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[Mini-review] The Global Impact and Management of Foodborne RNA Viruses

Ana Izabel Passarella Teixeira

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Abstract

This Mini-review addresses the significant health implications of foodborne RNA viruses, such as norovirus and hepatitis A, which are major contributors to global foodborne illnesses. These viruses are typically transmitted via the oral-fecal route and can contaminate food during production, processing, and handling. Characterized by their robust, non-enveloped structure and high genetic variability, they present unique challenges in control and prevention. This paper summarizes their prevalence, transmission, and risk factors, emphasizing the importance of stringent hygiene and food safety measures. It also discusses the necessity for comprehensive preventive strategies throughout the food supply chain and the critical role of surveillance and monitoring systems. The following Mini-review aims to enhance understanding and guide the development of effective interventions for mitigating the risk of foodborne RNA virus outbreaks.

Keywords: Foodborne RNA viruses, public health, Transmission routes, Prevention and control, Food safety measures.

Foodborne diseases are a group of infectious diseases transmitted by food or water and a significant public health concern globally, causing illness, hospitalizations, and even deaths. Among the various causes of foodborne diseases, RNA viruses play a crucial role. RNA viruses can be transmitted through contaminated food and water, leading to outbreaks and sporadic cases of infection. They can easily contaminate food during the production, processing, or handling stages because most of these viruses are transmitted through oral-fecal route (Koopmans and Duizeer, 2004; Di Cola et al., 2021). Therefore, it is crucial to maintain proper hygiene practices and food safety measures to prevent the spread of these viruses.

The impact of foodborne RNA viruses on public health is substantial, as they are responsible for a significant number of foodborne illnesses worldwide (Kirk et al., 2015; Di Cola et al., 2021). For instance, norovirus alone is estimated to cause over 200 million cases each year (CDC, 2023). These viruses can contain genetic material that is RNA-based, which makes them unique from other types of viruses (O'Shea et al., 2019). Understanding the scope and objectives of research on foodborne RNA viruses is crucial for developing effective prevention and control strategies. The main objective of this research paper is to summarize information about the prevalence, transmission routes, and risk factors associated with foodborne RNA viruses. Understanding the prevalence, transmission routes, and risk factors associated with foodborne RNA viruses is crucial for developing targeted interventions and implementing effective prevention and control measures.

The most prominent RNA viruses associated with foodborne outbreaks are norovirus and hepatitis A virus (Bányai et al., 2018; Di Cola et al., 2021). Also, we can cite other viruses, such as the hepatitis E virus, rotavirus, astrovirus, aichi virus as seen in Table 1.

Table 1. Virus transmitted thru food.

Virus	Genus/Family	Particle/Genome	Disease	Transmission route	Associated food
***Norovirus* (HuNoV)**	*Norovirus/Caliciviridae*	Non-enveloped/ssRNA	Acute gastroenteritis	Fecal–oral route/100 copies/mL	Shellfish oysters, fish, buffet meals, vegetables
***Rotavirus* (HRV)**	*Rotavirus/Reoviridae*	Non-enveloped/segmented dsRNA	Viral gastroenteritis in children, adult diarrhea	Fecal–oral route, possible aerosol/10–100 infectious viral particles	Clams and oysters, fruits, vegetables
Hepatitis A (HAV)	*Hepatovirus/Picornaviridae*	Non-enveloped/ssRNA	Hepatitis A	Fecal–oral route/10–100 viral particles	Sandwiches, fruits, vegetables, milk, shellfish
Hepatitis E (HEV)	*Orthohepevirus/Hepeviridae*	Non-enveloped/ssRNA	Hepatitis E	Fecal–oral route/Unknown	Raw/undercooked boar, deer and pork meat, livers and liver sausages
***Astrovirus* (HAtVs)**	*Mamastrovirus/Astroviridae*	Non-enveloped/ssRNA	Gastroenteritis	Fecal–oral route/Unknown; relatively low	Bivalve mollusks, fruits and vegetables
***Aichi virus (AiV)*)**	*Kobuvirus/Picornaviridae*	Non-enveloped/ssRNA	Gastroenteritis	Fecal–oral route/Unknown; relatively low	Raw shellfish
Enterovirus (EV)	*Enterovirus/Picornaviridae*	Non-enveloped/ssRNA	Heart disorders hand-foot-and-mouth disease (HFMD), natal sepsis, meningitis/encephalitis	Fecal–oral predominantly Respiratory route; inhaling contaminated airborne droplets/Low; 1–10 infectious viral particles	Shellfish (mainly oysters)

Resource: Adapted from Pexara and Govaris (2020)

It is interesting to note that all these viruses are RNA non-enveloped; they have a protein coat but do not have an outer envelope made of lipids (Pexara and Govaris, 2020), which makes them very resistant to environmental conditions. These viruses belong to various families and are characterized by their high genetic variability, partially due to the low fidelity of the RNA-dependent RNA polymerases (Gebreyes et al., 2014). This genetic variability poses challenges for developing effective interventions and control measures (Villa et al., 2021). Also, it is noteworthy that certain respiratory viruses, such as influenza virus and coronavirus, are also considered to be potential foodborne viruses. Although major foodborne outbreaks involving these viruses have not been reported to date, the possibility of foodborne transmission of these respiratory viruses cannot be ruled out (O'Brien et al., 2021).

These viruses, such as norovirus and rotavirus, are particularly worrisome due to their persistence in the environment and low infectious doses (Fuzawa et al., 2016). In addition, these RNA viruses can also be transmitted through direct contact with infected animals, highlighting the importance of proper hygiene and food safety practices in both domestic and commercial settings. In domestic and restaurant settings, poor food handling and hygiene practices are often associated with outbreaks of RNA viruses such as norovirus and hepatitis A virus. These viruses are resilient and can survive in various food matrices, including fruits, vegetables, shellfish, and ready-to-eat foods. Therefore, it is essential for individuals, food industries, and regulatory agencies to prioritize preventive measures and strict adherence to food safety guidelines to minimize the risk of foodborne RNA virus transmission and outbreaks (Koopmans and Duizeer, 2004; Di Cola et al., 2021).

Foodborne viruses have been recognized as a growing concern to the food industry and a serious public health problem. Each year worldwide, unsafe food causes 600 million cases of foodborne diseases and 420 000 deaths. 30% of foodborne deaths occur among children under 5 years of age. WHO estimated that 33 million years of healthy lives are lost due to eating unsafe food globally each year, and this number is likely an underestimation. The burden of foodborne diseases is not spread equally across the globe but correlates with the socio-economic development of countries (WHO, 2023).

Food contamination can occur at various stages of its production until it reaches the final consumer. Therefore, there are a series of measurements that can be placed to prevent food contamination: primary production – implementing best practices in agriculture and animal husbandry to ensure that viral (and other pathogen) contamination of raw materials is avoided; processing – implementing robust decontamination technologies and validation tools to demonstrate the effectiveness of processes used including training and compliance of food handlers in good hygienic practices; consumer use – implementing consumer-friendly guidelines based on sound science to ensure that foods do not become contaminated during use; surveillance and monitoring – implementing a robust surveillance and monitoring system that includes contamination incidents can increase trust in the food supply since data from surveillance networks are invaluable in understanding and predicting the spread of foodborne viruses (Bosch et al., 2018). It is also important to highlight that many outbreaks of foodborne illnesses are caused by sick or contaminated food handlers. It is important to establish control and training measures for food handlers so that they understand the risk of the disease that contaminated food can bring to those who consume it (Koopmans and Duizeer, 2004; Bosch et al., 2018; Di Cola et al., 2021).

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