit, affecting 13 cases and lasting 38 days. In addition to the standard control measures (disinfection, isolation and contact precautions), the authors reported that they tested all symptomatic patients and retested them weekly until a negative result was obtained. They found this approach beneficial because the majority of patients on their unit experienced treatment-related diarrhoea, and testing helped them to identify and isolate all cases of norovirus. Additionally, the authors reported that they found it beneficial to monitor all affected cases closely, which prevented deterioration. Following the introduction of control measures, the outbreak affected a further two cases, lasting 11 days. The authors reported that the control measures had a negative impact on ward resources as well as psychological well-being of the patients (details not reported). The second study [128] reported a prolonged outbreak, which affected 17 cases in a haematology unit and was initiated by a chronic norovirus carrier. The patient was reported to acquire norovirus during a previous outbreak (not described) on the same unit. This patient suffered from persistent diarrhoea and tested positive repeatedly. He had multiple stays on a ward over 10 months, during which time the patient was isolated in balanced or positive-pressure

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rooms which were disinfected after his discharge. Despite this, other patients on the unit were infected with the same norovirus strain when this patient was present or when they occupied the room after him. The authors reported that isolation of the patient and disinfection of the room had no effect on controlling the outbreak.

No studies were found in the existing literature that assessed the effectiveness of any management strategy of patients with chronic norovirus to prevent norovirus outbreaks in any setting.

Management of infected immunocompromised persons

Supportive measures. There was weak evidence of no benefit from eight case studies/series [281–288] which investigated the effectiveness of nutritional interventions in immunocompromised patients, all with chronic norovirus infection. These studies included nine patients prescribed a lactose-free diet, 14 patients prescribed a gluten-free diet, 16 patients who were given total parenteral or enteral nutrition, one patients who was given probiotics, and one patient prescribed an elemental diet. None of these interventions resulted in the clearance of norovirus. Symptom improvement was observed in three patients on a lactose-free diet and two patients on a gluten-free diet, but all five of these patients were reported to relapse later. No side effects were reported.

There was very weak evidence of no benefit from four case studies/series [282,289–291] which investigated the effectiveness of different antimotility medications administered to immunocompromised patients with chronic norovirus infection. These studies included a total of five patients, three of whom received loperamide (one in combination with Lomotil, one with opium and one alone). In the remaining two patients, the medication was not specified. Symptom improvement only occurred in one patient, who received loperamide with opium. It was reported that any attempts to taper this regime resulted in the recurrence of symptoms in this patient. The authors also reported that symptoms resolved only when the patient recovered their antibody production 8 months after their final chemotherapy session. No side effects were observed.

Direct antiviral therapy. There was very weak evidence of benefit from three case studies/series reported in four articles [281,284,288,292] which investigated the effectiveness of antiviral medications administered to immunocompromised patients with chronic norovirus infection. These studies included a total of 14 patients, 13 of whom received ribavirin (one with interferon). The remaining patient received favipiravir in combination with loperamide. Three of the 13 patients who received ribavirin had evidence of viral clearance, and one further patient experienced symptom improvement but subsequently relapsed. The three patients with viral clearance experienced treatment-related anaemia. The patient who received favipiravir also initially experienced norovirus clearance, but relapsed when treatment was withdrawn. The authors reported that episodes of clearance and relapse occurred when the patient was on and off treatment. It was also reported that the patient's liver profile deteriorated whilst the patient was given favipiravir.

