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 in this review. We have provided information according to the current state of knowledge, and within the 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.
CONTENTS

1. SUMMARY .................................................................................................................. 3
2. INTRODUCTION AND METHODS ............................................................................ 5
3. THE PATHOGEN: SARS-COV-2 ................................................................................. 8
   3.1. Background, nomenclature and classification ....................................................... 8
   3.2. Disease signs, symptoms and human susceptibility ............................................... 10
4. WHAT IS INTERNATIONAL BEST PRACTICE REGARDING REDUCING THE
   LIKELIHOOD THAT FOOD PRODUCTS OR PACKAGING ARE VECTORS FOR
   COVID-19? .................................................................................................................. 13
5. WHAT IS INTERNATIONAL BEST PRACTICE FOR MITIGATION OPTIONS TO
   REDUCE TRANSFER OF COVID-19 FROM WORKERS TO FOOD PRODUCTS? ...... 13
6. WHAT IS THE LATEST INFORMATION ON THE ROUTES OF TRANSMISSION FOR
   COVID-19 (INCLUDING ANYTHING THAT IMPLICATES FOOD AS A VECTOR)? ....... 23
   6.1. Definitions.............................................................................................................. 23
   6.2. Transmission Routes............................................................................................. 23
       6.2.1. Animal-to-human transmission ..................................................................... 24
       6.2.2. Human-to-human transmission ..................................................................... 25
   6.3. Persistence of coronaviruses on inanimate surfaces, in aerosols, and effect of
       temperature and inactivation treatments.................................................................. 28
       6.3.1. Persistence on inanimate surfaces................................................................. 29
       6.3.2. Persistence in aerosols and distribution......................................................... 30
       6.3.3. Effect of temperature on coronavirus infectivity ............................................. 32
       6.3.4. Inactivation treatments for coronaviruses ..................................................... 33
7. WHAT IS THE INTERNATIONAL CONSENSUS ON SURVIVAL RATES OF SARS-
   COV-2 ON AND IN FOOD PRODUCTS?................................................................. 37
8. WHAT IS THE INTERNATIONAL CONSENSUS ON SURVIVAL RATES FOR SARS-
   COV-2 ON SURFACES OF FRESH FOOD, ESPECIALLY IF THE FOOD IS
   CONSUMED FRESH AND NOT COOKED? ................................................................. 38
9. WHAT IS THE LIKELIHOOD OF A PERSON BECOMING INFECTED WITH COVID-19
   FROM CONSUMING THE VIRUS? .............................................................................. 39
10. WHAT ARE THE RISK MANAGEMENT OPTIONS FOR COMPANIES WHEN A
    WORKER IS IDENTIFIED AS HAVING COVID-19? ..................................................... 41
11. REFERENCES ............................................................................................................. 46
1. SUMMARY

The material covered in this report has been based on information available to ESR up to 4 May 2020. This report provides an update to an earlier report that was finalised on 16 March 2020 and a report update finalised on 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.

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 in this review. We have provided information according to the current state of knowledge, and within the 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. This includes workers informing their employer and seeking medical advice if they have any symptoms of respiratory illness. Employers can promote and implement good personal hygiene practices for all workers. A NZFSSRC review on their website also provides information on the use of personal protective equipment (PPE) to reduce COVID-19 transmission to and from people, fomites and food.

On their website New Zealand Food Safety has provided extensive advice for primary industries and food businesses on operating under Alert Level 3.

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 be infected with SARS-CoV-2 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 SARS-CoV-2 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 the virus for up to 72 hours. Pasteurisation inactivated the virus.

5. What is the international consensus on survival rates of SARS-CoV-2 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 (NZFSSRC). 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 finalised on 6 April 2020 and included an additional question regarding risk management options. This report comprises the second update, which was requested on 15 April 2020, to be submitted on 8 May 2020.

The material in this report is based on information available to ESR up to 4 May 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 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 New Zealand sources for information on management of COVID-19 and SARS-CoV-2 are the Ministry of Health website:


and the Ministry for Primary Industries website:

