Viruses in the food chain

Mummy: Three kids vomited at school today – could it be the berries they ate yesterday?

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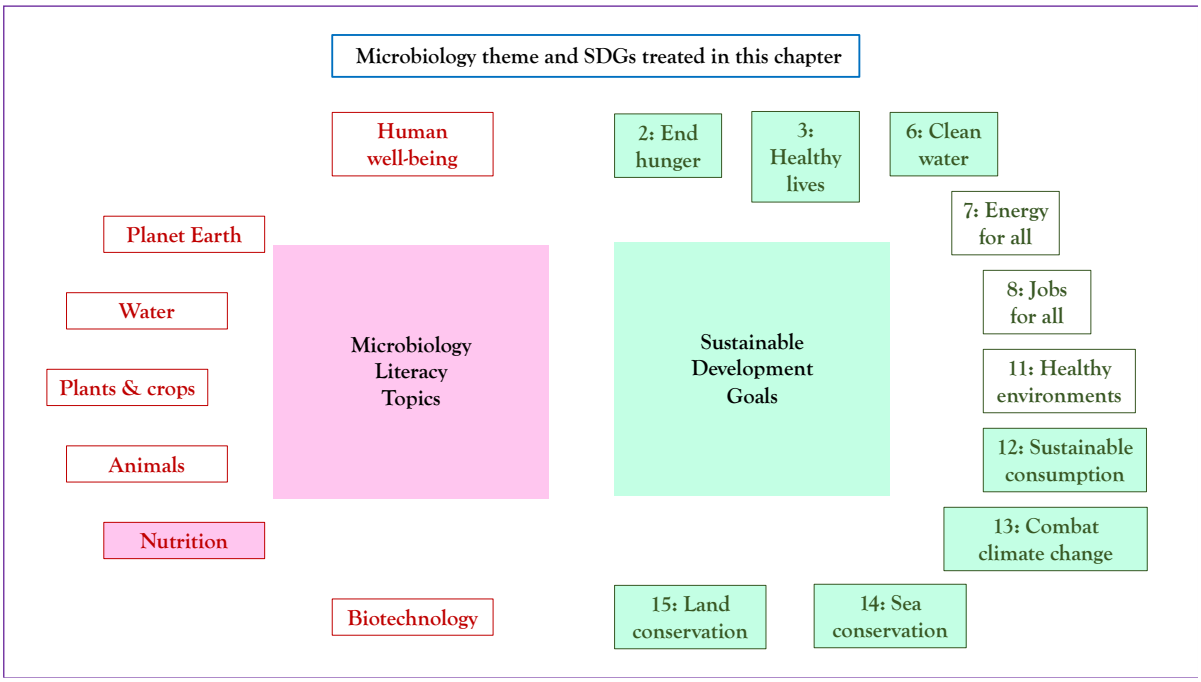
Storyline

Bacteria are not the only microorganisms responsible for foodborne outbreaks. Viruses, more specifically enteric viruses which infect through the gastroenteric tract, also lead to an important number of foodborne outbreaks. They are transmitted either from person to person but can also end up on food, be transported from one country to another, and make the person who eats the contaminated food sick.

Learning about the modes of transmission of foodborne viruses such as Norovirus (NoV) and hepatitis A virus (HAV) will help to adopt the right behaviours to reduce the number of illnesses linked to these viruses. This Topic Framework describes the most important viruses of concern and the illnesses linked to the infections they cause. It explains why fresh food is of greatest concern and that mild processing, such as washing and freezing, is not be sufficient to remove or kill these viruses.

Understanding that contamination with enteric viruses is linked to sewage-contaminated sea or irrigation water and bad hygienic practices of food workers will help to convince why it is key to buy fruits and vegetables which will be eaten raw from local sources, grown and processed under hygienic conditions. The Topic Framework also emphasizes the importance of hand washing along the entire supply chain, in order to interrupt infection chains. Importantly, it demonstrates the link with other topics, such as sustainability (e.g. carbon footprint linked to imported frozen food) and water/climate change (e.g. risks linked to water sources which are prone to microbiological contamination after heavy rains, thunderstorms or floods).