Indirect antiviral therapy. There was weak evidence of benefit from one cross-sectional study [293] and 16 case studies/series [281–285,289,290,294–302] which investigated the effectiveness of immunoglobulin administration in immunocompromised patients with norovirus infection. The cross-sectional study [293], which was conducted in patients with acute norovirus infection, reported a significant difference in the volume of stool output 7 days after the start of immunoglobulin administration (data not provided), but did not report a significant difference in diarrhoea resolution (OR 65.3, 95% CI not reported; P=0.078) or the duration of diarrhoea (12.8 vs 11.91 days in intervention and control groups, respectively; P=0.63). The case studies/series [281–285,289,290,294–302] included a total of 53 patients, of whom 18 were chronically infected, 14 were acutely infected, and it was not possible to determine how long the infection lasted in 21 patients. Of 18 chronic patients who were administered immunoglobulin, three (17%) patients had evidence of norovirus clearance from faeces (defined as negative PCR test) and a further two (11%) patients experienced symptom improvement without evidence of norovirus clearance. It was also reported that one patient developed graft rejection following immunoglobulin therapy. Of the 14 acute patients, all but one (93%) had evidence of norovirus clearance, although it was also reported that four of these patients experienced a relapse. One patient, who did not have norovirus clearance, was reported to experience fewer symptoms following immunoglobulin therapy. From the group of patients in whom it was not possible to determine the duration of infection, improvement was noted in 18 (86%) patients; three (14%) patients did not respond to immunoglobulin therapy.

There was weak evidence from nine case studies/series [281,282,284,290,294,303–306] which investigated the effectiveness of nitazoxanide administration in immunocompromised patients with norovirus infection. These studies included a total of 20 patients, all of whom were chronically infected. It was reported that three (15%) patients had evidence of norovirus clearance, and symptoms improved in a further five (25%) patients. Four patients who experienced symptom improvement relapsed after nitazoxanide was withdrawn. Of the three patients who had evidence of norovirus clearance, two deteriorated and one experienced gastrointestinal distress.

There was very weak evidence of no benefit from five case studies/series [281,285,288,305,307] which investigated the effectiveness of different immune therapies administered to immunocompromised patients with chronic norovirus infection. These studies included a total of six patients. None of these interventions resulted in norovirus clearance. Symptom improvement was observed in one patient given ibrutinib (who subsequently relapsed) and one patient given infliximab rescue therapy. Patients given rituximab (with high-dose steroids), interleukin-2 therapy, interferons and anti-tumour necrosis factor-α antibodies did not respond to these therapies. It was also reported that a patient given rituximab together with a high dose of steroids deteriorated further.

Modulators of gut microbiome. There was inconsistent evidence from two case studies [307,308] which investigated the effectiveness of faecal microbiota transplant administered to two immunocompromised patients with chronic norovirus infection. One study reported that norovirus clearance occurred in one patient, and the other patient did not respond to the therapy. Side effects were not observed.

There was weak evidence of no benefit from one case study [282] which investigated the effectiveness of probiotics in one

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immunocompromised patient with chronic norovirus infection. The intervention did not result in norovirus clearance or symptom improvement. No side effects were reported.

Modifications to immunosuppression therapy regimens. There was weak evidence of benefit from 11 case studies/series [286,289,291,296,299,303,309–313] which investigated the effectiveness of reducing or withdrawing immunosuppression in patients with norovirus infection. These studies included a total of 17 patients, of whom 12 patients were chronically infected, two patients were acutely infected, and it was not possible to determine how long the infection lasted in three patients. Of 12 patients with chronic infection who had immunosuppression reduced or withdrawn, six (50%, one in conjunction with nitazoxanide and one with immunoglobulin) patients had evidence of norovirus clearance, and symptoms improved in a further three (25%) patients. It was reported that one of the patients who experienced improvement subsequently relapsed, and also required an increase in immunosuppression for graft rejection. Both patients with acute norovirus infection experienced an improvement in symptoms without norovirus clearance. From the group of patients in whom it was not possible to determine the duration of infection, improvement was noted in two (67%) patients, and one (33%) patient did not respond to therapy.

There was very weak evidence of benefit from two case studies [303,314] which investigated the effectiveness of changing immunosuppressive therapy in patients with chronic norovirus infection. One study reported that norovirus clearance occurred in one patient with sirolimus substituted for tacrolimus, and another patient experienced symptom improvement with a change from mycophenolate to azathioprine. No side effects were observed.