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

<table>
<thead>
<tr>
<th>Database</th>
<th>Search terms</th>
<th>Search date</th>
<th>Reference results</th>
<th>Retained references</th>
</tr>
</thead>
<tbody>
<tr>
<td>PubMed</td>
<td>COVID-19 &amp; food</td>
<td>09-03-2020, 19-03-2020, 28-04-2020</td>
<td>4, 13, 85</td>
<td>1, 0, 6</td>
</tr>
<tr>
<td></td>
<td>SARS-CoV-2 &amp; food</td>
<td>09-03-2020, 19-03-2020, 28-04-2020</td>
<td>2, 6, 51</td>
<td>0, 0, 0</td>
</tr>
<tr>
<td></td>
<td>coronavirus &amp; foodborne</td>
<td>09-03-2020, 19-03-2020, 28-04-2020</td>
<td>6, 7, 9</td>
<td>3, 0, 0</td>
</tr>
<tr>
<td></td>
<td>(COVID-19 OR 2019-nCoV OR severe acute respiratory syndrome coronavirus 2) &amp; foodborne</td>
<td>09-03-2020, 25-03-2020, 28-04-2020</td>
<td>0, 0, 1</td>
<td>0, 0, 0</td>
</tr>
<tr>
<td></td>
<td>(COVID-19 OR 2019-nCoV OR severe acute respiratory syndrome coronavirus 2) &amp; food</td>
<td>09-03-2020, 25-03-2020, 28-04-2020</td>
<td>4, 18, 85</td>
<td>0, 1, 1</td>
</tr>
<tr>
<td></td>
<td>SARS-CoV &amp; food</td>
<td>09-03-2020, 25-03-2020, 28-04-2020</td>
<td>97, 106, 137</td>
<td>0, 0, 1</td>
</tr>
<tr>
<td></td>
<td>MERS-CoV &amp; food</td>
<td>09-03-2020, 25-03-2020, 28-04-2020</td>
<td>67, 70, 78</td>
<td>3, 0, 0</td>
</tr>
<tr>
<td></td>
<td>COVID &amp; food worker</td>
<td>09-03-2020, 25-03-2020, 28-04-2020</td>
<td>0, 2, 2</td>
<td>0, 0, 0</td>
</tr>
<tr>
<td></td>
<td>COVID &amp; food hygene</td>
<td>09-03-2020, 25-03-2020, 28-04-2020</td>
<td>1, 3, 9</td>
<td>0, 0, 0</td>
</tr>
<tr>
<td></td>
<td>COVID &amp; food</td>
<td>09-03-2020, 25-03-2020, 28-04-2020</td>
<td>3, 15, 79</td>
<td>0, 0, 0</td>
</tr>
<tr>
<td></td>
<td>SARS-CoV &amp; food</td>
<td>09-03-2020, 25-03-2020, 28-04-2020</td>
<td>40, 106, 137</td>
<td>0, 0, 0</td>
</tr>
<tr>
<td></td>
<td>Coronavirus &amp; gastric</td>
<td>09-03-2020, 25-03-2020, 28-04-2020</td>
<td>39, 42, 54</td>
<td>1, 0, 2</td>
</tr>
<tr>
<td></td>
<td>COVID &amp; asymptomatic</td>
<td>18-03-2020</td>
<td>33</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>COVID &amp; transmission</td>
<td>25-03-2020</td>
<td>259</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>(COVID OR Coronavirus) &amp; (freezing OR refrigeration OR temperature)</td>
<td>27-03-2020</td>
<td>387</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>(COVID-19 OR SARS-CoV-2) &amp; (freezing OR refrigeration OR temperature)</td>
<td>28-04-2020</td>
<td>55</td>
<td>0</td>
</tr>
</tbody>
</table>
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:


Google searches included:

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

<table>
<thead>
<tr>
<th>Search Query</th>
<th>Dates</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(COVID OR Coronavirus OR SARS-CoV-2) AND (seawater OR marine)</td>
<td>30-03-2020</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>29-04-2020</td>
<td>41</td>
</tr>
<tr>
<td>(COVID OR Coronavirus OR SARS-CoV-2) AND ozone</td>
<td>30-03-2020</td>
<td>4</td>
</tr>
<tr>
<td>COVID-19 &amp; diarrhoea</td>
<td>02-04-2020</td>
<td>43</td>
</tr>
<tr>
<td>(COVID-19 OR coronavirus OR SARS) &amp; (UV OR ultraviolet)</td>
<td>16-04-2020</td>
<td>146</td>
</tr>
<tr>
<td>(COVID-19 OR coronavirus OR SARS) &amp; (cruise ship)</td>
<td>29-04-2020</td>
<td>25</td>
</tr>
<tr>
<td>(SARS-CoV OR MERS-CoV) AND (feces OR faeces OR stool)</td>
<td>30-04-2020</td>
<td>148</td>
</tr>
<tr>
<td>Web of Science COVID AND food AND worker</td>
<td>09-03-2020</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>20-03-2020</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>29-04-2020</td>
<td>0</td>
</tr>
<tr>
<td>COVID AND food</td>
<td>09-03-2020</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>20-03-2020</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>29-04-2020</td>
<td>7</td>
</tr>
<tr>
<td>SARS AND CoV AND food</td>
<td>09-03-2020</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>20-03-2020</td>
<td>11</td>
</tr>
<tr>
<td>SARS-CoV AND food</td>
<td>29-04-2020</td>
<td>69</td>
</tr>
</tbody>
</table>
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 Organization (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. 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 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

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 receptor 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). This is the “gold standard” diagnostic test for current infection [11]. Because the viral RNA remains intact in the body for some time after the virus has been inactivated, detection by RT-qPCR in clinical samples detects both infectious and non-infectious virus. Several RT-qPCR tests have been developed based on different target regions of the SARS-CoV-2 RNA genome, such as different regions within the nucleocapsid phosphoprotein (N), envelope (E), spike (S) or RNA-dependent RNA polymerase (RdRP) genes². These molecular assays can also be used to determine the presence of virus, through the detection of its RNA, in foods and the environment, but do not give any information on its infectivity.

