A systematic review of the survival of norovirus in foods and on food contact surfaces

Background

Human NoVs are currently recognised as the single most common cause of acute non-bacterial gastroenteritis in the industrialised world. Genogroup II, genotype 4 (GII.4) strains of hNoV are detected most commonly in association with human disease, although there is a greater diversity of genotypes associated with foodborne outbreaks. Most hNoV foodborne disease outbreaks are associated with consumption of food outside of the home, where poor hygiene of infected food handlers is the major source of contamination. Contamination of fresh produce (eg berries, leafy greens) may be associated with human handling or the use of raw sewage or contaminated water during production or processing. Additionally, hNoV disease is highly contagious and shows rapid person-to-person transmission directly or indirectly through the faecal-oral route, from contaminated fomites and from aerosolized vomitus. Effective control measures for water treatment, food processing, cleaning and disinfection of surfaces, personal hygiene and hand washing, and/or sanitation are required in order to control the spread of hNoV along the food chain. However, the effectiveness of control measures to reduce the burden of foodborne norovirus infections remains largely unknown, partly because of the inability to grow the virus and partly due to the large number of surrogate studies of unknown relevance.

Research Approach

A systematic review of the persistence and survival of human noroviruses (hNoVs) in foods and the environment was carried out based upon PRISMA guidelines. Over 10,000 citations relevant to viruses present in foods and the environment were screened using defined inclusion and exclusion criteria from which 126 citations were identified for further evaluation. Persistence data from each of these publications were extracted for the conditions of the treatment (chemical dose, pH, and temperature, time, infectivity, and Real-Time quantitative polymerase chain reaction (RT-qPCR) results).

The only marker for hNoV persistence and survival is RTqPCR data and clinical studies. Therefore citations for inclusion were further restricted to only those that included hNoV RT-qPCR studies, in direct comparison with surrogate virus RT-qPCR and infectivity data; and also data

from clinical trials. This resulted in 27 eligible laboratory-based studies and 3 clinical trials. Eligible studies were diverse and utilised different experimental approaches and methods. Few data were relevant to persistence and survival of hNoVs in real foods and on food contact surfaces. Data were further extracted for common treatments (heat and available chlorine) and for important additional experimental variables such as the matrix and RT-qPCR product size.

Results

Systematic review of the published data showed that when inactivation treatments resulted in reduction in surrogate virus infectivity, this was nearly always accompanied to some degree by corresponding reduction in surrogate RT-qPCR signals, and to a lesser extent by reductions of the magnitude of hNoV RT-qPCR signals. This together with the results of clinical trials, and other supporting data, provides a large body of evidence showing that hNoVs are both more persistent and more resistant than surrogate viruses. Therefore the evidence suggests that infectious hNoVs are more likely to persist in foods and on food contact surfaces than currently predicted by most surrogate studies. Although reductions in infectivity following different treatments were frequently accompanied by reductions in RT-qPCR signal, the use of RT-qPCR signals to predict the effectiveness of control measures beyond that already observed in comparison to surrogates is unclear and limitations remain.

There are very little data on hNoV persistence or survival in real-food systems under many commonly used food processing conditions, including heat. Further, currently available data for hNoV survival and persistence in foods lacks direct and comparable surrogate data. In the absence of data and relevant studies, it is difficult to draw conclusions or make recommendations about the survival of hNoV in foods and on food contact surfaces. However where comparisons could be made in answering the PRISMA questions a qualitative meta-analysis shows that hNoVs appear more persistent than surrogate feline calicivirus or murine norovirus in response to heat and available chlorine than recognised previously. Unfortunately a lack of data meant that quantitative meta-analysis could not be used to define conditions that might more accurately predict the inactivation of hNoVs.

There remain many unanswered questions, for example:

- he best means by which to use RT qPCR to measure virus infectivity (e.g. enzymatic pre-treatments, ligand-based capsid capture)
- the impact of the sample matrix on virus inactivation
- strain differences

Further studies are necessary to determine the nature of hNoV persistence and to define optimal methods to evaluate hNoV inactivation in the absence of cultivable strains.

Published Papers

1. Angus Knight, John Haines, Ambroos Stals, Dan Li, Mieke Uyttendaele, Alistair Knight and Lee-Ann Jaykus (2015) A systematic review of human norovirus survival reveals a greater persistence of human norovirus RT-qPCR signals compared to those of cultivable surrogate viruses. International Journal of Food Microbiological 216 (2016) 40-49

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