There was very weak evidence of no benefit from five case studies/series [281,288] which investigated the effectiveness of steroids administered to immunocompromised patients with chronic norovirus infection. These studies included a total of nine patients, none of whom had norovirus clearance. One patient experienced symptom improvement when given a low dose of prednisolone with abatacept. There were no side effects in seven patients who were given a low dose of steroids, but two patients on higher doses of steroids were reported to have deteriorated further.

Other therapies. There was very weak evidence of no benefit from five case studies/series [282,288,291,303,307] which investigated the effectiveness of other medications administered to immunocompromised patients with chronic norovirus infection. No response was observed in three patients given octreotide [282,291], two patients given cholestyramine [282,291], one patient given azathioprine [288], two patients given mesalamine [282,307] and one patient given ivermectin [303]. No side effects were observed in any of these patients. Additionally, three patients were reported to have received antibiotics [281], of whom two patients improved; however, both these patients also had concomitant bacterial infections. The patient who did not respond to antibiotic therapy, and who did not have a bacterial infection, was reported to have deteriorated further.

The Working Party concluded that there is some evidence of benefit for some therapeutic interventions for immunocompromised patients with norovirus infection; however, more work would be needed before any recommendations could be made. The Working Party would like to highlight that, for some of these therapies, the harms may outweigh the benefits. Thus, any decision about norovirus therapy for immunocompromised patients needs to be made based on the individual's risk. Similarly, no recommendations can currently be made for patients with chronic norovirus infection.

Recommendations

28.1: No recommendations.

Good practice points

None.

What is the clinical effectiveness of conducting norovirus surveillance in different settings?

Surveillance systems tend to underestimate the population burden of norovirus. The last time that national surveillance systems were calibrated in 2008–2009, it was estimated that, for every case of norovirus reported to national surveillance systems in the UK, there were around 300 cases in the community. The reasons for such a wide disparity between measured burden and actual burden include widespread variations in health-seeking behaviour, sampling, testing algorithms and reporting criteria. Norovirus is neither a notifiable disease nor a notifiable organism, so reporting is entirely voluntary. The UK Health Security Agency relies on several sources of data to build up a picture of the burden of norovirus. These are laboratory reports of norovirus infection in cases of acute gastroenteritis (usually outbreaks), the Hospital Norovirus Outbreak Reporting System, HPZone and norovirus characterization data from the Enteric Virus Unit. Similar systems exist in the devolved administrations. In Scotland, norovirus ward and bay closures are also published. However, none of these systems give an accurate picture. Surveillance is a prerequisite for understanding when an outbreak has started (i.e. when it should be declared), how it is evolving (whether control measures are working) and when it is over. Surveillance provides vital baseline information on the incidence of norovirus for these assessments, and continuous surveillance is very important. Previous UK guidelines [1] also acknowledged the importance of surveillance, although they did not review the evidence about its effectiveness systematically.

There was weak evidence of benefit from one UBA study [315] which reported the effectiveness of an established surveillance programme on the prevention of outbreaks in a healthcare setting. This was a quality improvement project which introduced a bundle of interventions in one hospital over the course of 2 years. The interventions included education, improving environmental cleaning, prompt identification and isolation of norovirus cases, and the availability of more single rooms. The last phase was the introduction of a surveillance system which electronically recorded data for gastroenteritis symptoms of patients each time their vital signs were taken. The authors reported some effect (not significant) on the outbreak pattern after introduction of the first interventions (from 59 outbreaks per year to 31 to 21), but the number of outbreaks reduced rapidly to three, two, two and one following the introduction of a surveillance system. Similar patterns were also observed for other outcome measures (data

