POTENTIAL FOR FOODBORNE TRANSMISSION OF COVID-19: LITERATURE REVIEW UPDATE

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1. SUMMARY

The material covered in this report has been based on information available to ESR up to 1 April 2020. This report provides an update to an earlier report that was finalised on 16 March 2020 and which covered information up to 11 March 2020. There is significant ongoing research into COVID-19 (the disease), and SARS-CoV-2 (the virus), and new information is appearing on a daily basis. New information relevant to the questions addressed in this report may have appeared since the report date.

Because SARS-CoV-2 has only recently been discovered, there are still considerable gaps in our understanding of both the disease and the virus. Therefore, there is still a lack of international consensus or best practice for many of the questions asked of this review. We have provided information according to the current state of knowledge, and within the short time available to conduct this review. Some of the information we found involved studies of other coronaviruses, and it cannot be guaranteed that the data also apply to SARS-CoV-2.

The report addresses the following seven research questions:

1. What is international best practice regarding reducing the likelihood that food products or packaging are vectors for COVID-19? In this context, sources of COVID-19 may be production or supply chain workers?

2. What is international best practice for mitigation options to reduce transfer of COVID-19 from workers to food products?

Key finding for questions 1 and 2: In our opinion the best practice for reducing the risk of contamination of food products or packaging continues to be managing the risk of SARS-CoV-2 infection amongst workers. The Ministry for Primary Industries has provided advice on this. This includes workers informing their employer and seeking medical advice if they have any symptoms of respiratory illness, or have travelled to affected regions. Employers can promote and implement good personal hygiene practices for all workers. A new NZFSSRC review also provides information on the use of personal protective equipment (PPE) in reducing COVID-19 transmission to and from people, fomites and food.

3. What is the latest information on the routes of transmission for COVID-19 (including anything that implicates food as a vector)?

Key finding: The primary transmission route for human infection with SARS-CoV-2 is via respiratory droplets. It may be possible that a person can get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose, or possibly their eyes, but this is not thought to be the main way the virus spreads. Infectious virus has been found in faeces of some infected people, raising the possibility of faecal-oral transmission via contaminated vehicles such as food, but there is no evidence for this having occurred.

4. What is the international consensus on survival rates of COVID-19 in food products?

Key finding: No published studies of SARS-CoV-2 survival in or on food products were located. A study of MERS-CoV in various types of unpasteurised milk showed survival of infective virus for up to 72 hours. Pasteurisation inactivated the virus.

5. What is the international consensus on survival rates on surfaces of fresh food especially if the food is consumed fresh and not cooked?

Key finding: No published studies of SARS-CoV-2 survival on fresh food were located. A study of another coronavirus showed survival on lettuce for up to two days. This coronavirus could not be recovered after inoculation onto strawberries.

6. What is the likelihood of a person becoming infected with coronavirus from consuming the virus?

Key finding: No information was located on the likelihood of infection from consuming SARS-CoV-2 through food. Normal intestinal conditions (stomach acid and bile salts) are thought to inactivate SARS-CoV-2, but more research is needed.

7. What are the risk management options for companies when a worker is identified as having COVID-19?

Key finding: We consider that these situations would need to be assessed on a case-by-case basis. General advice has been offered by Food Safety Authority of Ireland, The United States Food and Drug Administration (US FDA) and Centres for Disease Control (US CDC), and the Occupational Safety and Health Administration (OSHA) on their websites.

2. INTRODUCTION AND METHODS

Introduction

This review was commissioned to attempt to answer specific questions about the current COVID-19 disease pandemic, submitted by the food industry, via the New Zealand Food Safety Science and Research Centre. The questions for the initial review were submitted on Thursday 5 March 2020, with the draft review delivered on Thursday 12 March 2020. Two more questions were added during the course of the review and the report was finalised 16 March 2020 [1]. An updated version of the document was requested on 18 March 2020, to be submitted 6 April 2020. One more question regarding risk management options was added to the updated review.

The material in this report is based on information available to ESR up to 1 April 2020. There is significant ongoing research into COVID-19 (the disease) and SARS-CoV-2 (the virus), and new information is appearing on a daily basis. New information relevant to the questions addressed in this report may have appeared since the report date.

Information provided in the first version of this report has been retained, unless it has been superseded. Quotes from websites, articles and reports are given in italics.

There are still considerable gaps in our understanding of both the disease and the virus. Therefore, there is still a lack of international consensus or best practice for many of the questions asked of this review. We have provided information according to the current state of knowledge, and within the short time available to conduct this review. Some of the information we found involved studies of other coronaviruses, and it cannot be guaranteed that the data also apply to SARS-CoV-2.

The primary sources for information on management of COVID-19 and SARS-CoV-2 are the Ministry of Health website:

https://www.health.govt.nz/our-work/diseases-and-conditions/covid-19-novel-coronavirus

and the Ministry for Primary Industries website:

https://www.mpi.govt.nz/protection-and-response/responding/alerts/coronavirus/

Methods

A systematic approach was undertaken to identify relevant literature from electronic scientific databases. References were assessed for relevance (title screening) and non-duplicates were retained.

Table 1. Search terms and results

Database	Search terms	Search date	Reference results	Retained references
Pubmed	COVID-19 & food	09-03-2020, 19-03-2020	4 13	1 0
	SARS-CoV-2 & food	09-03-2020, 19-03-2020	2 6	0 0
	coronavirus & foodborne	09-03-2020, 19-03-2020	6 7	3 0
	(COVID-19 OR 2019-nCoV OR severe acute respiratory syndrome coronavirus 2) & foodborne	09-03-2020, 25-03-2020	0 0	0 0
	(COVID-19 OR 2019-nCoV OR severe acute respiratory syndrome coronavirus 2) & food	09-03-2020, 25-03-2020	4 18	0 1
	SARS-CoV & food	09-03-2020, 25-03-2020	97 106	0 0
	MERS-CoV & food	09-03-2020, 25-03-2020	67 70	3 0
	COVID & food worker	09-03-2020, 25-03-2020	0 2	0 0
	COVID & food hygiene	09-03-2020, 25-03-2020	1 3	0 0
	COVID & food	09-03-2020, 25-03-2020	3 15	0 0
	SARS-CoV & food	09-03-2020, 25-03-2020	40 106	0 0
	Coronavirus & gastric	09-03-2020, 25-03-2020	39 42	1 0
	COVID & asymptomatic	18-03-2020	33	9
	COVID & transmission	25-03-2020	259	20
	(COVID OR Coronavirus) & (freezing OR refrigeration OR temperature)	27-03-2020	387	16
	(COVID OR Coronavirus OR SARS-CoV-2) & (seawater OR marine)	30-03-2020	30	0
	(COVID OR Coronavirus OR SARS-CoV-2) & ozone	30-03-2020	4	2
	COVID-19 & diarrhoea	02-04-2020	43	7
Web of Science	COVID AND food AND worker	09-03-2020 20-03-2020	0 0	0 0
	COVID AND food	09-03-2020 20-03-2020	0 0	0 0
	SARS AND CoV AND food	09-03-2020 20-03-2020	11 11	0 0

Other sources for information included references cited in reviews and other scientific literature.

Information and advice was also obtained from public websites over the dates 6-27 March 2020, including:

- https://www.cdc.gov/coronavirus/2019-ncov/index.html
- https://www.who.int/emergencies/diseases/novel-coronavirus-2019
- https://www.health.govt.nz/our-work/diseases-and-conditions/covid-19-novel-coronavirus
- https://www.efsa.europa.eu/en/news/coronavirus-no-evidence-food-source-or-transmission-route
- https://www.fda.gov/food/food-safety-during-emergencies/food-safety-and-coronavirus-disease-2019-covid-19

Google searches included:

- COVID food worker
- COVID food hygiene
- COVID food
- SARS CoV food

3. THE PATHOGEN: SARS-COV-2

3.1. Background, nomenclature and classification

In December 2019, a series of cases with symptoms resembling viral pneumonia emerged, all were epidemiologically associated with the Huanan Wholesale Seafood Market in Wuhan, Hubei, China [2, 3]. By using next-generation sequencing methods, a novel coronavirus was identified in samples taken from the lower respiratory tract of these patients [3]. On 7 January 2020, the virus associated with this outbreak was tentatively named 2019 novel coronavirus (2019-nCoV). By 16 January, there were 43 cases reported and by 11 February 2020, there were over 43,000 cases reported. On that day, the disease associated with the virus was named Coronavirus Disease 2019 (abbreviated to COVID-19) by the World Health Organisation (WHO) and the virus was renamed severe acute respiratory syndrome-related coronavirus 2 (abbreviated to SARS-CoV-2) by the International Committee on Taxonomy of Viruses (ICTV) [4]. The COVID-19 outbreak was characterised as a pandemic by the WHO on 11 March 2020. A pandemic is a new disease that has spread over several countries or continents, and usually affects a large number of people because there is no existing immunity.