2. Serology, which detects antibodies to indicate that a person has mounted an immune response to SARS-CoV-2 whether or not they actually developed symptoms. Because the earliest that IgM or IgG antibodies to SARS-CoV-2 can be detected is several days after initial infection [12, 13], the test may not detect antibodies in someone with a current COVID-19 infection, depending on the timing of the test relative to the time the person became infected. Serology testing has not yet been extensively validated for SARS-CoV-2 and the growing number and types of tests being developed likely differ in sensitivity and specificity [14]. Additionally, it is still not known whether someone who has developed antibodies to SARS-CoV-2 is immune from another infection, and how long such immunity lasts. A range of serology tests have been developed but these are not yet widely accessible [11]. In addition, the importation, manufacture, sale, supply and use of COVID-19 point of care test kits and materials is prohibited in New Zealand, unless authorised by Medsafe³.

3. Growing the virus in cell culture. This can only be undertaken in highly contained specialist laboratories and hence is rarely performed, and not used for diagnosis.

---


³ [https://www.medsafe.govt.nz/Medicines/policy-statements/COVID19PointOfCareTestKits.asp](https://www.medsafe.govt.nz/Medicines/policy-statements/COVID19PointOfCareTestKits.asp); accessed 18 May 2020
However, culturing SARS-CoV-2 is important for demonstrating whether the virus is infectious [11].

3.2. Disease signs, symptoms and human susceptibility

Signs and symptoms

COVID-19 presentation can range from mild symptoms to severe pneumonia and death [15]. Infection by SARS-CoV-2 may be associated with no signs or symptoms (i.e. asymptomatic infection). 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 COVID-19 cases were reported with nausea or vomiting (1-5%), or diarrhoea (2-10%) in the early studies [2, 15-18]. However, recent reports suggest that up to 79% of patients may be presenting with gastrointestinal symptoms (reviewed by [19]). 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 [20].

Significant numbers of patients (30% in South Korea and >66% in Germany) who tested positive for SARS-CoV-2 infection had lost their sense of smell (i.e. developed anosmia) or had
a reduced ability to smell (hyposmia)\textsuperscript{4,5}. In a study of 202 patients in an Italian hospital, 130/202 (64\%) reported some loss of their sense of smell or taste [21]. In a scale where level 1 is very mild smell alteration and level 5 is “as bad as it can be”, 24\% of patients reported experiencing level 5 symptoms. The timing of any altered sense of smell or taste onset in relation to other symptoms occurred before other symptoms in 12\% patients; at same time as in 23\% patients; after other symptoms in 27\% of patients; and as the only symptom by 3\% of patients. In this study, an alteration to smell/taste was reported more frequently among women (72\% of 105 women) compared with men (56\% of 97 men).

Emerging evidence suggests that infection with SARS-CoV-2 may also be causing Kawasaki disease in some children [22, 23]. Kawasaki disease is a rare acute, self-limiting paediatric vasculitis, with coronary artery aneurysms as its main complication, that affects previously healthy young infants and children. Shortly after the spread of COVID-19 to the Bergamo region of Italy, a 30\% increased incidence in a severe form of Kawasaki disease was reported [22].

Signs and symptoms, including mild respiratory symptoms and fever, occur on an average of 5-6 days after infection (i.e. mean incubation period 5-6 days, range 1-14 days) [24, 25]. The average time from onset of symptoms to death is 14 days, which is reduced to 11.5 days for patients aged ≥70 years [25]. The incubation period for COVID-19 disease can be longer than for SARS-CoV-mediated disease which is 2-7 days [25].

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) [15].

Asymptomatic infection is increasingly reported, including in infants [26, 27]. In one Chinese study the proportion of asymptomatic cases was 25\% [28] 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 transmission [29]. Two models attempted to estimate the number of infections caused by asymptomatic, pre-symptomatic, or mildly symptomatic infected people (reviewed by [30]). While the modelling estimates varied widely (50\% and 80\%), both suggest that a significant number of people with asymptomatic or mildly symptomatic infections were not detected by the health system and whom meaningfully contributed to ongoing community transmission.

\textsuperscript{4} The term “anosmia” appears to be used in the literature to also mean some loss of the ability to smell, rather than absolute loss.

\textsuperscript{5} https://www.entuk.org/sites/default/files/files/Loss%20of%20sense%20of%20smell%20as%20marker%20of%20COVID-ID.pdf; 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 [15].

However, there is a low prevalence of disease occurrence in children aged ≤18 years (1-5% of reported cases [15, 31, 32]). 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 [32, 33]. 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 [15, 31].
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. This includes workers informing their employer and seeking medical advice if they have any symptoms of respiratory illness. Employers can promote and implement good personal hygiene practices for all workers. A NZFSSRC review on their website also provides information on the use of personal protective equipment (PPE) to reduce COVID-19 transmission to and from people, fomites and food.