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not reported). The incidence rate ratio for outbreaks occurring after introduction of the surveillance system was 0.095 (95% CI 0.042—0.215), which represented a -90.5% change from the number of outbreaks before the interventions. The surveillance also had a positive effect on the number of patients (-92.0% change) and staff (-81.4% change) affected by the outbreaks, and the number of days when disruption (e.g. bed closures) was reported (-88.4% change). At the same time, a positive change was observed for the average annual percentage of bed occupancy (range 78.5—83.1% pre-intervention vs 86.9—91.2% post-intervention; significance not reported). To balance the risk of bias due to the study design, the authors also compared the incidence risk ratio of norovirus outbreaks occurring in neighbouring hospitals in the area, as well as the overall incidence of norovirus outbreaks occurring in all hospitals in England for the same period. The authors reported that the incidence decreased slightly in other hospitals, but this difference was not significant (0.854, 95% CI 0.435—1.676 for neighbouring hospitals; 0.724, 95% CI 0.412—1.272 for England overall). These ratios represent percentage changes of -14.5% and -27.5%, respectively, which are much lower than that observed in the hospital where the quality improvement project was undertaken.

There was weak evidence of benefit from one surveillance study [316] and two outbreak studies [48,317] which reported the effectiveness of an established surveillance programme on outbreak progression outside a healthcare setting. One study [316] described the results of a surveillance programme in Shanghai, China over an 18-month period. This surveillance system was designed to detect possible disease outbreaks based on student and staff absences in all schools and kindergartens each day. The authors reported that a total of 189 norovirus bud events (early sign of potential infectious disease outbreaks) occurred in schools and kindergartens during the study period, and these events affected a total of 3840 students and staff. The authors reported that the median number of cases per bud event, and the attack rates, were lower than what had been reported in the literature. They hypothesized that this could have been due to early detection of these events from the surveillance system, and the subsequent control measures being put in place. It was reported that the average time from occurrence of the first case to reporting was 2 days and the maximum time was 6 days. The authors concluded that this type of surveillance system was beneficial in recognizing outbreaks early, and therefore potentially preventing transmission of norovirus to unaffected individuals. Both outbreak studies also reported the benefit of the existing surveillance system. In the first outbreak [317], which reported 1121 cases across the entire country and lasted 31 days, the authors reported that syndromic surveillance was beneficial because it led to early identification of an outbreak, triggered investigations and identified shellfish as the source of transmission. This led to the closure of implicated harvesting sites and the withdrawal of raw shellfish products from the market, which subsequently prevented progression of the outbreak. The authors also reported that early withdrawal of the shellfish prevented outbreaks occurring in other countries to which these products were exported. The last study [48], which reported an outbreak in a military base involving 156 cases and lasting 17 days, also attributed the existing surveillance to early identification of the increase in gastrointestinal cases. Surveillance was based on an electronic database which recorded all healthcare consultations entered into the system, supported by additional information from medical staff reporting potential outbreaks. The authors reported that the system was of benefit because it identified an outbreak on the second day and allowed them to introduce a bundle of control measures early.

There was weak evidence of benefit from six outbreak studies [14,22,28,36,37,112] which reported the effectiveness of initiating an active surveillance programme in response to recognized outbreaks in healthcare settings in order to monitor progress and inform control measures. The studies reported outbreaks which affected three to 173 individuals (median 21 cases) and lasted 5—54 days (median 13 days). The extent of the surveillance differed between the studies, but all studies reported that a daily active search for symptomatic cases was in place, two studies reported that contact tracing was also in place [22,112], two studies reported that an IPC nurse visited the units daily to establish new cases and outbreak wards [14,36], and one study reported that laboratory surveillance was also in place, which included norovirus testing of all faecal specimens submitted for *C. difficile* testing with daily reports and automated one-hourly electronic reports which allowed staff to identify cases promptly. All studies reported a benefit of initiating an active surveillance as part of the control measures. Based on four studies [22,28,36,37] which reported a number of cases after surveillance was introduced, a further one to 10 individuals (median four cases) became ill. The outbreaks lasted for a further 3 [22,36] to 5 [28] days, although the last study [28] reported that the last case occurred 1 day after control measures, including surveillance, were introduced.