The Microbiology and Societal Context



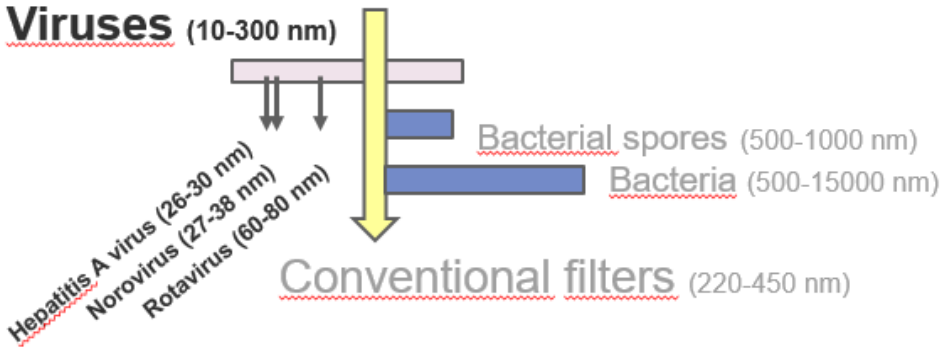
The Microbiology: viruses of concern; diseases; symptoms; water; foods of concern; control measures; vaccination; transmission cycle. This is linked to: primary production, use of water in agriculture, wastewater treatment, eating habits (e.g. raw fruits and vegetables) and nutrition. *Sustainability issues: hunger; healthy lives; clean water; sustainable consumption; climate change;* sea conservation; land conservation.

Viruses in the food chain: the Microbiology

1. ***Viruses of concern.***

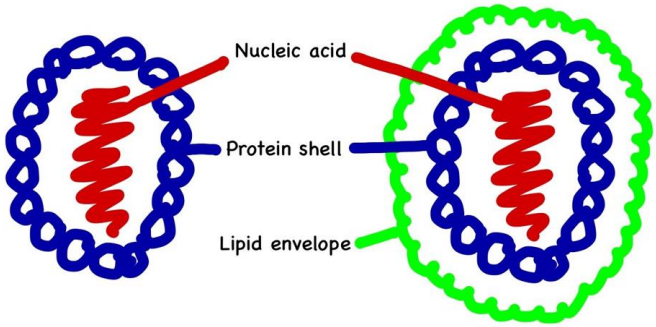
a. What is a food-borne virus? The two viruses of greatest importance for diseases linked to food are Norovirus (NoV) and hepatitis A virus (HAV). They belong to the vast group of enteric viruses to which e.g. also rotaviruses and astroviruses belong. These viruses are called enteric viruses or food-borne viruses because they infect through the gastroenteric tract by fecal-oral transmission.

Viruses are historically detected by their ability to pass through filters which retain even the smallest bacteria, and enteric viruses are especially small, typically at the small end of the virus size scale. For comparison, food-borne viruses are roughly ten times smaller than bacteria and not visible by light microscopy (they can be visualized by electron microscopy). They measure between 20-80 nm (one nm is a millionth of a mm) and are not retained by conventional bacterial filters (220-450 nm).



Size of enteric viruses such as NoV and HAV compared to other microorganisms.

Enteric viruses have a very simple structure. They consist of a small segment of nucleic acid encased in a simple protein shell and are referred to as non-enveloped or naked viruses. Many other viruses, especially respiratory viruses such as influenza virus, are referred to as enveloped viruses, because their protein shell is surrounded by a lipid envelope.



Structure of non-enveloped enteric viruses (left) compared to enveloped viruses (right).

Being non-enveloped makes Norovirus and hepatitis A virus especially sturdy and resistant in the environment, meaning that they can remain infectious outside of the human body for several days or weeks depending on the temperature and the surroundings.

b. NoV and HAV infections: How sick do these viruses make us? Viruses have no metabolism of their own but rather are obliged to invade cells and parasitize the cellular machinery of their host in order to produce the virus materials needed to multiply/replicate, i.e. create more virus particles. When a virus enters a cell, the cell is generally damaged, and especially when it lyses/bursts the cell, killing it in the process, in order to release the new virus particles, we experience various disease symptoms.

NoV infects cells of the gastrointestinal tract causing gastroenteritis (inflammation of the stomach or intestines) in people of all ages. Symptoms are sudden onset of (projectile) vomiting, stomach cramps, and diarrhoea. As NoV infections are more frequent in winter, NoV infections are sometimes referred to as "winter vomiting disease". Fever and headache may also occur. The illness is very unpleasant, but generally resolves within 1-3 days. It can be severe and require hospitalization in high-risk groups, especially the elderly or the very young, mainly due to dehydration caused by the excessive loss of fluids due to diarrhea and vomiting.

The infectious dose is very low, meaning that swallowing just 10-100 virus particles is enough to make you sick. The incubation time (the time between ingesting the virus and starting to feel sick) is short too (12-72 hours). What makes NoV very difficult to control, is the fact that large numbers of viral particles are shed in vomit and feces (>1 million particles/g) and that excretion of virus particles can last for much longer than symptoms (up to 8 weeks following infection).