Coronaviruses, named for the distinct crown-like spikes on their surface, belong to the subfamily *Coronavirinae,* family *Coronaviridae* and order *Nidovirales*. The viruses are enveloped and contain non-segmented, positive-sense, single-stranded RNA ranging from 26 to 32 kilobases which make it the largest known RNA virus genome [5]. The virions are spherical and can measure up to 170 nm diameter[1]. Coronaviruses infect vertebrates, causing a variety of disease in mammals, including humans and birds. Interspecies and zoonotic transmission of coronaviruses has been reported [6, 7].

In the current classification, in the family *Coronaviridae,* there are 39 species in 27 subgenera, five genera and two subfamilies. Of the seven identified coronaviruses now known to infect humans, four human coronaviruses (human coronavirus (HCoV)-229E, HCoV-NL63, HCoV-OC43 and HCoV-HKU1) usually cause mild illness consisting of self-limiting upper respiratory infection. The other three (severe acute respiratory syndrome-related coronavirus (SARS-CoV), Middle-East respiratory syndrome-related coronavirus (MERS-CoV) and SARS-CoV-2 can cause severe disease. SARS-CoV (causing SARS) and MERS-CoV (causing MERS) are both from a zoonotic reservoir and were introduced to humans in 2002 and 2012, respectively [5].

The family *Coronaviridae* are currently classified into four main known groups known as alpha, beta, gamma and delta (*Alphacoronavirus*, *Betacoronavirus*, *Gammacoronavirus* and *Deltacoronavirus)* [5]. Of the coronaviruses affecting humans, HCoV-229E and HCoV-NL63 are alphacoronaviruses, while HCoV-OC43, HCoV-HKU1, SARS-CoV, and MERS-CoV are

[1] https://talk.ictvonline.org/ictv-reports/ictv_9th_report/positive-sense-rna-viruses-2011/w/posrna_viruses/222/coronaviridae. Accessed 12 March 2020

betacoronaviruses. Full genome sequence analysis of SARS-CoV-2 (approx. 30 kilobases) showed that it belongs to the *Betacoronavirus* genus and forms a distinct clade with bat SARS-like coronaviruses (namely bat-SL-CoVZC45, Bat-SL-CoVZXC21 and BatCoV RaTG13) supporting the hypothesis that SARS-CoV-2 originated from bats [3, 8].

Angiotensin converting enzyme 2 (ACE2) is an enzyme attached to the outer surface (cell membranes) of cells in the lungs, arteries, heart, kidney, and intestines [9]. As a transmembrane protein, ACE2 serves as the main entry point into cells for some coronaviruses, including SARS-CoV-2 [10].

SARS-CoV-2 detection or infection diagnosis can be achieved by:

(1) detection of the RNA from the virus using the reverse transcription quantitative polymerase chain reaction (RT-qPCR; currently, the "gold standard" for detection)
(2) serology, which detects antibodies to indicate that a person had an immune response to SARS-CoV-2 whether or not they actually developed symptoms (note that the earliest that IgM can be detected is several days after symptoms develop, and serology testing has not yet been widely validated for SARS-CoV-2)
(3) growing the virus in cell culture (can only be undertaken in highly contained specialist laboratories and hence rarely performed, not used for diagnosis).

3.2. Disease signs, symptoms and human susceptibility

Signs and symptoms

Signs and symptoms of COVID-19 presentation can range from no symptoms (i.e. asymptomatic) to severe pneumonia and death [11]. The proportion of symptoms observed varied depending on the study. As of 20 February 2020 and based on 55,924 laboratory-confirmed cases, typical signs and symptoms from one study included:

- Fever (87.9%),
- Dry cough (67.7%),
- Fatigue (38.1%),
- Sputum production (33.4%),
- Shortness of breath (18.6%),
- Sore throat (13.9%),
- Headache (13.6%),
- Myalgia or arthralgia (muscle or joint pain) (14.8%),
- Chills (11.4%),
- Nausea or vomiting (5.0%),
- Nasal congestion (4.8%),
- Diarrhoea (3.7%),

- Haemoptysis (coughing up of blood or blood-stained mucous) (0.9%),
- Conjunctival congestion (red eyes) (0.8%).

Only a small percentage of patients were reported with nausea or vomiting (1-5%), or diarrhoea (2-10%) in the early studies [2, 11-14]. However, recent reports suggest that up to 79% of patients may be presenting with gastrointestinal symptoms (reviewed by [15]). The review reported that anorexia was the most frequent digestive symptom in adults (39.9%-50.2%), while diarrhoea was the most common symptom both in adults and children (2%-49.5%), and vomiting was more common in children. About 3.6%-15.9% of adult patients and 6.5%-66.7% of child patients had vomiting. Nausea was experienced by 1%-29.4% of patients, and gastrointestinal bleeding by 4%-13.7%; abdominal pain (2.2%-6.0%) was more frequent in severely ill patients. There are also reports of a small number of patients who presented with diarrhoea and vomiting with only low-grade or no fever and without a cough [16].

Significant numbers of patients (30% in South Korea and 66% in Germany) who tested positive for SARS-CoV-2 infection have developed anosmia, or a reduced ability to smell (hyposmia)[2].

Signs and symptoms, including mild respiratory symptoms and fever, occur on an average of 5-6 days after infection (mean incubation period 5-6 days, range 1-14 days) [17, 18]. The average time from onset of symptoms to death is 14 days, which is reduced to 11.5 days for patients aged ≥70 years [18]. The incubation period for COVID-19 disease can be longer than for SARS-CoV-mediated disease which is 2-7 days [18].

Approximately 80% of laboratory-confirmed patients have had mild to moderate disease and recover (both non-pneumonia and pneumonia cases), 13.8% have severe disease and 6.1% become critical (respiratory failure, septic shock, and/or multiple organ dysfunction/failure).

Asymptomatic infection is increasingly reported, including in infants [19, 20]. In one Chinese study the number of asymptomatic cases are 25% [21] and experts have suggested that numbers may actually be higher. Future sero-epidemiology studies will refine this number. Another study in China estimated that 12.6% of cases appeared to be caused by pre-symptomatic transmissions [22]. For this reason more western countries are asking their citizens to wear masks in public, like their eastern counterparts, primarily to reduce of transmission from asymptomatic and pre-symptomatic patients[3].

[2] https://www.entuk.org/sites/default/files/files/Loss%20of%20sense%20of%20smell%20as%20marker%20of%20COVID.pdf; accessed 6 April 2020

[3] https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/cloth-face-cover.html; accessed 6 April 2020

Demographics

Because SARS-CoV-2 is a newly identified pathogen, there is no known pre-existing immunity in humans. Certain risk factors might increase susceptibility to infection, but the epidemiologic characteristics observed so far in China support the assumption that everyone is susceptible [11].

However, there is a low prevalence of disease occurrence in children aged ≤18 years (1-5% of cases [11, 23, 24]). It is not yet known if children are less susceptible to SARS-CoV-2 infection, but accumulating data suggests that they have different (milder) clinical presentations and asymptomatic infections are not uncommon in this age group [24, 25]. Thus the earlier conclusion that there is a low prevalence of asymptomatic infection may change. Mortality increases with age, with the highest mortality from patients aged >80 years [11, 23].

4. WHAT IS INTERNATIONAL BEST PRACTICE REGARDING REDUCING THE LIKELIHOOD THAT FOOD PRODUCTS OR PACKAGING ARE VECTORS FOR COVID-19?

5. WHAT IS INTERNATIONAL BEST PRACTICE FOR MITIGATION OPTIONS TO REDUCE TRANSFER OF COVID-19 FROM WORKERS TO FOOD PRODUCTS?

