Superior Health Council

PUBLICATION OF THE SUPERIOR HEALTH COUNCIL No 8386

Viruses and food

February 2010

1. INTRODUCTION

Foodborne and waterborne viruses are currently acknowledged to be the source of a major public health issue in many parts of the world. These viruses are directly transmitted into the gastrointestinal tract via food and water and can induce gastroentiritis or hepatitis. This problem is referred to as emerging and requires that particular attention should be paid to informing the authorities, consumers and professional sectors about high-risk foodstuffs and the working methods concerned.

As this has implications for public health, it has been thought useful and advisable that the Superior Health Council (SHC) should draw up a synthetic assessment of the situation at the national level and issue recommendations on this subject, taking into account current developments within other national and international scientific bodies.

An ad hoc working group of the SHC (which included experts in food microbiology and virology) has reviewed the information that is currently available on the risks for humans involved in consuming foodstuffs contaminated by viruses, the purpose being to issue recommendations aimed at improving foodborne virus infection control. The SHC working group “foodstuff microbiology” then issued comments on the final version of this text, which it subsequently approved.

This document provides a brief survey of the main concepts that are discussed in the scientific report in the annex. It provides an overview of the following general aspects: the characteristics of the main foodborne viruses (and the questions that they may raise with the competent authorities) and the appropriate way to control outbreaks (i.e. how to behave in the event of an epidemic, at least from the viewpoint of foodborne transmission). The information collected is based on the recent scientific literature.

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rue de l’Autonomie 4 • 1070 Brussels • www.css-hgr.be

2. CONCLUSION

The findings and observations collated in the scientific report (cf. the annex to this publication) as well as the numerous points that are highlighted in this document have led to the following public-health oriented conclusions (both national and international aspects).

Only a small fraction of the cases are reported to the national surveillance system. In fact, many countries don't even have an effective surveillance system. Yet, the available epidemiological data and recent publications from the literature show that foodstuffs can act as an effective vehicle for the transmission of viruses.

Foodborne viruses are transmitted through the faecal-oral route. Faecal contamination occurs as a result of food-handlers handling such items as "ready-to-eat" food, as well as through the water which bivalve molluscs are grown in and the water that is used for growing/producing fresh produce. Viruses do not replicate in foodstuffs. This means that their quantity will never exceed the initial viral load. The fact that the viral load in the analysed food samples is usually low also accounts for the practical problems involved in detecting viral contamination. It follows from these considerations that molluscs are to be looked upon as a high-risk food source. Indeed, they are filter-feeders, which means that they physiologically concentrate virus particles in their digestive tract.

In Belgium, the most important viruses in terms of the number of cases and the severity of illness are noroviruses (NoV) and hepatitis A viruses (HAV). Other foodborne viruses that are less important but may still be taken into consideration are: hepatitis E viruses (HEV), human rotaviruses and human sapoviruses. HEV has been included in this category because it has recently been detected in humans and pigs in Belgium. Most of these viruses are transmitted via the faecal-oral route. A third category of viruses is also worth mentioning, i.e. astroviruses, adenoviruses types 40 and 41, Aichi viruses, enteroviruses and tick-borne encephalitis viruses (TBEV). This scientific report does not go into the details of some emerging zoonotic viruses for which it cannot be ruled out that they can be transmitted through food (e.g. the H5N1 avian influenza virus, Nipah virus, rabies virus). The reason is that the extent to which they are actually transmitted through food can be considered insignificant.

Although the most common viral pathogen, NoV, only induces a mild illness, its high incidence is indicative of its potential to cause very large international foodborne epidemics. Nevertheless, there is also a risk of more dangerous illnesses, such as hepatitis, being transmitted through food.

Good epidemiological studies will allow to identify any changes in the epidemiological profile of the viruses. They will especially contribute towards detecting the emergence of viruses like HEV, Aichi virus or TBEV, which particularly affect Northern Europe, or, at the very least, point to an increase in their incidence.

The genetic proximity of some animal and human virus strains raises questions about their potential zoonotic transmission and about "animal reservoirs". In order to improve our understanding of the way in which viruses like noroviruses and HEV are transmitted, it is crucial to unravel the sequences of the animal and human strains. It follows that it is important that research be carried out on both human and animal virus strains.

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3. THE SITUATION IN BELGIUM

According to the EFSA (*European Food Safety Authority*), the viruses transmitted through foodstuffs (adenovirus, norovirus, enterovirus, HAV and rotavirus) have been responsible for 10.2% of the epidemics declared in 2006, showing a considerable increase in one year (5.8% in 2005). In 2006 and 2007, the viruses became the second most frequent cause of foodborne infection, after *Salmonella*. Noroviruses are the most frequent cause of non-bacterial gastroentiritis (according to the Foodborne Viruses in Europe network, FBEV, 1995-2000) and account for more than 60% of the epidemics caused by foodborne viruses (196/315 outbreaks, which amounts to 6,006 individual cases in 2005) (Report of the EFSA, 2007).