On their website New Zealand Food Safety has provided extensive advice for primary industries and food businesses on operating under Alert Level 2 and 3.

New Zealand Food Safety have web pages offering advice for food handlers and food businesses. Because of the extended range of food businesses that were able to operate under Alert Level 3 compared with Alert Level 4, specific guidance around both levels was provided. Very recently, guidance for food businesses under Alert Level 2 was added.6

New Zealand Food Safety still provides the following commentary and advice regarding COVID-19 and food safety, along with information on registering a business to operate under Level 4, and verification activity:7

“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 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.

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.

**Good hygiene**

It is more important than ever that food businesses apply strict food preparation and hygiene practices.

In addition, if you are an employer, we ask that you:

- make sure staff are aware of the symptoms of COVID-19, and how they can self-isolate if the need arises
- 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
- be 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 and they are cleared to return to work
- make sure you are aware of staff who have recently returned from overseas
- should not require or knowingly allow workers to come to a workplace when they are sick with COVID-19, or if they have been advised to self-isolate under public health guidelines for COVID-19.

**Advice for food handlers**

Food handlers at businesses and at home should continue to follow standard, good personal hygiene practices that reduce the risk of transmission of most foodborne illnesses.

All the rules regarding food safety and hygiene still apply. It is more important than ever that these practices are maintained to reduce the risk.

Good practices include:

- regularly washing and thoroughly drying hands
• using clean utensils to handle cooked and ready-to-eat foods, and not touching the food directly
• not coughing or sneezing over food
• avoiding touching your nose, mouth and hair when preparing or serving food
• keeping people who are coughing and sneezing away from food.
• avoiding close contact, when possible, with anyone showing symptoms of respiratory illness such as coughing and sneezing.

The rules for hand washing don’t change – food handlers need to wash hands (even if they have no disease symptoms):
• when starting work
• before preparing or handling cooked or ready-to-eat food
• after handling or preparing raw food
• after handling waste food or rubbish
• after cleaning duties
• after using the toilet
• after blowing their nose, sneezing or coughing
• after eating, drinking, or smoking
• after handling money
• after touching items/furniture/fittings

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.

If staff have been overseas to affected regions or in contact with persons who have, they are expected to self-isolate for 14 days on arrival to New Zealand.

**Extra measures food manufacturers can take to protect their staff from illness**

Where businesses want to take extra measures to protect their staff and customers, they should do so in line with Ministry of Health advice on social/physical distancing and limiting the spread of the virus.

This includes communicating staff sickness policies to employees, and ensuring staff hygiene, cleaning and sanitation processes continue on the factory floor.

Ensure all contractors, visitors, delivery drivers coming into your plant follow Ministry of Health guidelines.
Other measures in line with the Ministry of Health’s advice on limiting the spread of the virus include sanitising shared equipment like forklifts, pallet jacks, box strappers and other equipment staff will touch directly throughout the day.

For communal areas, like canteens and break rooms, these extra precautions are in line with Ministry of Health advice:

- Increase the frequency of disinfecting touch-points on point of sale terminals, EFTPOS machines, door handles and other frequently-touched surfaces
- Sanitise chairs and tables frequently and between shifts
- Make hand sanitisers available
- Everyone at your business practicing frequent and thorough hand washing.
- Self-serve buffets and high-use utensils (tongs, serving spoons) taken out of use for the duration of COVID-19”

**Alert Level 2 and 3**

The Ministry for Primary Industries added considerable information for primary industries operating under Levels 3 and 2⁸,⁹. In the New Zealand Food Safety section, the process for developing and following a COVID-19 safe practice plan is described. On these webpages the following advice about safety and hygiene is provided:

**“Safety and hygiene checks for reopening food businesses**

Food businesses reopening under Alert Level 3 should go through the following checks to ensure food safety and hygiene practices.

1. Are premises OK for preparing or handling food?
   - Once your building has formally re-opened, you will need to make sure that nothing has happened during the closure that stops you from operating safely. Is there a chance that food will become contaminated from something that happened when the business was closed, such as maintenance activities, or a leaking pipe? Make sure the services you need for power, water supply and drainage are working as intended.
   - Have pests become a problem? Check for signs of insect pests (e.g. cockroaches) and rodents (rat, mice droppings, gnawed food and food packaging). Get rid of pests before re-opening. Throw away food exposed to pests and in gnawed packaging. Clean other packaging and follow steps in 2 below before opening.

2. Are toilets and personnel hygiene facilities working?
   - Make sure toilets and handwashing facilities for staff are in working order and have soap and towels.

3. Can the premises be thoroughly cleaned before use?

---

- Areas used for food preparation and serving will need to be thoroughly cleaned, and food preparation surfaces and utensils cleaned and sanitised before use to ensure there is no risk to food safety.