Key finding for questions 4 and 5: In our opinion the best practice for reducing the risk of contamination of food products or packaging continues to be managing the risk of SARS-CoV-2 infection amongst workers. The Ministry for Primary Industries has provided advice on this. This includes workers informing their employer and seeking medical advice if they have any symptoms of respiratory illness, or have travelled to affected regions. Employers can promote and implement good personal hygiene practices for all workers. A new NZFSSRC review also provides information on the use of personal protective equipment (PPE) in reducing COVID-19 transmission to and from people, fomites and food.

New Zealand Food Safety have a web page[4] offering the following advice for food handlers and food businesses:

"Can the virus be transmitted through food?

Experience with recent acute respiratory diseases such as Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) suggests that people are unlikely to be infected with the virus through food. There isn't evidence to date of this happening with the 2019 Coronavirus (COVID-19).

Coronaviruses cannot grow in food – they need a host (animal or human) to grow in. Cooking for at least 30 minutes at 60°C kills SARS, which is a similar coronavirus.

Coronaviruses are most commonly passed between animals and people and from person-to-person contact.

The source of the COVID-19 virus is believed to be animals, but the exact source is not yet known.

The virus is commonly transmitted through direct mucous membrane contact by infectious droplets, e.g. breathing in airborne virus from the sneeze of someone who is infected, or through hand to mouth/nose contact after fingers have touched a contaminated surface.

Investigations in China are continuing to identify the source of the outbreak and ways it can be transmitted to people.

[4] https://www.mpi.govt.nz/protection-and-response/responding/alerts/coronavirus/coronavirus-and-food-safety/ last reviewed by New Zealand Food Safety on 25 March 2020; accessed 31 March 2020

What can food handlers do?

It is possible that infected food handlers could introduce the virus to the food they are in contact with by coughing and sneezing, or through hand contact. However, this is unlikely to occur if food handlers in food businesses and in the home follow standard, good personal hygiene practices that reduce the risk of transmission of most foodborne illnesses. These practices include:

- *proper hand hygiene*
- *safe food practices*
- *cough/cold hygiene practices*
- *avoiding close contact, when possible, with anyone showing symptoms of respiratory illness such as coughing and sneezing.*

Food handlers must wash hands (even if they have no disease symptoms):

- *before starting work*
- *before handling cooked or ready-to-eat food*
- *after handling or preparing raw food*
- *after handling waste*
- *after cleaning duties*
- *after using the toilet*
- *after blowing their nose, sneezing or coughing*
- *after eating, drinking, or smoking*
- *after handling money.*

Good hygiene and cleaning will also prevent cross-contamination between raw or undercooked foods and cooked or ready-to-eat foods in the kitchen or service area.

It is important that food handlers inform their employer, avoid preparing food for other people, and seek medical advice if they think they have symptoms of respiratory illness.

What can food business owners/managers do?

It is unlikely that COVID-19 can be transmitted through food, and there isn't evidence to date of this happening. Usual good hygienic manufacturing practices and thorough cooking for cooked products will minimise the risk of transmission for any foodborne illness.

Manufacturers and employers still have an important role to play in preventing foodborne illness. They should:

- *ensure staff are aware of the COVID-19 issue*
- *stay informed of staff who have been overseas to affected regions or in contact with persons who have, and seek appropriate medical advice*
- *ensure that food handlers are trained appropriately in food hygiene practices appropriate to their premises*
- *ensure effective supervision of food handlers to reinforce hygienic practices*
- *ensure that appropriate facilities are provided for hand washing or sanitation (e.g. alcohol gels/wipes) to enable food handlers to practice good hygiene*
- *ensure that food handlers and external contractors are aware that they must report any signs/symptoms of respiratory illness before or during work*
- *keep vigilant and ensure that food handlers and other staff are not ill and are fit to work*
- *ensure that staff with symptoms stay home until medical advice is obtained*

- *fully support staff through access to medical advice and during convalescence.*

New Zealand Food Safety, in conjunction with the wider Ministry for Primary Industries, Ministry of Health and international organisations, is closely monitoring developments around the COVID-19 outbreak. We'll update this web page as needed and inform the New Zealand food industry of any developments that may adversely affect the safety of food.

Last reviewed: 27 Mar 2020"

This advice matches that provided by the website of the Food Safety Agency of Ireland[5]. In addition, that website provides the following information on recommended hand-washing technique, appropriate measures for wearing of gloves, social distancing and touch points.

*"**What is the proper hand washing technique?***

- *Wet hands under warm running water*
- *Use enough soap to form a good lather*
- *Rub all parts of hands with soap and water*
- *Lather for at least 20 seconds, vigorously and thoroughly rubbing all hand surfaces, including the fingertips and thumbs*
- *Rinse hands thoroughly with running water*
- *Dry hands thoroughly, using disposable paper towels, if possible*

Do food workers need to wear gloves?

No. It is perfectly acceptable to prepare and handle food with bare hands provided proper hand washing procedures are in place.

Gloves may be used by food workers, but they must ensure that the gloves are changed frequently and that hands are washed between glove changes and when gloves are removed.

Gloves must be changed after carrying out non-food related activities such as opening/closing doors by hand, emptying bins, handling money, etc.

Food workers should be aware that wearing gloves can allow bacteria to build up on the surface of the hands, so hand washing is extremely important when gloves are removed to avoid subsequent contamination of food.

It is important to wash your hands even when wearing gloves, as contaminated gloves can spread germs to your hands when removing the gloves.

If I wear gloves, is handwashing still important?

5 https://www.fsai.ie/faq/coronavirus.html last reviewed by Food Safety Authority of Ireland 23 March 2020; accessed 25 March 2020

Proper hand washing is extremely important, whether using gloves or not. If using gloves, hand washing should be carried out before putting gloves on, between glove changes and after gloves are removed.

The problem with the use of gloves is that if staff are not given proper training in food safety, gloves are often seen as a barrier to food contamination. Staff may then carry out many non-food related tasks (e.g. handling money, emptying bins, wiping counters) while wearing the same pair of gloves that they then use to prepare food.

When wearing gloves for a prolonged period of time, without frequent changing and hand washing, bacteria on the skin rapidly multiply due to the warm, moist environment created by the gloves. If the gloves tear or are removed and food is handled without hand washing, a high number of bacteria can be transferred to the food.

Social Distancing

Where employees attend work the HSE has recommended that social distancing is implemented to help slow the spread of COVID-19. This involves maintaining a distance of 2 metres (6.5 feet) between people and reduced social interactions. To implement social distancing, food businesses could:

- *limit the number of staff in a kitchen or food preparation area at any one time*
- *space out workstations and food preparation areas, if possible*
- *limit the number of people (staff, delivery drivers, customers) who can come into your premises at any one time*
- *use spacing measures (e.g. floor markers) at tills or queues, if possible*
  use a ticketing system if appropriate"

Touch Points

Touch points e.g. trollies, keypads, door handles etc., should be cleaned more frequently.

Wipes (or other forms of sanitisation) could be provided for customers to clean the handles of shopping trollies and baskets.

Ladles, tongs, condiment holders etc. should be washed and sanitised frequently.

Keep doors open where possible to minimise contact."

The Food Safety Authority of Ireland site also provides specific worker guidance for operating restaurants as takeaways, managing transport and delivery of food, and making food for vulnerable people.