In Belgium, the cause of the foodborne outbreak remains undetermined in 20 to 50% of the cases. This situation has improved since 2006, following the implementation of a detection method for noroviruses in foodstuffs. The number of norovirus infections is still being underestimated, as gastroentiritis passes quickly and patients therefore do not necessarily consult a doctor. Moreover, few clinical samples are analysed, because the costs involved are not refunded in Belgium. In 2006, 3 norovirus epidemics were identified in Belgium. Since 2007, there have been 75 foodborne outbreaks, 10 of which were caused by noroviruses. The latter have replaced *Salmonella* as the leading cause of foodborne outbreaks registered in this country.

HAV infections have been reported in Belgium on a regular basis: there were 194 cases in 2006 and 197 cases in 2007. Although HAV is mainly transmitted via the faecal-oral route, there are some cases in which the suspected origin is a member of staff infected with HAV and handling foodstuffs.

Rotavirus infections are also frequently reported in Belgium. These viruses too are mainly transmitted via the faecal-oral route, with only a very small proportion of the 4,194 cases reported in 2007 having been foodborne. Sapovirus infections also occur in Belgium, but their incidence is low compared to that of noroviruses and rotaviruses. There is no information available concerning the types of foodstuff involved in rotavirus and sapovirus infections.

HEV infections have already been identified in humans in Belgium. A recent study shows that these viruses are also present in pigs in this country. So far, no link has been found to exist between HEV infections and food.

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4. CONCLUSIONS AND RECOMMENDATIONS

Taking into account current scientific knowledge from the literature on foodborne viruses, the state of the art as regards the analytical methods and the epidemiological data available, the SHC issues a series of recommendations on this public health issue that are intended for the competent authorities as well as those in charge.

- Foodborne viruses are assigned a level of priority that is based on their involvement in foodborne transmission. **Noroviruses and HAV** are categorised as **level 1 viruses,** as they are the most common causes of foodborne virus outbreaks. Sapovirus, HEV and rotavirus are assigned to level 2. Aichi virus, TBEV, astrovirus, adenovirus, and enterovirus are all level 3 viruses. Indeed, there are few reports in which foodborne outbreaks are attributed to these viruses.

- There is no certainty over the **infectious dose of foodborne viruses**. On the one hand, it is estimated to be extremely low: approximately **10 to 100 virus particles**. On the other, foodborne viruses are often shed at extremely high titres that can reach up **to 10^9 virus particles/g faeces**.

- According to assessments carried out with sensitive techniques, norovirus and HAV can be **shed for up to several weeks** after a symptomatic or asymptomatic infection. There should be special hygiene measures recommended for individuals working in health care or food workers manually preparing or handling foodstuffs. Additional precautions should be taken with respect to individuals who have been found to excrete these viruses.

- Foodborne viruses are mainly spread via the faecal-oral route. **Person-to-person** transmission is significant, especially amongst family members. It is followed by transmission through contaminated **food, drinking water or recreational water**. The environmental causes of virus infections should not be underestimated. It is not always easy to determine to what extent human infectious diseases are due to foodstuff consumption. The same is true for the degree to which particular foodstuffs are concerned.

- **Fresh produce** can be considered as **high-risk food**. It can be contaminated at the pre-harvest level by contact with faecally polluted irrigation water, organic-based fertiliser, or food pickers (harvest). There is no certainty over the extent to which each of these potential routes of transmission is involved. Limited data are available on the presence of viruses in the different types of water that are used in the primary plant production in Belgium. Furthermore, the contamination risk factors that result from fresh produce being in contact with polluted irrigation water are not well known.

- **Manually treated food intended to be consumed without further heating, such as catered food, can pose a high risk** for viral contamination. Because of the low infectious dose and the considerable shedding of infectious viruses, infected food-handlers should be removed from work until at least the end of the acute illness. Additional hygiene measures need to be implemented once they have returned from illness.

- **High-risk foods** also include **shellfish,** as these animals are filter-feeders: viruses are filtered out of the surrounding polluted water. These viruses are retained and can even be concentrated in the digestive tissue of the bivalve molluscan shellfish (oysters, mussels, cockles, clams). If contaminated shellfish are consumed raw or only slightly cooked (just until the shells are open), this will hold a risk for virus infection.