The mutation rate of NoV is high. This means that the virus changes enough from one year to the other, so any immunity developed against a NoV infection one year may not protect against a new infection the next. For this same reason, there no vaccine is available against NoV.

Worldwide, about one out of every five cases of acute gastroenteritis that leads to diarrhea and vomiting is caused by NoV (estimated 120 million foodborne cases yearly).

HAV enters into the human body via oral transmission and replicates in the cells of the liver, causing hepatitis in people of all ages. Symptoms include loss of appetite, fever, headache, nausea and vomiting. This is followed 1-2 weeks later by jaundice, a yellowing of the skin. One of the functions of the liver is to break down our red blood cells which carry oxygen from our lungs to our tissues. This process involves production of bilirubin, which has a yellow colour, and which is excreted in our feces. When the liver is damaged by an infection, it cannot function efficiently and bilirubin accumulates and turns our skin yellow: we have jaundice!

The illness lasts long (from a few weeks to several months) and is typically more severe in adults than in children. As for NoV, the infectious dose of HAV is very low (10-100 virus particles) and, in addition, very large numbers of viral particles are shed in feces (>1 million particles/g). Unlike NoV, the incubation period for HAV is very long (2-7 weeks) and shedding of the virus in feces starts 10-14 days before the onset of symptoms.

A very good vaccine providing life-long immunity is available. Globally, around 14 million foodborne HAV cases occur yearly.

2. ***Foods of concern: Which foods are risky and why?*** Viruses cause at least 30% of cases of food borne infections in developed countries. Unlike bacteria, viruses will not replicate in food. Consequently, enteric viruses such as NoV and HAV virus will not cause deterioration of food, meaning that food will not look or smell differently if contaminated with viruses. Foods

frequently linked to NoV and HAV outbreaks are bivalve molluscs (shellfish), fresh produce, especially berries, lettuce and herbs, and ready-to-eat (RTE) foods requiring extensive manual handling (e.g. sandwiches and delicatessen).

a. **Shellfish**: Since bivalve molluscs (shellfish such as scallops, mussels, cockles, oysters etc.) are filter-feeders, they concentrate contaminants such as viruses in their digestive tissues to a much higher concentration than is present in the surrounding seawater. There is a direct correlation between degree of pollution in the mollusc harvesting area and the incidence of viral disease in the surrounding region. Viruses have been observed to persist for 8 to 10 weeks in contaminated live bivalve molluscs.

b. **Fresh produce**: Berries (raspberries, strawberries, blueberries etc.), vegetables (lettuce, spinach, leek, green onions etc.) and herbs (basil, parsley etc.) can get contaminated during primary production through irrigation with sewage-contaminated water, or when produce is manually picked (especially berries) and pickers do not follow proper hand hygiene and contaminate produce when touching it with virus contaminated hands.

c. **Ready-to-eat foods**: Infected food handlers are the main sources of contamination for RTE foods requiring extensive manual handling (e.g. sandwiches and delicatessen). In all instances where a food handler comes into contact with food, contamination might occur and, due to the survival characteristics of enteric viruses (see below), they are likely to survive in many foods that do not receive a terminal heating step prior to consumption.

Foods regularly linked to viral foodborne outbreaks.

3. ***Example: an outbreak linked to frozen berries.*** In September/October 2012, an outbreak of NoV gastroenteritis was recorded in eastern Germany. A total of 390 facilities, mostly schools, located in five Federal States of Germany were affected, with 10,950 registered gastroenteritis cases which included 38 hospitalizations. Results of epidemiological and trace-back investigations suggested that a consignment of frozen strawberries imported from China was the source of the outbreak. Case–control studies revealed a strong correlation between gastroenteritis and the consumption of strawberry compote served cold in canteens. This was the

largest foodborne outbreak to have ever been reported in Germany. Many other NoV and HAV outbreaks associated with fresh and frozen berries have been reported worldwide.

Chinese Strawberries Sickened Thousands of German Students

BY **NEWS DESK** | OCTOBER 9, 2012

Those frozen strawberries that were "very likely" the cause of food poisoning that sickened more than 11,000 German schoolchildren were very certainly grown in China.

China is now the world's biggest exporter of strawberries, and those going to German schools were grown in China's province of Shangdong. The Chinese strawberries were then transported by ship to Hamburg where, after a month at sea, the 44-ton order was delivered to Sodexo, a large food distributor that sells to German schools.

More than 11,000 youngsters attending schools and day cares were sickened throughout eastern German, with 32 requiring hospitalization. About 500 schools were involved in the outbreak.