A review was recently published by NZFSSRC on the effectiveness of personal protective equipment (PPE) in reducing COVID-19 transmission to and from people, fomites and food [26]. The key findings of the review are as follows:

"1. *As yet, we find no evidence of PPE being mandated in food production or processing premises in relation in COVID-19 globally.*

2. Gloves and masks are considered to reduce transmission to health workers who are dealing with known infections.

3. *The World Health Organisation (WHO) is strongly recommending that the use of face masks is rationalised as there is going to be a world shortage – they do not recommend the use of face masks for non-infected people. For people that are showing no signs of COVID-19, their recommendation is that PPE is not needed and that practicing good hygiene practices are all that are required.*
4. *Consistent with this, the USFDA (2020) recommends that personnel in food retail and service industry settings who are well should not wear a facemask. These people should use good hygiene actions and avoid close contact with people who are sick.*
5. *In contrast, the Occupational Safety and Health Administration (USA) recommends engineering controls and PPE for workers that need to be within 6 ft (1.8 metres) of each other and whose health status is unknown. This refers to workers that may be infected with SARS-CoV-2, but are not yet known or suspected as being infected.*
6. *For PPE to be effective (in the health setting), they must be worn correctly, particularly face masks – there can be issues with worker adherence to this.*
7. *There is some evidence of issues with doffing PPE and contamination of the surrounding environment and other people (in the health setting).*
8. *Individuals with beards and moustaches would not achieve the same protection as other individuals from a facemask or respirator due to leakage around the edges of the mask/respirator.*
9. *We have not found any specific scientific evidence of mitigations (the PPE aspects) that can be taken to ensure people working less than 2 m apart in abattoirs/processing plants can work safely. WHO note that a physical barrier may be useful (but this is specific advice to the health sector).*
10. *There are non-grounded suggestions that the use of such physical barriers, for e.g. screens and visors, may reduce the potential for spread via sneezes – however, it should be noted that people sneezing should be excluded from the workplace anyway, provided that the person is not suffering from hay fever.*
11. *We find some evidence that visors/shields do not provide complete protection as they do not always seal"*

The use of face masks

Internationally, guidance on the use of face masks by workers in a non-health care setting has been mixed to date. However, as discussed in Section 3.2, more countries are asking their citizens to wear masks in public, primarily to reduce transmission from asymptomatic and pre-symptomatic patients. For example, the US CDC is recommending wearing cloth face coverings in public settings where other social distancing measures are difficult to maintain (e.g., grocery stores and pharmacies) especially in areas of significant community-based transmission [6].

[6] https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/cloth-face-cover.html; accessed 6 April 2020

The latest guidance from the Ministry of Health is as follows[7]: *The Ministry is watching very closely advice from the WHO and CDC around whether or not people should wear face masks in public to limit spread of the virus from people who are infected but not showing symptoms.*

The best current advice is that basic hygiene measures such as frequent hand-washing, physical distancing and sneeze and cough etiquette remain the mainstay in our defence against COVID-19.

We know there are ways in which wearing a mask could be helpful and also ways in which it could be harmful.

In many countries individuals who are unwell often wear a mask when they go out. There is evidence that can be good practice particularly for protecting others.

However, there is also some evidence that wearing a mask can also do harm such as when it leads to people touching their face more often due to discomfort. That can increase the risk of contamination from your hand and wearing a mask can give a false sense of security."

General advice for managing infectious disease risk in any workplace would also apply, to avoid infecting co-workers or contaminating product. This includes informing the employer and seeking medical advice if the worker has any symptoms of respiratory illness, or has travelled to affected regions. Creating an atmosphere where staff feel supported in taking these actions would be an important function for employers.

Examples of general advice for workplace safety for infectious diseases:

Ministry of Health: https://www.health.govt.nz/your-health/healthy-living/environmental-health/infectious-disease-prevention-and-control/workplace-infectious-disease-prevention

WHO: https://www.who.int/docs/default-source/coronaviruse/getting-workplace-ready-for-covid-19.pdf

CDC: https://www.cdc.gov/coronavirus/2019-ncov/specific-groups/guidance-business-response.html

Norovirus is known to be transferred from infected workers to food and the transmission route is faecal-oral. The virus is shed by infected people in large numbers. Unlike coronaviruses which are enveloped, noroviruses are non-enveloped and as such, thought to be more robust and environmentally resistant than SARS-CoV-2. Food worker controls that focus on Good Hygiene Practices for managing the risk of norovirus transmission by reducing faecal contamination of food from hands could also be applicable.

[7] https://www.health.govt.nz/news-media/media-releases/82-new-cases-covid-19. Issued 4 April 2020; accessed 6 April 2020.

Norovirus advice is available at the following website:

https://www.cdc.gov/norovirus/downloads/foodhandlers.pdf

The Ministry for Business Innovation and Employment has provided answers to questions in relation to managing workers amidst the coronavirus outbreak, from a legal viewpoint.

https://www.employment.govt.nz/assets/Uploads/about-enz/News-and-updates/Coronavirus-questions-and-answers.pdf

Additional resources:

Washington State Department of Health:
https://www.doh.wa.gov/Emergencies/NovelCoronavirusOutbreak2020/FoodWorkers

Returning to work after confirmed or suspected COVID-19 illness

The following advice is provided by the Ministry of Health for returning to work following confirmed or suspected COVID-19 illness[8]:

"The Technical Advisory Group also considered and recommended no change to the recovery definition - an individual with COVID-19 can be released from isolation when at least 10 days has passed since the onset of symptoms and at least 48 hours of being symptom free.

A negative test result isn't required for an individual in isolation at home, although a test could be at the discretion of the clinician where the patient has been in hospital."

Researchers in Germany recently monitored the viral shedding of nine people infected with SARS-CoV-2 [27]. In addition to tests looking for fragments of the virus RNA using molecular methods, they also tried to grow viruses from sputum, blood, urine and faeces samples taken from the patients to see if live (infectious) viruses were present. The latter type of testing — trying to grow viruses — is critical in the quest to determine how people infect one another and how long an infected person poses a risk to others.

Importantly, the scientists could not grow viruses from throat swabs or sputum specimens taken from these patients, all with comparatively mild symptoms, eight days after their symptoms appeared. The authors stated:

"Based on the present findings, early discharge with ensuing home isolation could be chosen for patients who are beyond day 10 of symptoms with less than 100,000 viral RNA copies per ml of

[8] https://www.health.govt.nz/news-media/media-releases/82-new-cases-covid-19. Issued 4 April 2020; accessed 6 April 2020.

sputum". The authors went on to suggest that at that point *"there is little residual risk of infectivity, based on cell culture"* [27].

The United States Centers for Disease Control and Prevention (US CDC) have recently updated their guidance for health care personnel (HCP) returning to work.[9] This information also is relevant for other worker categories. The guidance takes into account that testing of people with COVID-19 symptoms is not always carried out.

*"**Return to Work Criteria for HCP with Confirmed or Suspected COVID-19***

Use one of the below strategies to determine when HCP may return to work in healthcare settings.

***1. Test-based strategy.** Exclude from work until*

- *Resolution of fever without the use of fever-reducing medications and*
- *Improvement in respiratory symptoms (e.g., cough, shortness of breath), and*
- *Negative results of an FDA Emergency Use Authorized molecular assay for COVID-19 from at least two consecutive nasopharyngeal swab specimens collected ≥24 hours apart (total of two negative specimens). See Interim Guidelines for Collecting, Handling, and Testing Clinical Specimens for 2019 Novel Coronavirus (2019-nCoV).*

***2. Non-test-based strategy.** Exclude from work until*

- *At least 3 days (72 hours) have passed since recovery defined as resolution of fever without the use of fever-reducing medications and improvement in respiratory symptoms (e.g., cough, shortness of breath); and,*
- *At least 7 days have passed since symptoms first appeared*

If HCP were never tested for COVID-19 but have an alternate diagnosis (e.g., tested positive for influenza), criteria for return to work should be based on that diagnosis.

Return to Work Practices and Work Restrictions

After returning to work, HCP should:

- *Wear a facemask at all times while in the healthcare facility until all symptoms are completely resolved or until 14 days after illness onset, whichever is longer*

[9] https://www.cdc.gov/coronavirus/2019-ncov/healthcare-facilities/hcp-return-work.html. Updated by CDC on 16 March 2020; accessed 30 March 2020.

- *Be restricted from contact with severely immunocompromised patients (e.g., transplant, haematology-oncology) until 14 days after illness onset*
- *Adhere to hand hygiene, respiratory hygiene, and cough etiquette in CDC's interim infection control guidance (e.g., cover nose and mouth when coughing or sneezing, dispose of tissues in waste receptacles)*
- *Self-monitor for symptoms, and seek re-evaluation from occupational health if respiratory symptoms recur or worsen"*

Note that the above guidance suggests a return to work after seven days past symptom onset, which is shorter than the more conservative ten days suggested by the German study [27].

6. WHAT IS THE LATEST INFORMATION ON THE ROUTES OF TRANSMISSION FOR COVID-19 (INCLUDING ANYTHING THAT IMPLICATES FOOD AS A VECTOR)?