4. Is the water safe to use?
- Follow information from the Ministry of Health for flushing-through water systems before you start to clean and sanitise food areas. If you notice anything unusual with the colour or cloudiness or smell after this, contact your water supplier for advice. If you know of a water supply issue near your business, confirm with your supplier it is OK to use the water. Further information about water in food businesses can be found at: www.health.govt.nz/
- Don’t forget to flush clean water through machines that are plumbed into the water supply, such as ice machines, drinking fountains, coffee machines, slush-ice makers, post mix guns, self-service soft drink machines and water coolers, especially if these haven’t been turned off during lock-down.
- Further information about water in food businesses

1. Is food still safe to use?
- Check whether fridges, chillers and freezers have been without power, as the safety of stored food may have been affected. As a ‘rule of thumb’:
  - If power was off for more than 24 hours, or chillers were opened, potentially-hazardous foods (such as foods that contain meat, fish and dairy products) should be thrown away.
  - If power to fridges and chillers was off for less than 24 hours, and chillers were not opened, contents must be checked for odours and other signs of spoilage before using.
  - Perishable foods in the chiller, for example fruit and hard cheeses, may still be safe to use if these are not showing obvious signs of spoilage.
  - If a freezer was full, power was off for less than 4 days and the freezer was not opened during the power cut and there is no evidence of thawing, contents should be OK to use.
  - If the freezer was opened during the power cut, the freezer was not full, there is any evidence that contents have completely thawed, or have thawed then refrozen, throw this food out. Don’t feed it to pets or use as pig food.
  - If in doubt, throw it out.
- Food still frozen with ice crystals throughout can continue to be kept frozen, if you are sure it did not thaw out and then re-freeze when the power came back on. Frozen food that has defrosted and was refrozen when the power was restored should not be used. This will not always be obvious, but important signs of defrosting and refreezing will be: misshapen products; drip from packaging that has become frozen; packages stuck together; or the pooling of frozen fluids in the bottom of sealed packages. Again, if in doubt, throw it out.

2. Is refrigeration working?
- Make sure chillers, freezers, display cabinets and other equipment will work as intended.
3. Food for sale or wholesale
   - For restaurants and cafe businesses, think about providing food that needs minimum handling and is thoroughly cooked; particularly until you have identified what normal trading will look like for you and your staff, and you get back into routine.

4. Sourcing new supplies
   - If you are restocking chilled and frozen food from suppliers that were not trading during COVID-19 Level 4, check your supplier has taken the steps in 5 above.
   - If you are supplied with different products or brands, check they meet your recipes and/or processes and don’t contain unexpected ingredients or allergens. If these do, you will need to let customers know what these are.

5. Are your staff available and know what to do?
   - Any new or replacement staff must receive food safety training before starting work. It is a good idea to remind staff of sickness policies, and that it is always vital that hands and food preparation surfaces and equipment are kept clean, even more so at this time. If in any doubt about what you should do, contact your food safety verifier.”

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 [34].

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, 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 10.

The Ministry of Health has now issued specific guidance about face masks.11 Advice in relation to workplaces is as follows:

“Workplaces

1. Workplaces where people can maintain more than 1 metre contact distance from people with potential COVID-19 symptoms – facemasks and gloves are not recommended.

Examples of these workplaces include, but not limited to education facilities, pharmacies, retail outlets

---

2. Workers where people can maintain more than 1 metre contact distance from people with potential COVID-19 symptoms but work in an environment where they are touching surfaces or items touched by others – they may consider wearing gloves. Facemasks are not recommended. Regular hand hygiene must continue.

Examples of these workplaces include, but not limited to supermarkets, services stations

3. People who, due to the nature of their job, may be unable to maintain more than 1 metre contact distance from people with potential COVID-19 symptoms – facemasks and gloves are recommended when this contact is likely to occur.

Examples of these workplaces include but not limited to police, prison staff, customs staff

These recommendations are a guide only and workplace settings should consider their ability to maintain the 1 metre rule. In general, surgical/medical masks prevent the dispersal of droplets by an infected patient and the inhalation of droplets if within 1 metre of a coughing individual.

Hand hygiene and cough / sneeze etiquette (maintain distance, cover coughs and sneezes with disposable tissues and wash hands) will have a bigger impact.”

A review of science and policy around face masks and COVID-19 has just been published by the Ministry of Health.

Managing disease in the workplace

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:


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\(^\text{13}\):

“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, all with comparatively mild symptoms, and found that there was no infectious virus detected from throat swabs or sputum specimens taken from these patients eight days after their symptoms appeared\(^\text{13}\). 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 sputum”. The authors went on to suggest that at that point “there is little residual risk of infectivity, based on cell culture”\(^\text{13}\).

The United States Centers for Disease Control and Prevention (US CDC) have recently updated their guidance for health care personnel (HCP) returning to work\(^\text{14}\). This information also is relevant for other worker categories.