Headlines of the article published in Food Safety News in 2012 (Food Safety News | Breaking News about Food Safety)

4. ***The economic burden of foodborne infections.*** Overall, foodborne illness carries a high economic burden and it is estimated to cost the US economy between $55.5 and $93.2 billion per year (mainly medical costs and productivity losses from missed work). In the Western World, comprehensive analyses are available for the health impacts of foodborne viral disease and costs associated to NoV are approximately $2 billion per year.

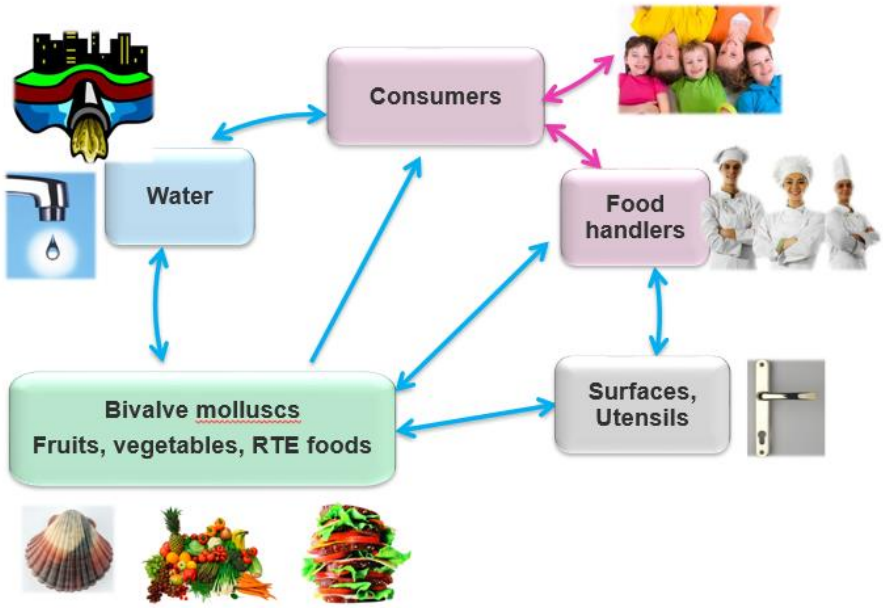
5. ***How are viruses detected in food?*** Considerable progress has been made in recent years in the development and number of methods for the detection of food borne viruses in different food matrices. However, detection of foodborne viral contamination remains much more difficult, and hence costly, than the detection of bacterial pathogens in food or the detection of viruses in clinical samples, because NoV and HAV are present in low numbers in food. Virus detection usually targets the viral genome which therefore requires amplification.

Molecular detection methods based on amplification techniques (Reverse Transcription Polymerase Chain Reaction, RT-PCR) have been developed. A sophisticated laboratory is necessary to perform extraction of viral genomes from food matrices and amplification of the genomes by RT-PCR. It is important to note that these methods cannot discriminate between infectious and non-infectious virus particles; they merely indicate the presence of viral genome fragments and hence that a fecal contamination has taken place.

6. ***How to these viruses get on my food?*** Water cycle, human-to-human transmission. NoV and HAV are transmitted by the fecal-oral route, either by ingestion of food or water contaminated with fecal matter, or by person-to-person contact. There is ample documentation of the potential for virus transmission via sewage-contaminated drinking water, ice, and water used for food preparation. Contamination can also be indirect through surfaces and utensils.

a. **Shellfish**: NoV and HAV contamination of the sea water in which bivalve molluscs grow happens when sewage treatment is insufficient for virus removal and/or virus inactivation. This can lead to big outbreaks, such as in 1988 in Shanghai (China) where an epidemic of hepatitis A attributable to the ingestion of raw clams led to nearly 300'000 cases (11).

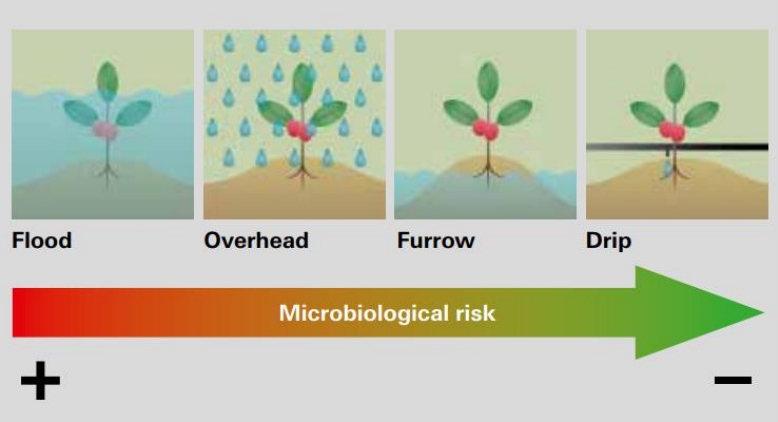
It is important to note that pathogen removal efficacy of wastewater treatment plants is usually monitored by quantifying bacteria such as *Escherichia coli*, but that non-enveloped enteric viruses are generally more resistant than bacteria. After heavy rainfall, untreated or partially treated human sewage is sometimes discharged in the surroundings of shellfish growing areas. This is especially problematic during disease outbreaks close to these sites and, for NoV, this corresponds to the winter months when the peak of illnesses is highest.