Key finding: The primary transmission route for human infection with SARS-CoV-2 is via respiratory droplets. It may be possible that a person can get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose, or possibly their eyes, but this is not thought to be the main way the virus spreads. Infectious virus has been found in faeces of some infected people, raising the possibility of faecal-oral transmission via contaminated vehicles such as food, but there is no evidence for this having occurred.

6.1. Definitions

Respiratory infections can be transmitted through the viruses becoming associated with expelled droplets of different sizes. If the droplet particles are relatively large (>5-10 μm in diameter) they are referred to as respiratory droplets. Such droplets are mostly associated with sneezing and coughing and they usually travel less than 1 m as they fall from the air more rapidly than droplet nuclei.

If the droplet particles are <5μm in diameter, they are referred to as droplet nuclei and these particles can remain in the air for long periods of time and be transmitted over distances greater than 1 m. If a virus can be spread in this manner it is referred to as being capable of airborne transmission.

Airborne transmission has been suggested to contribute to transmission in healthcare settings by aerosols created by medical and dental procedures on infected people.

6.2. Transmission Routes

The US Centres for Disease Control (CDC) published a summary on 23 March 2020:[10]

"Coronaviruses are generally thought to be spread from person-to-person through respiratory droplets. Currently there is no evidence to support transmission of COVID-19 associated with food. Before preparing or eating food it is important to always wash your hands with soap and water for 20 seconds for general food safety. Throughout the day wash your hands after blowing your nose, coughing or sneezing, or going to the bathroom.

[10] https://www.cdc.gov/foodsafety/newsletter/food-safety-and-Coronavirus.html. Accessed 4 April 2020

It may be possible that a person can get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose, or possibly their eyes, but this is not thought to be the main way the virus spreads.

In general, because of poor survivability of these coronaviruses on surfaces, there is likely very low risk of spread from food products or packaging that are shipped over a period of days or weeks at ambient, refrigerated, or frozen temperatures."

WHO updated their view on transmission on 27 March 2020 [28]:

"Respiratory infections can be transmitted through droplets of different sizes: when the droplet particles are >5-10 μm in diameter they are referred to as respiratory droplets, and when then are <5μm in diameter, they are referred to as droplet nuclei. According to current evidence, COVID-19 virus is primarily transmitted between people through respiratory droplets and contact routes. In an analysis of 75,465 COVID-19 cases in China, airborne transmission was not reported.
….

There is some evidence that COVID-19 infection may lead to intestinal infection and be present in faeces. However, to date only one study has cultured the COVID-19 virus from a single stool specimen. There have been no reports of faecal−oral transmission of the COVID-19 virus to date."

On 9 March 2020 the European Food Safety Authority (EFSA) published their opinion:[11]

"EFSA is closely monitoring the situation regarding the outbreak of coronavirus disease (COVID-19) that is affecting a large number of countries across the globe. There is currently no evidence that food is a likely source or route of transmission of the virus.

EFSA's chief scientist, Marta Hugas, said: "Experiences from previous outbreaks of related coronaviruses, such as severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV), show that transmission through food consumption did not occur. At the moment, there is no evidence to suggest that coronavirus is any different in this respect."

6.3. Animal-to-human transmission

Phylogenetic analyses suggest that bats might be the original host of SARS-CoV-2 [29]. However, most bat species were hibernating at the time of the outbreak and no bats were found or sold at the Wuhan seafood market (while other non-aquatic mammals were). Therefore, another animal sold at the Wuhan seafood market is thought to have been acting as an intermediate host responsible for the initial transmission of the virus to humans [29]. The mode of transmission between the hypothetical intermediate host and humans is unknown.

[11] https://www.efsa.europa.eu/en/news/coronavirus-no-evidence-food-source-or-transmission-route accessed 31 March 2020

Consumption of wild animal meat is common in China. However, because the main symptoms in patients are fever and respiratory-related, this suggests that the original mode of transmission was respiratory rather than an oral mode via food [17].

There is limited evidence of passage from humans to animals, and if it does occur it is unlikely to be important in the epidemiology of COVID-19.

A recent report by French Agency for Food, Environmental and Occupational Health & Safety (ANSES) stated[12]:

"*Potential role of domestic animals in virus transmission*

With regard to possible transmission of the virus by livestock and domestic animals, the conclusions of the expert group indicate that:

- *The genetic structure of the SARS-CoV-2 virus does indeed suggest that an animal was its initial source. It probably comes from a species of bat, and an intermediate host may or may not have been involved. However, as things stand today and in light of the published information available, the passage of SARS-CoV-2 from humans to another animal species currently seems unlikely.*

- *The SARS-CoV-2 virus binds to a specific cellular receptor, which allows it to gain access to cells. Although this receptor has been identified in domestic animal species and appears to be capable of interacting with the human virus – and further studies on this subject are needed – the experts reiterate that the receptor's presence is not a sufficient condition for infection in these animals. This is because the virus uses not only the receptor, but also other cell components that allow it to replicate.*

- *While the virus genome was detected in the nasal and oral cavities of a dog in contact with an infected patient in Hong Kong, detection of the genome is not sufficient evidence to conclude that the animal was infected. Passive contamination cannot be ruled out, especially since the virus may be able to survive in moist mucous membranes without necessarily replicating. In view of this, the experts stress the need to investigate this case further by carrying out additional analyses, and to continue publishing the results as they are produced."*

6.4. Human-to-human transmission

Coronaviruses are generally thought to be spread from person-to-person through respiratory droplets, usually generated by coughing or sneezing. According to preliminary data from Guangzhou CDC as of 20 February 2020, SARS-CoV-2 can initially be detected in upper respiratory samples 1-2 days prior to symptom onset, and can persist for 7-12 days in moderate cases and up to 2 weeks in severe cases [11].

12 https://www.anses.fr/en/content/covid-19-cannot-be-transmitted-either-farm-animals-or-domestic-animals-0 accessed 20 March 2020

Airborne spread has not been reported and is not thought to be a major transmission route based on available evidence at the time of the report assessed [11].

It may be possible that a person can get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose, or possibly their eyes, but this is not thought to be the main way the virus spreads.

New information suggests that asymptomatic and pre-symptomatic transmission may be occurring [30-34]. From four clusters of COVID-19 in Singapore for where the date of exposure could be determined, pre-symptomatic transmission occurred one to three days before symptom onset in the pre-symptomatic source patient [34]. The significance of pre-symptomatic and asymptomatic transmission in the overall spread of COVID-19 disease is unknown. However, symptomatic people are still considered to be more contagious. Dr. Charles Chiu (professor of laboratory medicine in the division of infectious diseases at University of California, San Francisco) was reported as saying:[13]

""When somebody sneezes or coughs, the respiratory secretions are aerosolized, and if you're near, typically within 6 feet, you may be at risk of being exposed. That's the most common route of transmission. Patients who have minimal symptoms or no symptoms may be infectious — they may have the virus in their mucus or their secretions — but unless they're actually coughing or sneezing, it's unlikely that they would transmit to someone else." He said it's possible that someone who is infected but not sneezing or coughing could spread the virus by touching their nose, mouth or eyes and then contaminating a surface such as a doorknob that someone else then touches, but that's not the likeliest way the virus is spread."

The current safety measures instituted (hygiene, distancing) are adequate enough for us not to worry about the remote possibility from infection from asymptomatic people (Dr Erasmus Smit, ESR, pers. comm.)

Evidence from China indicates that the majority of human-to-human transmission is occurring within families. Among 344 clusters involving 1308 cases (out of a total 1836 cases reported at the time of the publication) in Guangdong Province and Sichuan Province, most clusters (78%-85%) have occurred in families [11]. In New Zealand, there have been clusters of cases associated with schools and domestic events [14].

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13 https://www.nbcnews.com/health/health-news/can-coronavirus-be-spread-people-who-don-t-have-symptoms-n1140106.Reported on 22 February 2020; accessed 18 March 2020.

14 https://www.health.govt.nz/our-work/diseases-and-conditions/covid-19-novel-coronavirus/covid-19-current-situation/covid-19-current-cases/covid-19-clusters; accessed 2 April 2020.

Transmission in health care settings and amongst health care workers has also been reported. As of 20 February 2020, 2,055 cases of laboratory-confirmed COVID-19 were reported in health care workers from 476 hospitals across China [11]. Latest figures show that healthcare workers make up 9% of Italy's COVID-19 cases[15] and in Spain 14%[16]. Transmissions in prisons and a long-term living facility have also been reported.