“Decisions about return to work for HCP with confirmed or suspected COVID-19 should be made in the context of local circumstances. Options include a symptom-based (i.e., time-since-illness-onset and time-since-recovery strategy) or time-based strategy or a test-based strategy. Of note, there have been reports of prolonged detection of RNA without direct correlation to viral culture.

**Symptomatic HCP with suspected or confirmed COVID-19:**

Symptom-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 10 days have passed since symptoms first appeared

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 COVID-19 molecular assay for
detection of SARS-CoV-2 RNA from at least two consecutive nasopharyngeal swab
specimens collected ≥24 hours apart (total of two negative specimens)[1]. See Interim
Guidelines for Collecting, Handling, and Testing Clinical Specimens for 2019 Novel
Coronavirus (2019-nCoV). Of note, there have been reports of prolonged detection of
RNA without direct correlation to viral culture.

HCP with laboratory-confirmed COVID-19 who have not had any symptoms:

Time-based strategy. Exclude from work until:
• 10 days have passed since the date of their first positive COVID-19 diagnostic test
assuming they have not subsequently developed symptoms since their positive test. If
they develop symptoms, then the symptom-based or test-based strategy should be
used. Note, because symptoms cannot be used to gauge where these individuals are in
the course of their illness, it is possible that the duration of viral shedding could be longer
or shorter than 10 days after their first positive test.

Test-based strategy. Exclude from work until:
• Negative results of an FDA Emergency Use Authorized COVID-19 molecular assay for
detection of SARS-CoV-2 RNA from at least two consecutive nasopharyngeal swab
specimens collected ≥24 hours apart (total of two negative specimens). Note, because
of the absence of symptoms, it is not possible to gauge where these individual are in the
course of their illness. There have been reports of prolonged detection of RNA without
direct correlation to viral culture.

Note that detecting viral RNA via PCR does not necessarily mean that infectious virus is
present.

Consider consulting with local infectious disease experts when making decisions about
discontinuing Transmission-Based Precautions for individuals who might remain infectious
longer than 10 days (e.g., severely immunocompromised).

If HCP had COVID-19 ruled out and have an alternate diagnosis (e.g., tested positive for
influenza), criteria for return to work should be based on that diagnosis.

After returning to work, HCP should:
• Wear a facemask for source control at all times while in the healthcare facility until all
symptoms are completely resolved or at baseline. A facemask instead of a cloth face
covering should be used by these HCP for source control during this time period while in
the facility. After this time period, these HCP should revert to their facility policy
regarding universal source control during the pandemic.
- A facemask for source control does not replace the need to wear an N95 or higher-level respirator (or other recommended PPE) when indicated, including when caring for patients with suspected or confirmed COVID-19.
- Of note, N95 or other respirators with an exhaust valve might not provide source control.

- *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 [13].
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 be infected with SARS-CoV-2 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 <5 μm 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 [35-37].

6.2. Transmission Routes

The US Centres for Disease Control (CDC) published a summary on 23 March 2020:15

“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.

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 [38]:

“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:[16]

“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.”

6.2.1. Animal-to-human transmission

Phylogenetic analyses suggest that bats might be the original host of SARS-CoV-2 [39]. 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 [39]. The mode of transmission between the hypothetical intermediate host and humans is unknown.

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 [24].

There is limited evidence of passage from humans to animals, for example two pet cats with mild respiratory illness have tested positive for COVID-19 in New York [17]. In addition, two out of 15 dogs from households with confirmed human cases of COVID-19 in Hong Kong SAR were found to be infected with SARS-CoV-2 [40]. This was demonstrated using RT–qPCR, serology, sequencing the viral genome, and in one dog, the virus was also isolated. The dogs remained asymptomatic. Transmission from pets to humans is considered unlikely to be important in the epidemiology of COVID-19. However, until more is known, the US CDC recommends limiting interaction with pets and other people or animals outside of the household. They also recommend that people with COVID-19 (either confirmed or suspected) should restrict contact with pets and other animals, as they would around other people.

6.2.2. Human-to-human transmission

Transmission via respiratory droplets

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 [15].

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 [41-45]. 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 [45]. 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: [18]

“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.

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 [15]. In New Zealand, there have been clusters of cases associated with travel, schools, aged care facilities, a conference, a workplace and domestic events, including weddings [19]. No clusters in food production or processing workplaces have been reported in New Zealand to date.

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 [15]. Latest figures show that healthcare workers make up 9% of Italy’s COVID-19 cases[20] and in Spain 14%[21]. 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.[22]

Food service workers did represent a high proportion of the infected crew members involved in a large outbreak on a cruise ship (in Japan) in February 2020 [46]. A total of 15/20 of infected crew members were food service workers who prepared food for other crew members and passengers. These workers lived on the same deck and congregated with other crew in the shared dining area. It was considered that transmission was probably through contact or droplet spread, which is consistent with current understanding of COVID-19 transmission.