There was weak evidence of benefit from one surveillance study [318] and six outbreak studies [48,193,216,319—322] which reported the effectiveness of initiating an active surveillance programme in response to a recognized outbreak outside a healthcare setting in order to either prevent its recurrence [319] or monitor its progress and inform control measures [4,12—17]. One study [318] reported that an outbreak occurred shortly before the Winter Olympics were due to start, and although the outbreak was resolved, the health authorities made the decision to search actively for possible cases among asymptomatic food handlers. Throughout the duration of the event, all food handlers working for catering companies supplying Olympic villages and gymnasiums were required to provide rectal samples for norovirus testing. The study reported that five of 707 (0.7%) food handlers were found to be positive for norovirus, and were subsequently excluded from work until a negative test was obtained; all food handled by them was discarded. The authors concluded that this active surveillance was beneficial in preventing re-occurrence of the outbreak, and only four cases of norovirus occurred in athletes, which was substantially lower than the incidence reported in the previous Winter Olympics. The six outbreak studies [48,193,216,319—322], one of which was reported in two separate articles [321,322] occurred in different types of settings, including a military base [48], evacuee shelters [320—322], schools [216] and a wider community affecting an entire region [193,319], and affected a large number of cases from 79 to over 1000 (median 230 cases), lasting from 10 days to over 3 months (median 16 days). The studies reported using different approaches to survey the outbreaks, which suited different types of setting and circumstances in which the outbreaks occurred. One study reported that daily surveillance of food handlers was in place [48], two studies reported setting up an enhanced reporting system where cases could report their symptoms to the health authorities [193,319] (one of which also

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actively searched for cases which presented to local emergency departments [319]), one study reported active searching for any undiagnosed cases [216], one study reported collecting data on gastrointestinal symptoms from anyone who entered the evacuee shelters [320], and one study reported collecting data on gastrointestinal symptoms from anyone who presented at the shelter clinic. Of these six outbreak studies, five [48,193,216,319,320] reported a benefit of introducing surveillance to monitor the outbreak. One study reported that the surveillance identified that the initial control measures were not sufficient, and prompted the introduction of additional interventions [48]. Three studies [193,216,319] reported that surveillance allowed identification of the source of an outbreak, which subsequently led to restrictions to remove the source. One further study [320] reported that surveillance allowed the cases to be isolated promptly from others, which slowed down and eventually terminated the outbreak. The study which did not report a benefit of surveillance (anyone who presented to the shelter clinic) [321,322] also acknowledged that the type of surveillance may have been insufficient to identify some cases of norovirus, but they also mentioned that this was the only type of surveillance that was possible in the circumstances as it was not possible to control who entered and left the shelter, which included indoor and outdoor facilities. The study also reported that control measures were introduced almost daily, but they did not seem to have an effect on outbreak progression, and cases continued to occur until the shelter was closed. The authors also noted that the outbreak was due to at least three distinct norovirus strains, which suggests multiple introductions within the facility.

No studies were found in the existing literature that assessed the cost of any type of surveillance in any type of setting.

The Working Party agreed that, although the evidence was weak, it demonstrates the benefit of surveillance both before and during norovirus outbreaks. However, both types of surveillance require additional resources which may not always be available. Therefore, the Working Party recommends that, as a minimum, surveillance is undertaken during norovirus outbreaks.

Recommendations

29.1: Introduce surveillance for symptoms/cases during a norovirus outbreak.

Good practice points

GPP 29.1: If initiating surveillance for norovirus is considered outside outbreaks, ensure that appropriate resources are available to put in place.

GPP 29.2: Participate in national surveillance programmes for norovirus outbreaks.