Schematic representation of enteric virus transmission between humans, water, food and surfaces.

b. **Fresh produce**: The source of water used for irrigation and the method of delivery affects the risk of contamination of fresh produce during production. Surface water or sewage water which has not been properly disinfected can contain viruses and should not be used for irrigation or application of fertilizer, pesticides or herbicides. The risk of viral contamination will vary depending on the irrigation method, i.e. the risk will increase when there is contact between water and produce, meaning that for example overhead irrigation is riskier than drip irrigation.

c. **Fresh produce and RTE foods**: Another important risk for viral contamination of food is handling of food or utensils by infected workers (fruit pickers, food handlers) practicing poor personal hygiene in the fields, factories or canteens, for example by not washing their hands after visiting the toilet and before going back to work. Infected food handlers can contaminate sanitary facilities, toilets, food contact surfaces and food they manipulate.



The risk of viral contamination varies with the irrigation method. Taken from "Minimizing the risk of microbial contamination in primary production of berries" (page 37) available at best-practices-suppliers-minimizing-risk-microbial-contamiation-berries-2016.pdf (nestle.com).

7. ***How can I get rid of these viruses on my food?*** Heat kills viruses, washing does not. Norovirus and hepatitis A virus are small and highly resistant entities which remain infectious in the environment (in water and shellfish, on produce and food, on surfaces and hands). One of the physical treatments that inactivates enteric viruses efficiently is heat. This is very fortunate, as it means that water which is boiled or food which is cooked becomes safe. A thermal treatment is considered efficient in killing enteric viruses, if an internal temperature of 90 °C is reached for at least 90 seconds. Indeed, such a treatment consistently allows the reduction of 99.9%-99.99% of viruses (or 3-4 logs). In this context it is interesting to mention that in the 2012 outbreak in Germany (see above), no illnesses were recorded in schools where the canteens had chosen to cook the strawberries before serving them as compote to the students.

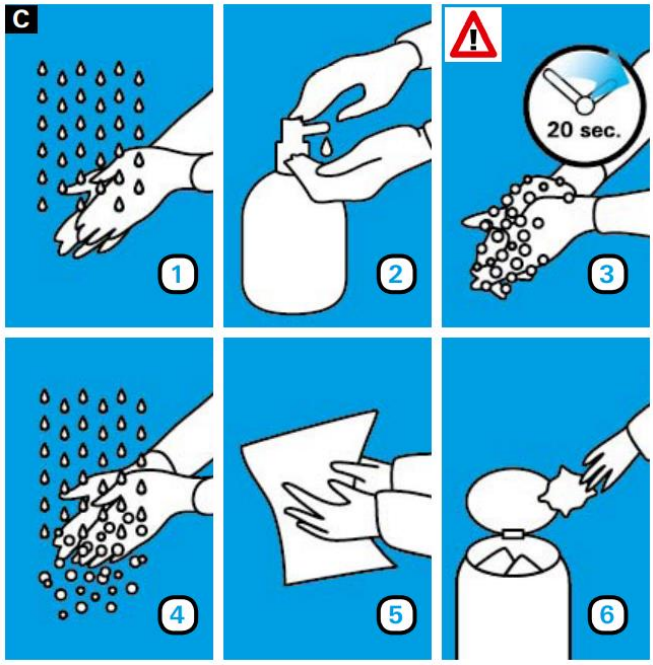
Chlorine is also highly viricidal and enteric viruses are inactivated by commonly used free chlorine concentrations and contact times applied to drinking water treatment, meaning that properly treated drinking water is free of viruses and safe.

In contrast, foods which do not receive a terminal heating step prior to consumption, such as oysters or fresh berries, are risky and may lead to illness. This is because treatments commonly applied to these foods such as washing or freezing do not represent effective control measures for viruses. Washing removes some viruses from a food surface (typically 90% of the viruses present or 1 log), but this is not enough to reduce the number of viruses to below infectious dose which is very low (see above). Indeed, viruses are very small, they are able to attach to the food surface and scanning electron microscopy observations of fruit surfaces showed that microorganisms can easily hide in structures such as cracks and crevices. Freezing does not affect enteric viruses, rather the contrary: NoV and HAV have been shown to remain infectious in frozen foods for months.