---

Multiple outbreaks of COVID-19 have also occurred among meat and poultry processing facility workers recently, including one facility in Australia\(^\text{23}\) and multiple facilities in the United States \(^\text{47}\) \(^\text{24}\). In the United States during April 9–27, COVID-19 was diagnosed in 4,913 (approximately 3%) of workers and 20 COVID-19–related deaths were reported, from 115 meat or poultry processing facilities in 19 states. Workers were not exposed to SARS-CoV-2 through the meat products they handle. Instead, aspects of their work environments, including processing lines and other areas in busy plants where they have close contact with co-workers and supervisors, were thought to place them at increased risk of exposure.

**Faecal-oral transmission**

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.

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 shown the presence of SARS-CoV-2 through the detection of RNA in faecal specimens, oesophagus, stomach, duodenum or rectal samples of COVID-19 cases \([13, 15, 48-54]\). Depending on the study, the percentage of COVID-19 patients in which SARS-CoV-2 RNA was detected in faeces varied, the timing of specimen collection was not always consistent, and some studies only tested a small number of patients (reviewed by \([55]\)). For example, detection rates of SARS-CoV-2 RNA in the faeces of 55% (41/74) \([48]\), 59% (55/96) \([53]\) and 67% (28/42) of patients \([54]\) has been reported. SARS-CoV-2 viral RNA could also be detected in anal swabs taken over a 42-day period from a child who remained asymptomatic \([56]\). The virus has been detected in faeces from cases with moderate symptoms for almost seven weeks after initial symptom onset \([48]\).

By comparison, SARS-CoV RNA was highly prevalent in faecal samples from SARS patients (87% (82/94) of samples) \([57]\). However, the detection rate was lower for MERS-CoV RNA in faeces from MERS patients (15% (12/82) of samples) \([58, 59]\). The World Health Organization Consensus Document on the epidemiology of SARS stated:\(^\text{25}\)

“The role of faecal-oral transmission is unknown; however, there is no current evidence that this mode of transmission plays a key role in the transmission of SARS though caution was expressed on this point because of the lack of surveys and transmission studies among children where this is a common mode of transmission of other viral infection.”

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 [13].

Although it is fairly common to detect SARS-CoV-2 RNA in faeces, infectious SARS-CoV-2 has only been grown in cell culture ('isolated') from a small number of patients by Chinese researchers [49, 55, 60]. Infectious 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 [61]. It is also possible that the viral RNA detected in faeces represents virus-containing mucous that has been swallowed 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 could 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 [62].

Several studies have shown that the salivary gland and tongue also express the ACE2 receptor, suggesting the oral cavity as a host for 2019-nCoV to infect. Furin (a cellular protease enzyme) has been implicated in virus infection by cleaving viral envelope glycoproteins and enhancing infection with host cells. Furin expression was detected by immunostaining in human tongue epithelia and combined with high expression of ACE2, the tongue has a high risk of coronavirus infection among the oral cavity [63].

Previous research has suggested that the presence of influenza A virus RNA and virions in faeces is because they are surrounded by swallowed mucus which protect them from inactivation or degraded by the gastrointestinal environment [64]. 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.

### 6.3. Persistence of coronaviruses on inanimate surfaces, in aerosols, and effect of temperature and inactivation treatments

Transmission of non SARS-CoV-2 coronaviruses from contaminated dry surfaces has been postulated [65, 66]. 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 are 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.

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 [67-69].

Persistence studies described below use both RT-PCR and cell culture assays, but only cell culture informs on infectivity.

### 6.3.1. Persistence on inanimate surfaces

A recent review summarised data on the persistence of all coronaviruses on different types of inanimate surfaces [70]. 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 [71]) to nine days (SARS-CoV strain FFM1 [72]).

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 [73]. Stability was quantified by virus infectivity using end-point titration using Vero E6 cells. 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 (below limit of detection after 4 days) and shortest on copper surfaces (below limit of detection after 8 hours). Results for cardboard (below limit of detection after 2 days) 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.

Since the last version of this report, a new study by Chin et al. (2020) has assessed the stability of SARS-CoV-2 on inanimate surfaces using endpoint titration in Vero-E6 cells to determine infectivity [74]. Surfaces were inoculated with a 5 μl droplet of virus culture (~7-8 log_{10} of 50% tissue culture infectious dose (TCID₅₀) per ml) and incubated at 22°C, 65% relative humidity.
Virus was eluted from samples at time periods 0, 30 min, 3 and 6 hours, and 1, 2, 4 and 7 days. No infectious virus could be detected from printing and tissue paper at 3 hours, nor from treated wood and cloth at day 2. SARS-CoV-2 was more stable on smooth surfaces, with detection of infectious virus from glass and banknotes at day 2 but not at day 4, and detection on stainless steel and plastic at day 4 but not at day 7. Infectious virus could still be detected on the outer (but not inner) layer of a surgical mask on day 7 (~0.1% of the original inoculum).