- A full assessment of the risks posed by the main viral pathogens, NoV and HAV, in the high-risk foods mentioned above is not available at the moment and will be difficult to perform. Such an assessment requires a better understanding of the transmission routes, prevalence, persistence and infectious particle titres of these viruses in the food supply chain. In addition, there are currently insufficient quantitative data available.

- The mandatory microbiological criterion (Regulation (EC) No 854/2004 and No 2073/2005) that needs to be observed whilst checking live bivalve shellfish is based on the level of bacterial indicators (***E. coli*** **and faecal coliforms), not on the presence of viruses**. Additional viral indicators that point to the presence of human pathogenic viruses are therefore required.

- Unlike bacteria, viruses cannot grow outside their host. As a result, they cannot be grown in culture media. Furthermore, most **foodborne viruses cannot be cultivated** in cell culture i**n the laboratory** or show fastidious growth. They are therefore detected by means of **molecular detection assays**. **Reverse transcriptase (RT)-PCR** is the pre-eminent technique for detecting foodborne viruses. In order to obtain reliable test results, it is necessary to carry out **adequate controls of the molecular detection assays, including an** internal amplification control to check PCR inhibition and a process control to check sample processing.

- With no culturing methods available, virus extraction requires adequate **methods to prepare** small volume **samples** from the food for (RT-)PCR, even when there are only low numbers of viruses present. It is not possible to apply any **horizontal virus detection methods**. It seems necessary to categorise foods according to their composition (e.g. foods of the fatty type, of the watery type). **Harmonisation** and categorisation are still ongoing in Europe (CEN), as well as worldwide (US, Canada). There is a need for extensive ring-trials to select robust, simple and reliable viral extraction methods.

- As virus **detection** relies on molecular detection, it targets the **viral genome**. The molecular detection assay will reveal whether or not there are any viral genome copies present. A positive result indicates that there has been viral contamination. However, the fact that viral genomic copies have been detected by means of (RT-)PCR does not necessarily mean that there are infectious virus particles present. Given this state of affairs, novel detection methodologies are required which are able to **distinguish** between **infectious and non infectious virus particles**.

- Good agricultural practices (GAP), good manufacturing practices (GMP) and good food hygiene practices (GHP) are of major importance to avoid the viral contamination of food products. The frequent occurrence of foodborne virus outbreaks shows that these "good practices" are not always met in the food supply chain. Typical shortcomings include the effectiveness itself of the preventive measures and poor procedure compliance (e.g. poor cleaning practices, unhygienic behaviour). Procedure compliance may be influenced by guideline and procedure awareness and knowledge, but also by the persistence of existing habits and attitudes. The risk of contamination can be reduced by vaccinating food-handlers. Such vaccines are already available for HAV and poliomyelitis, but not for NoV.

- **Food preservation methods** that are based on the inhibition and inactivation of microbial growth need to be assessed **in order to determine their effectiveness in** reducing/eliminating **foodborne viruses**. There are currently insufficient data available on the stability of viruses that are subjected to food processing technologies.

- Outbreaks in elderly homes and cruise ships have been traced down to c**ontaminated surfaces** as well as food-handler and nursing staff hands, which is indicative of the stability of foodborne viruses. More data are required on the effectiveness of cleaning and disinfecting agents (biocides).

- **The investigation of foodborne outbreaks** needs to be improved. This will require sufficient resources to **enhance the network** between the Reference laboratory of foodborne outbreaks, which analyses the foods, and the epidemiological unit, which collects epidemiological information. This will reduce the underreporting of foodborne virus outbreaks in Belgium.

- The analysis of clinical samples for virus detection should be encouraged and alternative sources of financing should be found. This will in turn lead to reduced underreporting, thus improving the estimate of the burden of foodborne viral disease to society.

- The zoonotic properties of **foodborne viruses** as well as the presence of **animal reservoirs** are still **being investigated**. At present, there is no evidence that production or companion animals play a part in the transmission chain of noroviruses. However, HEV are found in pigs, which makes it necessary to clearly determine the significance of this reservoir. The presence of sapoviruses and Aichi viruses in production animals is a point of interest that also requires special attention.

- Noroviruses are not known to the general public in Belgium. Also many doctors, health workers in semi-closed institutions such as hospitals, nursing homes and day care centres are not aware of the existence of this virus. As NoVs are **highly contagious**, they can be spread very easily. NoVs normally cause mild gastroenteritis, but they can also lead to **severe disease** in sensitive groups such as **young children, the elderly and immunocompromised individuals**.