Aerosols may be created by certain medical procedures, including dental procedures. The Ministry of Health and the New Zealand Dental Council have published guidelines to control this risk.[17]

Faecal-oral transmission

While person-to-person transmission by respiratory droplets is considered the primary transmission route, it is still possible that faecal-oral transmission could occur. Faecal-oral transmission could hypothetically occur directly, or indirectly via contaminated food, water or fomites.

The first indication that faecal-oral transmission might occur is that various studies have reported gastrointestinal symptoms for COVID-19 patients (discussed in Section 3.2).

In addition, multiple studies have detected SARS-CoV-2 RNA in faecal specimens or rectal swabs of COVID-19 patients [11, 27, 35-38]. SARS-CoV-2 RNA has been detected in faecal samples from up to 30% of patients five days or more after symptom onset. SARS-CoV-2 viral RNA could also be present in people who are asymptomatic [19]. The virus has been detected in faeces up to 5 weeks in cases with moderate symptoms.

For faecal-oral transmission to occur, the virus must remain infectious. It is not clear whether the detection of SARS-CoV-2 RNA in faeces always correlates with the presence of infectious virus. Researchers from one publication found high concentrations of SARS-CoV-2 in 13 faecal samples from four patients in their study, but they were unable to grow the virus in cultured cells which would have demonstrated virus infectivity [27].

Although it is fairly common to detect SARS-CoV-2 RNA in faeces, infectious SARS-CoV-2 has only been grown (isolated) from a small number of patients by Chinese researchers [36, 39, 40]. Live virus most likely comes from infected epithelial cells of the small and large intestine as these cells also express a high concentration of ACE2 receptors which the virus needs to enter cells [41]. It is also possible that the faecal RNA detected by PCR comes from virus laden

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15 https://www.icn.ch/news/high-proportion-healthcare-workers-covid-19-italy-stark-warning-world-protecting-nurses-and; accessed 5 April 2020

16 https://www.nytimes.com/2020/03/24/world/europe/coronavirus-europe-covid-19.html; accessed 5 April 2020

17 https://www.dcnz.org.nz/assets/Uploads/COVID/Guidelines-at-Alert-Level-4-updated-26Mar20.pdf accessed 31 March 2020

swallowed mucous from the upper respiratory tract, at least early in the infection. However, the fact that an infected person tends to remain PCR-positive for SARS-CoV-2 in faeces long after they become PCR-negative in a throat swab would suggest viral production in the gastrointestinal tract. Coronaviruses, like influenza viruses, are enveloped viruses and therefore can be inactivated by low pH and are vulnerable to surfactants such as soap and bile [42].

Previous research has suggested that the presence of influenza RNA and virions in faeces is because they are surrounded by swallowed mucus which protect them from inactivation or degraded by the gastrointestinal environment [43]. SARS-CoV-2 could employ a similar mechanism to reach the lower gastrointestinal tract.

Limited data have shown that viral RNA could be detected in plasma or serum from COVID-19 patients. In the first 41 patients in the city of Wuhan, viremia was found in 6/41 (15%) patients [2]. This is another conceivable method by which SARS-CoV-2 could be reaching the ACE2-rich intestinal epithelial cells of the small and large intestine.

The role and significance of faecal-oral route for COVID-19 remains to be determined and is not thought to be a main driver of COVID-19 transmission.

6.5. Persistence of coronaviruses on inanimate surfaces, effect of temperature and inactivation treatments

Transmission of non SARS-CoV-2 coronaviruses from contaminated dry surfaces has been postulated [44, 45]. Understanding the persistence and decontamination of these coronaviruses on inanimate surfaces is relevant to considering the risks and control of SARS-CoV-2 on foods, food-contact surfaces and food packaging. Although limited data is currently available for the behaviour of SARS-CoV-2, a similar effect for a) survival on inanimate surfaces, b) a temperature-dependant effect on survival, and c) efficacy of sterilisation regimens, would be expected for SARS-CoV-2 as has been reported for other related coronaviruses.

Persistence on inanimate surfaces and in aerosols

A recent review summarised data on the persistence of all coronaviruses on different types of inanimate surfaces [46]. The coronaviruses assessed included SARS-CoV and MERS-CoV, other human coronaviruses (HCoV) and animal coronaviruses such as transmissible gastroenteritis virus (TGEV), mouse hepatitis virus (MHV) and canine coronavirus (CCV). Depending on the study, surface types included steel, aluminium, metal, wood, paper, glass, plastic, PVC, silicon rubber, surgical gloves, disposable gowns, ceramic and teflon. Human coronaviruses were able to remain infectious on inanimate objects at room temperature from two hours (HCoV 229E on aluminium [47]) to nine days (SARS-CoV strain FFM1 [48]).

New data have been published by van Doremalen *et al*. (2020) who compared the surface stability of SARS-CoV and SARS-CoV-2 at room temperature (21-23°C) and 40% relative

humidity [49]. Stability was quantified by virus infectivity using end-point titration on Vero E6 cell culture. Four surface types were compared, plastic (polypropylene), stainless steel, copper and cardboard. The concentration of infectious viruses decreased on all surfaces for both viruses. Both viruses survived longest on plastic and stainless steel and shortest on copper surfaces. Results for cardboard were variable because virus recovery was by swabbing rather than washing but these data suggest a shorter survival compared to plastic and stainless steel. Specifically, median half-lives for SARS-CoV-2 on the different substrates were 6.81, 5.63, 3.46, and 0.77 hours on plastic, steel, cardboard and copper, respectively. Median half-lives for SARS-CoV on the different substrates were 7.55, 4.16, 0.59 and 1.5 hours on plastic, steel, cardboard and copper, respectively. The data support that transmission of SARS-CoV-2 from fomites could occur. The length of time the virus can remain infectious on surfaces will depend on the initial inoculum.

The US CDC reported on a study that used PCR methods, rather than cell culture, to determine the persistence of SARS-CoV-2 on the surfaces within cruise ship cabins of symptomatic and asymptomatic COVID-19 passengers. The study showed that SARS-CoV-2 could be detected 17 days following the vacation of the cabins and pre-cleaning [50]. Because viral RNA can persist longer than the time over which the virus remains infectious, the presence of RNA does not necessarily show the presence of infectious virus. Based on the findings reported by van Doremalen *et al.* (2020) [49], it is unlikely that the virus remained infectious after this 17-day period.

Van Doremalen *et al.* (2020) also compared the stability of SARS-CoV and SARS-CoV-2 in aerosols (<5 µm, created and maintained by a nebuliser; 21-23°C and 65% relative humidity) [49]. Median half-lives were 1.18 and 1.09 hours for SARS-CoV and SARS-CoV-2, respectively. Under these experimental conditions, the virus could remain infectious in aerosols for at least three hours. However, the study does not indicate how long aerosols remain airborne. The more likely vector for transmission is respiratory droplets (as discussed elsewhere in this document), which fall from the air more quickly compared with aerosols. In a study where researchers assessed the presence of SARS-CoV-2 in the air from symptomatic COVID-19 patients' isolation rooms using RT-PCR, all samples tested negative [51]. This suggests that droplets of any size do not remain airborne for long.

Effect of temperature on coronavirus infectivity

Temperature is known to affect the persistence of at least non SARS-CoV-2 coronaviruses on inanimate surfaces. For example, MERS-CoV persistence on steel was 48 hours at 20°C and 8-24 hours at 30°C. The persistence of TGEV and MHV was increased to ≥28 days when held at 4°C compared with 3-28 days at 20°C [52]. Thus viral persistence on surfaces is prolonged under cooler conditions.

Freezing has very little impact on the infectivity of foodborne enteric viruses, with multiple outbreaks of hepatitis A and norovirus, for example, attributed to frozen foods [53, 54]. However, only sparse information was found on the effect of freezing on coronavirus infectivity.

The infectious titre of human coronavirus 229E was found to be stable to multiple rounds (25 cycles) of freezing and thawing [55].

Inactivation treatments for coronaviruses

Non-enveloped viruses are usually more resistant to harsh environmental conditions (e.g. heating and drying) and the action of biocides, and persist longer on inanimate surfaces than enveloped viruses such as coronavirus [56-58].