8. ***How do I remove NoV and HAV from hands and surfaces?*** Efficient disinfectants. The best way to remove enteric viruses from hands is traditional hygienic hand washing with streaming water and soap for a minimum of 20 seconds followed by drying using disposable towels. Most hand sanitizing agents, such as alcohol-based hand disinfectants, are not able to eliminate enteric virus infectivity from hands. Everyone needs to be regularly reminded about the importance of hand washing and how to perform a proper hand wash.

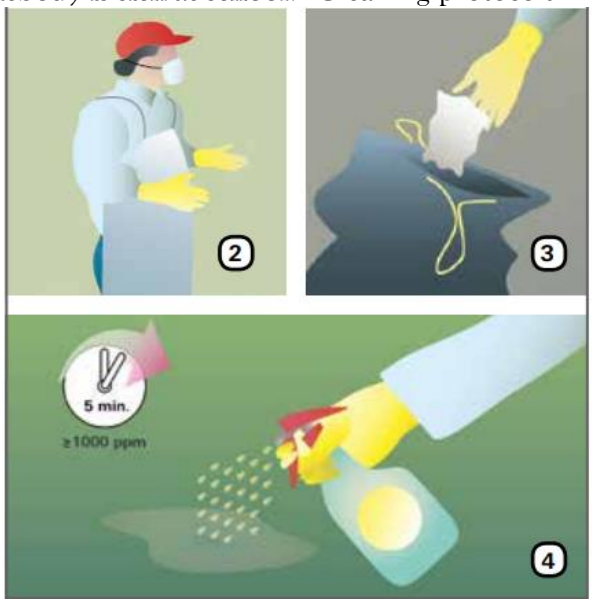
Most surface routine cleaning and disinfection regimes using standard disinfectant solutions (e.g. 70% ethanol) are generally ineffective in inactivating non-enveloped viruses. HAV is especially resistant and ethanol at 80% or 95% was not sufficiently effective within 2

min . Products containing phenolic compounds (including triclosan and quaternary ammonium compounds) are not recommended against NoV and HAV. The most effective agent to disinfect contaminated surfaces is sodium hypochlorite. Solutions of 1000 ppm free chlorine applied for at least 5 min consistently show a >3 log (99.9%) reduction in viral infectivity.



Six simple steps to follow for a proper handwash. Graphic taken from "Minimizing the risk of microbial contamination in primary production of berries" (page 62) available at best-practices-suppliers-minimizing-risk-microbial-contamiation-berries-2016.pdf (nestle.com).

9. ***What to do if somebody is sick at school?*** Cleaning protocols in case of a vomiting



Cleaning and disinfection protocol, especially in case of a vomiting incident. Graphic taken from "Minimizing the risk of microbial contamination in primary production of berries" (page 73) available at best-practices-suppliers-minimizing-risk-microbial-contamiation-berries-2016.pdf (nestle.com).

event. The sudden and uncontrollable nature of the vomiting which is characteristic for NoV infections is responsible for spreading of the infection for example in a class setting. Only one person may have been infected by eating a contaminated food, but many more might get infected directly from this person leading to big numbers in outbreaks. Inadequate cleaning after a diarrhea and/or vomiting event causes further spreading of the infection.

Disinfection, preceded by cleaning, must take place after each vomiting event. Any spillage or contamination with vomit should be dealt with immediately, but only a person trained in cleaning-up infectious material should be assigned to the task. The person should wear appropriate personal protective equipment (PPE), including disposable gloves, a disposable facemask and a disposable apron. A freshly prepared sodium hypochlorite solution is the recommended treatment to apply in case of a vomiting event at school, in the work place or at home. Debris of vomit should be immediately covered with an absorbent gelling powder (designed for spillage of bodily fluids) or if this is not available, disposable paper towels/cloths.

10. ***What else can be done?*** Prevention of viral contamination at primary production. Enteric viruses are very difficult to remove from food once they are there and finding NoV or HAV virus on food ultimately means that this food has come into contact with human fecal material. This should never be the case and the best way to avoid foodborne viral illnesses is to ensure a virus-free food supply chain from farm to fork. This happens through the implementation of GAPs (Good Agricultural/Aquacultural Practices).

a. **Shellfish**: For shellfish, this means growing shellfish in clean water only. This can only be ensured if microbiological sanitary surveys of the growing and harvesting waters are conducted regularly, indicating potential sources of fecal contamination and should include NoV and HAV monitoring. Action plans must be in place after e.g. heavy rains, thunderstorms, floods or other events and should lead to the closure of the area. Sewage treatment plants in proximity of the growing area must apply water treatment technologies achieving a 4 log (99.99%) reduction in viral infectivity, but ideally shellfish is grown as far away from a sewage treatment plant as possible.