- **It is strongly recommended to deliver information** on foodborne viruses (NoV, HAV) to medical doctors, to those working in health care or with sensitive groups and to those in charge of food safety management systems. It is also advised to provide specific and appropriate training to food-handlers.

5. CONSIDERATIONS FOR FUTURE RESEARCH

- Fresh produce is to be looked upon as high-risk food. The routes through which viruses are transmitted onto fresh produce are not clear. Still, water is generally acknowledged to be a potential route of transmission. Limited data are available in Belgium on the presence of viruses in different types of water used in primary plant production. It is necessary to shed light on the link between viral contamination and the presence of faecal indicators and bacterial pathogens.

- Furthermore, the contamination risk factors that result from fresh produce being in contact with polluted irrigation water are not well known. In addition, there is no information available about the ability of foodborne viruses to attach or adhere to and/or penetrate into the tissue of fruits and vegetables, nor on their survival in the ecological niche formed by the crop.

- More data are needed on the stability of foodborne viruses that are subjected to food processing technologies. It has been suggested that viruses are more stable in this environment than bacteria. This requires further examination. Inactivation rates should be defined on the basis of various model viruses.

- The resistance of viruses should be examined under various physical and chemical conditions that mimic those that are reached during the production process.

- One should assess the effectiveness of disinfectant biocides against typical foodborne viruses.

- The presence of foodborne viruses or related viruses in domestic animals calls for a better understanding of their potential zoonotic transmission.

- Data on the molecular epidemiology of human and animal noroviruses and HEV (zoonotic risk and animal reservoir) are needed for future intervention and for the prevention programme, both of which are based on their role as a potential zoonotic agent or on the presence of an animal reservoir.

- There is a need for prospective studies that investigate the virus-host interaction of viruses which will potentially emerge, such as HEV or Aichi viruses.

- It is necessary to develop novel methodologies that can distinguish between infectious and non-infectious foodborne viruses. Improving the risk assessment involves quantifying these viruses as well as assessing the doses that are infectious for humans more accurately. This will help to determine the risk for public health whenever viruses are detected in foodstuffs, water or in the environment by means of molecular techniques such as RT-PCR.

6. ANNEX

Scientific report entitled: “Annex to the publication of the Superior Health Council No 8386 – Viruses and food (SHC 8386) *Scientific report* ” (71 pages).

The following experts were involved in drawing up the scientific report:
Baert Leen, Botteldoorn Nadine, Dierickx Katelijne, Daube Georges, Goubau Patrick, Houf Kurt, Scipioni Alexandra, Thiry Etienne, Uyttendaele Mieke, Van Coillie Els and Van Ranst Marc.
Ms. Christina Espert (ULg) finalised the scientific report and Ms. Evelyn Hantson (SHC) proofread the English version of this document.
The working group was chaired by Etienne THIRY.

7. COMPOSITION OF THE WORKING GROUP

All the experts joined the working group in a private capacity. The names of the experts of the SHC are indicated with an asterisk*.

The following experts were involved in drawing up and/or approving the advisory report :

BAERT Leen	(Food microbiology, UGent).
BOTTELDOORN Nadine	(Food microbiology, IPH)
DIERICK Katelijne	(Food microbiology, IPH)
DAUBE Georges *	(Food microbiology, ULg).
DE SCHRIJVER Koen*	(Epidemiology, UA)
DE ZUTTER Lieven*	(Food microbiology, UGent).
GEERAERD Annemie*	(Food microbiology, KULeuven)
GOUBAU Patrick*	(Medicine, virology, Clin. Univ. St.-Luc - UCL)
HEYNDRICKX Marc*	(Food microbiology, ILVO)
HOUF Kurt*	(Food microbiology, UGent).
MAHILLON Jacques*	(Microbiology, UCL)
MELIN Pierrette*	(Medical microbiology, ULg)
MICHIELS Chris	(Food microbiology, KULeuven)
NOIRFALISE Alfred*	(Toxicology and bromatology, ULg).
PIERARD Denis*	(Medical microbiology, VUB)
SCIPIONI Alexandra	(Vet. medicine, vet. virology and viral diseases, ULg)
SINDIC Marianne*	(Food microbiology, Gembloux Agro-Bio Tech)
THIRY Etienne*	(Vet. medicine, vet. virology and viral diseases, ULg)
UYTTENDAELE Mieke*	(Food microbiology and food preservation, UGent).
VAN COILLIE Els	(Biotechnology, food virology, ILVO-Vlaanderen)
VAN RANST Marc*	(Medicine, virology, UZ-KUL)

The Administration was represented by Benoît HORION and Isabel DE BOOSERE.

The working group was chaired by Etienne THIRY, the scientific secretary was Jean-Jacques DUBOIS.