The reported efficacy of commonly used biocidal agents used in surface disinfectants against coronaviruses using suspension tests has been reviewed [46]. Depending on the study, biocidal agents tested included ethanol (70-95%), 2-propanol (50-100%), 2-propanol (45%) plus 1-propanol (30%), benzalkonium chloride (0.00175-0.2%), didecyldimethyl ammonium chloride (0.0025%), chlorhexidine digluconate (0.02%), sodium hypochlorite (0.001-0.21%), hydrogen peroxide (0.5%), formaldehyde (0.009-1%), glutardialdehyde (0.5-2.5%) and povidone iodine (0.23-7.5%).

After 30 seconds, coronavirus infectivity was reduced by ≥4 log10 in ethanol (≥78%), 2-propanol (≥75%) and 2-propanol (45%) plus 1-propanol (30%). Hydrogen peroxide (0.5%) was as effective within 1 minute, as was povidone iodine at concentrations ranging 0.23%-4.5%. Longer contact times (2-5 min) were needed for equivalent inactivation in glutardialdehyde (0.5-2.5%). Other biocidal agents were also effective but the reduction in infectivity was relatively less and/or exposure times were much longer, e.g. formaldehyde, didecyldimethyl ammonium chloride, sodium hypochlorite. Benzalkonium chloride (2.0%) and chlorhexidine digluconate (0.02%) was not effective. In carrier tests, surface disinfection with ≥0.1% sodium hypochlorite or ≥70% ethanol significantly reduced coronavirus infectivity on stainless steel surfaces within 1 min exposure time.

The United States Environmental Protection Agency (US EPA) has provided a list of disinfectants recommended for use against SARS-CoV-2 [18]. The database lists active ingredients, the producer, guidelines for formulations and contact times, and whether the product qualifies for the “Emerging Viral Pathogen Claim” (which indicates that it has demonstrated efficacy against a harder-to-kill virus than the enveloped human coronavirus).

Ozone reduces virus infectivity through lipid peroxidation and damage to the lipid envelope (for enveloped viruses) and to a lesser extent protein peroxidation and consequential protein shell damage (non-enveloped viruses) [59, 60]. Ozone is widely used as a disinfectant in water treatment (including wastewater) and food processing, and is used in either gaseous (for surface or air sterilisation) or aqueous form [60-64]. No information was found on the efficacy of

[18] https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2; accessed 27 March 2020

ozone on SARS-CoV-2 or other coronaviruses. However, ozone treatment has been found to be effective against a range of viruses, and is more effective against enveloped than non-enveloped viruses [59]. As such, ozone treatments that are effective against other more resilient viruses are also likely to be effective against SARS-CoV-2. However, ozone is toxic to humans, with strict restrictions around its use [60, 65].

It has been suggested that washing fruit and vegetables with soap and water in the home should be conducted. A commentary from various US food safety scientists recommends against this idea, on the basis of adverse effects from consuming soap residues.[19]

[19] https://www.livescience.com/do-not-wash-fruits-vegetables-with-soap.html accessed 31 March 2020.

7. WHAT IS THE INTERNATIONAL CONSENSUS ON SURVIVAL RATES OF COVID-19 ON AND IN FOOD PRODUCTS?

Key finding: No published studies of SARS-CoV-2 survival in or on food products were located. A study of MERS-CoV in various types of unpasteurised milk showed survival of infective virus for up to 72 hours. Pasteurisation inactivated the virus.

Only one reference addressing this question for coronavirus was located.

The stability of MERS-CoV in **unpasteurised** dromedary camel milk, goat milk and cow milk was investigated at different temperatures [66]. Milk samples were inoculated with a median dose of $10_{5.5}$/mL (as measured by tissue culture) and incubated at -80, 4 or 22°C for 0, 8, 24, 48, and 72 hours. After 72 hours at 4°C, viral infectivity reduced up to 64%, with the reduction differing between milk types. Loss of infectivity was higher at 22°C than at 4°C. A 99% loss of infectivity was observed in goat milk after 48 hours at 22ºC. No infectious virus was found in any milk types following treatment at 63°C for 30 minutes (pasteurisation conditions).

The WHO advises against consuming unpasteurised camel milk and undercooked camel meat but the advice is to avoid infections of a variety of organisms, not MERS-CoV in particular. There have been no reported cases of oral transmission of MERS-CoV.[20]

[20] https://www.who.int/csr/disease/coronavirus_infections/faq/en/ accessed 11 March 2020

8. WHAT IS THE INTERNATIONAL CONSENSUS ON SURVIVAL RATES FOR COVID-19 ON SURFACES OF FRESH FOOD, ESPECIALLY IF THE FOOD IS CONSUMED FRESH AND NOT COOKED?

Key finding: No published studies of SARS-CoV-2 survival on fresh food were located. A study of another coronavirus showed survival on lettuce for up to two days. This coronavirus could not be recovered after inoculation onto strawberries.

One study examined the recovery efficiencies of infectious virus and the survival over storage of two respiratory viruses, namely, human adenovirus type 2 (HAdV-2, non-enveloped) and HCoV-229E (enveloped), on fresh produce in comparison to the enteric poliovirus type 1 (PV1, non-enveloped) [56].

The survival of infectious HAdV-2, HCoV-229E and PV1 was determined for periods up to 10 days on fresh produce. PV1 survived better than both respiratory viruses on lettuce and strawberries, with only ≤1.03 $\log_{10}$ reductions after 10 days of storage at 4°C. HCoV229E on lettuce could be recovered after 1 and 2 days of storage but was not recovered after 4 days. This coronavirus could not be recovered after inoculation onto strawberries. Reductions of 1.97 $\log_{10}$ and 2.38 $\log_{10}$ of Ad2 on lettuce and strawberries, respectively, after 10 days were found. Nevertheless, these respiratory viruses were able to survive for at least several days on produce.

Coronaviruses are inactivated over time in water and wastewater [67]. Inactivation of coronavirus (HCoV-229E) in water was highly dependent on temperature, level of organic matter, and presence of antagonistic bacteria. In dechlorinated, filtered tap water, the time required for the virus titer to decrease 99.9% (T99.9) was 10 days at 23ºC and >100 days at 4°C. The infectivity of coronaviruses reduces rapidly in wastewater, with T99.9 values of between two and four days. No specific information was found on the survival of SARS-CoV-2 or other coronaviruses in seawater or the marine environment.

9. WHAT IS THE LIKELIHOOD OF A PERSON BECOMING INFECTED WITH COVID-19 FROM CONSUMING THE VIRUS?

Key finding: No information was located on the likelihood of infection from consuming SARS-CoV-2 through food. Normal intestinal conditions (stomach acid and bile salts) are thought to inactivate SARS-CoV-2, but more research is needed.

Like a number of other organisations, EFSA has indicated that there is currently no evidence that food is a likely source or route of transmission of the virus.[21] It links to a FAQ on the topic published by the German Federal Institute for Risk Assessment[22], which links general advice about avoiding foodborne infections in private households.[23]

There is a possibility that infection of the pharynx could occur as the food passes through to the oesophagus, but this possibility is considered very remote (Dr Erasmus Smit, ESR, pers. comm.). See also the comment by ANSES on this topic, below.

The ability to retain infectivity in gastrointestinal fluids would be one prerequisite for SARS-CoV-2 to establish infection in the human alimentary tract. Coronaviruses are considered to be sensitive to acidic pH and bile and for this reason it is conceivable that a higher infectious dose would be necessary compared to a respiratory route of infection. One study reported that MERS-CoV was inactivated in fasted-state simulated gastric fluid (pH 2) after two hours [68]. However, the virus retained infectivity after two hours in fed-state simulated gastric fluid. It was less tolerant to fed-state simulated intestinal fluid (which contains a high concentration of bile salts that solubilise the lipid membrane of enveloped viruses) than fed-state simulated gastric fluid.

ANSES convened an expert group to assess the potential for foodborne transmission.[24] The following is from their report.