b. **Fresh produce**: Preventive measures taken by producers should concentrate on the prevention of human fecal contamination by ensuring the use of high quality water (irrigation water, water used for fertilizer, pesticide or herbicide application, wash water) and the implementation of stringent personal hygiene during the whole production process. As for seawater, microbiological sanitary surveys of the waters need to be conducted regularly which will allow to detect potential sources of fecal contamination. Action plans need to be in place after e.g. heavy rains, thunderstorms or floods which may lead to microbiological contamination of the water source.

c. **Fresh produce and RTE**: Most importantly, food handlers must be trained to wash their hands with soap and water, e.g. before starting work and after using the toilet (see above). Everyone working in contact with food needs to be regularly reminded about the importance of hand washing and how to perform a proper hand wash by using hand washing signs, in local languages and/or pictures adjacent to hand wash stations.

When to wash hands (e.g. before starting work and after using the toilet). Graphic taken from "Minimizing the risk of microbial contamination in primary production of berries" (page 61) available at best-practices-suppliers-minimizing-risk-microbial-contamiation-berries-2016.pdf (nestle.com).

Relevance for Sustainable Development Goals and Grand Challenges

The microbial dimension of viruses in the food chain relates to several SDGs (*microbial aspects in italics*), including

- **Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture** *(end hunger and malnutrition, increase agricultural productivity).* The production of fresh produce is very important to offer everyone fresh and nutritious foods. For example, berries are known to be full of vitamins and antioxidants and a balanced diet requires the consumption of unprocessed (uncooked) fresh fruits and vegetables. However, these foods need to be produced in good hygienic conditions, as pathogens (viruses and bacteria) will not be subjected to killing by cooking and are very difficult to remove by washing. Ideally, produce should be produced locally and sustainably to avoid degradation of vitamins during transport and to ensure visibility of hygienic growth conditions from the farm to the consumer.
- **Goal 3. Ensure healthy lives and promote well-being for all at all ages** (*improve health, reduce preventable disease and premature deaths).* Foodborne outbreaks are a major burden to public health and have economic consequences for health budgets. Foodborne viral outbreaks are especially tricky, as one person may have been infected by eating a contaminated food, but many more might get infected directly from this person leading to large outbreaks. Hence it is important to avoid foodborne viral outbreaks and to ensure that only safe products are available to consumers.
- **Goal 6. Ensure availability and sustainable management of water and sanitation for all** *(assure safe drinking water, improve water quality, reduce pollution, protect water-related ecosystems, improve water and sanitation management).* NoV and HAV contaminate river

and sea water when the sewage treatment is insufficient for virus removal and/or virus inactivation. They can then end up in irrigation and drinking water supplies if water has not been properly disinfected. This is especially problematic in winter when the NoV incidence is high. After heavy rainfall, untreated or partially treated sewage is sometimes discharged in the surroundings. This cycle shows the importance of sustainable management of water and sanitation of water supplies for the production of safe drinking water, shellfish and fresh produce.

- **Goal 12. Ensure sustainable consumption and production patterns** *(achieve sustainable production and use/consumption practices, reduce waste production/pollutant release into the environment, attain zero waste lifecycles, inform people about sustainable development practices).* The NoV outbreak which happened in September/October 2012 in Germany is a good example of the problematic linked to the import of big quantities of frozen food with a high food safety risk and emphasizes the advantages of food produced locally to ensure visibility of hygienic growth conditions from the farm to the consumer.
- **Goal 13. Take urgent action to combat climate change and its impacts** *(reduce greenhouse gas emissions, mitigate consequences of global warming, develop early warning systems for global warming consequences, improve education about greenhouse gas production and global warming).* Viral foodborne outbreaks are often linked to frozen goods (see also Goal 12 above). Local production is more sustainable and climate-friendly, as it does not require energy to freeze and transport the frozen goods from one continent to another.
- **Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development** *(reduce pollution of marine systems by toxic chemicals/agricultural nutrients/wastes like plastics, develop mitigation measures for acidification, enhance sustainable use of oceans and their resources).* Since shellfish such as scallops, mussels, cockles, oysters etc. are filter-feeders, they concentrate contaminants such as viruses in their digestive tissues to a much higher concentration than is present in the surrounding seawater. Hence the importance to grow shellfish in clean water and to make sure that sewage water is properly treated before discharging it into the sea water. Ideally shellfish is grown as far away from a sewage treatment plant as possible.
- **Goal 15. Conserve and sustainably use the land resources for sustainable development**. Berries, vegetables and herbs can get contaminated during primary production through irrigation when produce is irrigated with sewage-contaminated water. Additionally, previous land use (land and adjacent land) needs to be taken into consideration to minimize the risk of microbial contamination of the soil. Farmers should avoid use of land that may have been previously contaminated or is too close to municipal waste/sewage disposal or treatment sites. If there is a risk of water run-off from higher lands, farmers should implement physical barriers such as vegetative buffer areas or crop production which is not sensitive to microbial contamination.