Overarching recommendations

During the review of the existing evidence, it has become apparent that there are some overarching themes that underpin good IPC practice for preventing and controlling norovirus outbreaks. The Working Party agreed that the quality of the evidence for or against some of the control measures is either low or is inconsistent, and that one of the themes that emerged was a variation between institutions. Therefore, the Working Party agreed that during norovirus outbreaks, the affected institutions should undertake continuous risk assessment and choose good practice points which are suited to their context and do not compromise the quality of care. For example, the good practice point which recommends the removal of exposed foods may not be suitable for settings where the individuals are also at risk of undernutrition or dehydration. Another theme that emerged is the ability of staff to recognize the outbreak early and act on this knowledge as soon as possible. To be able to do so, staff need to be provided with adequate information about the nature of the virus, possible routes of transmission and the control measures that could be introduced quickly.

OR 1: During norovirus outbreaks, undertake continuous risk assessment to establish which good practice points need to be introduced to minimize transmission.

OR 2: Provide staff with sufficient information and training so that they are able to recognize and act quickly when a norovirus outbreak occurs.

Further research

RR 1.1: Assess the role of flexible designs in the context of norovirus outbreak prevention and control.

RR 9.1: Studies that explore the clinical and cost effectiveness of different diagnostic methodologies to identify norovirus-positive patients.

RR 9.2: Studies that explore turnaround time for PCR, POCT and other assays and its effect on prompt management of norovirus cases.

RR 10.1: Studies which evaluate the clinical and cost effectiveness of alternative storage/transport systems for specimens intended for norovirus testing.

RR 14.1: Assess whether removing alcohol hand rub encourages hand hygiene with soap and water during norovirus outbreaks.

RR 16.1: Investigate the effectiveness of structured environmental surveillance for norovirus in outbreak situations.

RR 17.1: Studies that develop a robust culture method which would enable better-quality research of norovirus in laboratory settings.

RR 27.1: Well-conducted studies which assess the effectiveness of different medications which show a potential benefit for relief of the symptoms of norovirus infection.

RR 28.1: More robust studies which investigate different types of therapy for immunocompromised patients with norovirus infection.

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Author contributions
All authors except AB and GM provided advice and contributed to writing; AB and GM conducted searches, evidence syntheses and contributed to writing.

Appendix A. Supplementary data

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Abbreviations

A&E: accident and emergency
AHR: alcohol hand rub
ATP: adenosine triphosphate
BAC: benzalkonium chloride
BIA: British Infection Association
BSS: bismuth subsalicylate
CDC: Centers for Disease Control
CHG: chlorhexidine gluconate
CI: confidence interval
Ct: cycle threshold
DAS: diagnostic accuracy study
ECO: electrochemically activated water
EIA: enzyme immunoassay
EPA: Environmental Protection Agency
ETA: ethanol or ethyl alcohol
FCV: feline calicivirus
GRADE: Grading of Recommendations Assessment, Development and Evaluation
HIS: Healthcare Infection Society
HNV: human norovirus
HPV: hydrogen peroxide vapour
ICA: immunochromatography assay
IPA: isopropanol or isopropyl alcohol
IPC: infection prevention and control
IPS: Infection Prevention Society
IQR: interquartile range
ITS: interrupted time series
LEV: levulinic acid
LTCF: long-term care facility
MNV: murine norovirus
NaCl: sodium hypochlorite
NHS: National Health Service
NICE: National Institute for Health and Care Excellence
NLV: Norwalk-like virus
OR: odds ratio
P=NS: P-value not significant
PCR: polymerase chain reaction
PFU: plaque-forming unit
POCT: point-of-care testing
PPE: personal protective equipment
ppm: parts per million
PVP: povidone-iodine
QAC: quaternary ammonium compound
RCT: randomized controlled trial
RR: risk ratio
SDS: silver dihydrogen citrate
SEM: scanning electron microscope
UBA: uncontrolled before/after
UK: United Kingdom
UV: ultraviolet
UVC: ultraviolet C

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