"Potential transmission of the virus via food

21 https://www.efsa.europa.eu/en/news/coronavirus-no-evidence-food-source-or-transmission-route accessed 25 March 2020

22 https://www.bfr.bund.de/en/can_the_new_type_of_coronavirus_be_transmitted_via_food_and_toys_-244090.html, updated by BfR 23 March 2020;accessed 25 March 2020

23 https://www.bfr.bund.de/cm/364/protection-against-foodborne-infections.pdf accessed 25 March 2020

24 https://www.anses.fr/en/content/covid-19-cannot-be-transmitted-either-farm-animals-or-domestic-animals-0 accessed 20 March 2020

"Since contamination of an animal is unlikely, the possibility of direct transmission of the virus through food derived from a contaminated animal was ruled out by the experts. ***Only the hypothesis of contamination of food by a person who is sick, or is an asymptomatic carrier of the SARS-CoV-2 virus****, was investigated. This could occur through respiratory droplets from a contaminated patient. However, the question of the faecal-oral route was also raised, as viral particles have been detected in the faeces of some patients.*

The expert group reached the following conclusions:

- *Based on the current state of knowledge,* ***transmission of the SARS-CoV-2 virus directly via the digestive tract can be ruled out****. Indeed, while the virus has been observed in patients' faeces, it was probably due to circulation of the virus in blood following respiratory infection rather than through the digestive tract. However,* ***the possibility of the respiratory tract becoming infected during chewing cannot be completely ruled out.***
- *As with other known coronaviruses, this virus is sensitive to cooking temperatures.* ***Heat treatment at 63°C for 4 minutes*** *(temperature used when preparing hot food in mass catering) can therefore reduce contamination of a food product by a factor of 10,000.*
- *An infected person can contaminate food by preparing or handling it with dirty hands, or via infectious droplets produced when coughing or sneezing.* ***Good hygiene practices, when properly applied, are an effective way to prevent food from being contaminated with the SARS-CoV-2 virus"***

10. WHAT ARE THE RISK MANAGEMENT OPTIONS FOR COMPANIES WHEN A WORKER IS IDENTIFIED AS HAVING COVID-19?

Key finding: We consider that these situations would need to be assessed on a case-by-case basis. General advice has been offered by Food Safety Authority of Ireland, The United States Food and Drug Administration (US FDA) and Centres for Disease Control (US CDC), and the Occupational Safety and Health Administration (OSHA) on their websites.

An additional question has been asked for the April update of this report regarding risk management options. This question has three parts and encompasses the question (section 10) on food recalls raised in the earlier report.

- Is there any suggestion that a thorough clean down is required of processing/production areas in which a sick worker with COVID-19 has been in?
- Should self-isolation of co-workers in contact with the primary case be implemented?
- What is the best practice for managing situations around potential product recalls if a worker on a production line becomes infected?

Scientific studies provide limited information to answer these questions. Each situation would need to be assessed on a case-by-case basis. General advice is available from the Food Safety Authority of Ireland, The United States Food and Drug Administration (US FDA) and Centres for Disease Control (US CDC), and the Occupational Safety and Health Administration (OSHA). The advice is focussed on preventing person-to-person transmission within the workplace since there is currently no evidence to support foodborne transmission of SARS-CoV-2.

The following general advice was provided by the US FDA[25]:

"A worker in my food production/processing facility/farm has tested positive for COVID-19. What do I need to do to continue operations while protecting my other employees?

[25] https://www.fda.gov/food/food-safety-during-emergencies/food-safety-and-coronavirus-disease-2019-covid-19, updated by US FDA 23 March 2020; accessed 27 March 2020.

All components of the food industry are considered critical infrastructure and it is therefore vital that they continue to operate.

The Occupational Safety and Health Administration (OSHA) issued Guidance on Preparing Workplaces for COVID-19 that includes information on how a COVID-19 outbreak could affect workplaces and steps all employers can take to reduce workers' risk of exposure to SARS-CoV-2 (COVID-19)[26]*.*

Food production/processing facilities/farms need to follow protocols, including cleaning protocols, set by local and state health departments, which may vary depending on the amount of community spread of COVID-19 in a given area. ***These decisions will be based on public health risk of person-to-person transmission – not based on food safety****.*

If an employee is confirmed to have COVID-19, employers should inform fellow employees of their possible exposure to COVID-19 in the workplace but maintain confidentiality about individual employees' identities. Sick employees should follow the CDC's What to do if you are sick with coronavirus disease 2019 (COVID-19)[27]*.*

CDC's Interim US Guidance for Risk Assessment and Public Health Managements of Persons with Potential Coronavirus Disease 2019 (COVID-19) Exposures: Geographic Risk and Contacts of Laboratory-confirmed Cases, provides a framework for assessing and managing risks of potential exposures to SARS-CoV-2.

Do I need to recall food products produced in the facility during the time that the worker was potentially shedding virus while working?

We do not anticipate that food products would need to be recalled or be withdrawn from the market because of COVID-19, as there is currently no evidence to support the transmission of COVID-19 associated with food or food packaging.

Additionally, facilities are required to control any risks that might be associated with workers who are ill regardless of the type of virus or bacteria. For example, facilities are required to maintain clean and sanitized facilities and food contact surfaces.

If a worker in my food processing facility/farm has tested positive for COVID-19, Should I close the facility? If so, for how long?

Food facilities need to follow protocols set by local and state health departments, which may vary depending on the amount of community spread of COVID-19 in a given area. These

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26 https://www.osha.gov/Publications/OSHA3990.pdf; accessed 27 March 2020

27 https://www.cdc.gov/coronavirus/2019-ncov/downloads/sick-with-2019-nCoV-fact-sheet.pdf; accessed 27 March 2020

decisions will be based on public health risk of person-to-person transmission – not based on food safety."

More detailed information from the US CDC and OSHA regarding food industry-recommended protocols when an employee/visitor/customer tests positive for COVID-19 is also available [28]. Specifically, the recommendations cover:

a) Steps to be taken when an employee tests positive for COVID-19 or has symptoms associated with COVID-19

b) Steps to be taken when an employee/visitor/customer is exposed (in close contact) with an individual who is positive For COVID-19

c) Cleaning and disinfection guidelines

d) Disposition of food

Similar advice was also provided by Food Safety Authority of Ireland[29], as follows:

"***Do I need to recall food products if a food worker was potentially shedding the virus while working?***

There is currently no evidence to indicate transmission of COVID-19 through food or food packaging.

Food businesses are required to maintain clean and sanitized facilities and food contact surfaces, therefore a 'deep clean' is advised following potential infection of a food worker in the premises along with exclusion of co-workers who are close contacts (anyone who has spent more than 15 minutes within 2 meters of an infected person) in line with HSE [Health Service Executive] advice.

If a staff member in my food business has tested positive for COVID-19, do I need to close?

Food businesses should follow the advice of the HSE. Any decision to close a business will be based on public health risk of person-to-person transmission and not based on a food safety risk.

[28] https://static1.squarespace.com/static/5e7d1107dac60a6b3e3f098d/t/5e8664c27e5db072ad336918/1585865924826/FBIA+COVID19%2BCase+Recommended+Protocols_2April20+Version+4.pdf; Issued 2 April 2020; accessed 6 April 2020.

[29] https://www.fsai.ie/faq/coronavirus.html; last reviewed by Food Safety Authority of Ireland 23 March 2020; accessed 25 March 2020

If a food worker has tested positive for COVID-19, do I need to advise other food workers to self-isolate?

Food businesses should follow the advice of the HSE."

The following additional risk management guidance was also provided by Food Safety Ireland:

"*What should food business owners/managers do if they have a supply chain problem caused by COVID-19?*

Due to a disruption in their supply chain, certain ingredients and packaging might be in short supply and food businesses may be considering some of the following:

- *leaving out or substituting ingredients in a product*
- *changing their packaging*
- *changing their process*

In these situations, it is important that food businesses remember their legal obligations to only place safe food on the market.

Any change to product, packaging or processing requires a full review of the businesses food safety management system (GHP and HACCP).

This will allow them to:

- *risk assess any food safety issues that could result from the proposed changes*
- *put in place controls to manage any risks identified*
- *document the changes*

Examples of issues to consider include:

- *the introduction of allergens when changing ingredients and/or ingredient suppliers*
- *safe shelf-life if packaging changes and/or the product is formulated differently*
- *the introduction of new microbiological, physical, chemical hazards with new ingredients*

There may be other issues depending on the type of business/product involved.

Is there a risk with food products or ingredients which are imported from an affected country/region?

No, COVID-19 is not transmitted through food or ingredients. Even if surfaces or packaging have been contaminated, the virus will only survive on such surfaces for a short period, therefore there is no risk of contamination."

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