Potential Implications for Decisions

1. ***Individual***
    - **a.** Frozen versus fresh berries,
    - **b.** Locally produced versus imported high-risk products such as berries
    - c. Washing versus cooking
    - d. Hand hygiene

2. ***Community policies***

a. Health costs associated with enteric virus disease.
b. How to avoid transmission in public settings such as restaurants, schools
c. The importance of personal hygiene and education/training

3. ***National policies***
   a. Environmental pollution, management of sewage treatment plants
   b. Ensuring safe drinking water supplies
   c. Border control of imported of frozen food, surveillance programs.
   d. Good Agricultural Practices (GAPs) and Good Manufacturing Practices (GMPs)

Pupil Participation

1. ***Class discussion of the issues associated with viruses in the food chain***

2. ***Pupil stakeholder awareness***
   a. Can you think of anything that might be done to reduce the viral contamination of food, make risky food safer?
   b. Can you think of anything you might personally do to reduce transmission of enteric viral disease?
   c. What needs to be done if somebody gets sick at school?

3. ***Exercises (could be made at any level, but these are probably secondary education level)***
   a. How can I make risky food safe (e.g. shellfish, raspberries, lettuce)?
   b. What happens in the sewage system with enteric viruses?
   c. Can drinking water be contaminated with viruses?
   d. How are viruses detected in foods?

The Evidence Base, Further Reading and Teaching Aids

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Seafish. Delivering Safe Bivalves to the Market. Bivalve Mollusc Safety — Seafish

Glossary

Berries: are small, pulpy, and often edible fruits, typically, juicy, rounded and brightly colored, without a stone or pit, but pips or seeds may be present.
Contamination: making or being made impure by polluting or poisoning, e.g. by pathogenic viruses.
Detection method: a laboratory-based method to detect and measure something, e.g. a virus in stool or blood.
Enteric virus: virus that can multiply in the gastrointestinal tract of humans or animals.
Food: any nutritious substance that people or animals eat or drink or that plants absorb in order to maintain life and growth.

Foodborne outbreak: a foodborne disease outbreak is defined as an incident in which two or more persons experience a similar illness resulting from the ingestion of a common food.
Food worker: is an individual working with unpackaged food, food equipment or utensils, or food-contact surfaces.
Gastroenteritis: inflammation of the stomach and intestines, typically resulting from bacterial toxins or viral infection and causing vomiting and diarrhoea.
Good Agricultural Practices (GAPs): collection of principles to apply for on-farm production and post- production processes, resulting in safe and healthy food.
Hand hygiene: is the act of cleaning one's hands with soap and water to remove viruses/bacteria/microorganisms, dirt, grease, or other harmful and unwanted substances stuck to the hands.
Hepatitis A virus (HAV): the virus which causes hepatitis A, a vaccine-preventable liver infection. HAV is found in the stool and blood of people who are infected. Illness can last for several weeks.
Incubation time: the period between exposure to an infection and the appearance of the first symptoms.
Infectious dose: that quantity of a pathogen (measured in number of organisms) that is necessary to cause infection in a susceptible human or animal.
Irrigation: is the agricultural process of applying controlled amounts of water to land to assist in the production of crops.
Non-enveloped virus: a virus without a lipid envelope around its protein shell.
Norovirus (NoV): a group of viruses that are a common cause of food poisoning and acute gastroenteritis ("stomach flu") that can strike quickly with force and make a person feel very sick but which typically resolves within 2-3 days.
Primary production: means the production, rearing or growing of primary products including harvesting of fruits and vegetables.
Produce: is a generalized term for many farm-produced crops, including fruits and vegetables. More specifically, the term produce often implies that the products are fresh and generally in the same state as where and when they were harvested.
Sewage: wastewater and excrement that is produced by a community of people, typically transported through a sewer system.
Shellfish: an aquatic shelled mollusc (e.g. an oyster or cockle), especially one that is edible.
Symptoms: are the observed or detectable signs of an illness, injury, or condition.
Training: the action of teaching a person or animal a particular skill or type of behaviour.

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