The infectious virus survival periods for different surfaces from these two studies are comparable.

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 [75]. 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) [73] and Chin et al. (2020) [74], it is unlikely that the virus remained infectious after this 17-day period.

A further study by Guo et al. (2020) sought to determine the presence of SARS-CoV-2 on surfaces in Wuhan, China intensive care and general COVID-19 hospital wards [76]. SARS-CoV-2 RNA was widely detected on floors (including samples from a pharmacy which was accessed by staff and not patients, presumably transmitted on shoe soles), shoe soles of intensive care unit staff, surfaces touched by patients and/or intensive care staff (computer mice, trash cans, and sickbed handrails and doorknobs) and on patient masks. Contamination was greater in intensive care units than general wards. As with the cruise ship cabin study, results do not show that the detected virus was infectious, but instead show potential for SARS-CoV-2 transmission via contact surfaces in the absence of effective cleaning.

### 6.3.2. Persistence in aerosols and distribution

Van Doremalen et al. (2020) 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) [73]. 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 (which was the length of time the experiment was conducted).

A new study posted on April 18 2020 (that has not undergone peer-review) assessed the stability of SARS-CoV-2 (23°C and 53% relative humidity) when maintained in aerosol format for up to 16 hours [77]. Conflicting with the decay in infectivity of SARS-CoV-2 over time in aerosol format that was reported by van Doremalen et al. (2020), this study reported consistent levels of infectious SARS-CoV-2 over the 16 hour duration of aerosolization. In addition, the SARS-CoV-2 virus particles from the 16 hour aerosol suspension maintained integrity when examined visually by scanning electron microscopy.
Although the level of stability of SARS-CoV-2 in aerosols differed between studies, both studies show that the virus remains infectious in aerosol format. However, the studies do not indicate how long aerosols remain airborne. The more likely vector for transmission is respiratory droplets (as discussed earlier 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 [78]. This suggests that droplets of any size do not remain airborne for long periods of time.

Guo et al. (2020) tested for the presence of SARS-CoV-2 RNA (using RT-PCR) from air supply (upstream of airflow) and air discharge samples (downstream of airflow) from Wuhan intensive care and general COVID-19 hospital wards [76]. A total of 35% (14/40) of intensive care air samples and 12.5% (2/16) of general ward air samples tested positive. Air outlet swab samples also tested positive (66.7% (8/12) in intensive care units and 8.3% (1/12) in general wards). Detection rates included 35.7% (5/14) near air outlets and 44.4% (8/18) in patients’ rooms. At a site located against the airflow, which was four metres away from a patient’s bed, virus was detected in 12.5 per cent (1/8) of samples. Based on this finding, the report suggested that the aerosol transmission distance of SARS-CoV-2 might be four metres.

A commentary was recently published regarding this study26. The authors stated that:

“We should consider the results from this study with caution. The study tests for the presence of the virus on surfaces and in the air, but doesn’t indicate if the virus was living and infectious. The authors didn’t describe the nature of medical procedures undertaken in these wards, particularly if any might be likely to generate aerosols. The virus sample detected four metres away was described as a “weak positive”. Both “intense positive” and “weak positive” samples were grouped together as positive samples in the results without defining what a “positive sample” was or explaining the distinction between the two outcomes. The study had a small sample size and importantly, researchers didn’t use any statistical tests to determine the significance of their findings. So the results have limited utility in the real world.”

The four metre distance reported by Guo et al. (2020) [76] is longer than the one-to-two metre rule of spatial separation guidelines recommended by regulatory authorities to prevent spread of the virus. The one-to-two metre rule of spatial separation assumes that large respiratory droplets do not travel further than 2 metres. Bahl et al. (2020) reviewed the evidence for horizontal distance travelled by droplets [79]. They concluded that the evidence for the one-to-two metre rule was sparse and that eight of ten studies reviewed reported travel of droplets from two to eight metres. As discussed by the authors of the commentary:

“Of the ten studies, five were conducted using human subjects. These studies looked at the dynamics of droplet transmission but were not specifically related to SARS-CoV-2-containing

droplets. So we need more research to better understand transmission of SARS-CoV-2 in hospital settings. Health-care settings should adopt measures to prevent airborne transmission, such as using N95 respirators and gowns, if conducting any aerosol generating procedures.”

A further study of potential aerosol transmission within the environment of two additional hospitals in Wuhan has been reported [80]. One hospital was a tertiary facility designated for treatment of severe symptom COVID-19 patients, while the other was representative of the make-shift field hospitals which was renovated from indoor sports facilities or exhibition centres to quarantine and treat patients with mild symptoms. SARS-CoV-2 was quantified by PCR in three types of samples: all aerosol samples, size segregated aerosol samples, and aerosol deposition samples. The concentration of SARS-CoV-2 RNA in aerosols detected in isolation wards and ventilated patient rooms was very low, but it was elevated in the patients’ toilet areas. Levels of airborne SARS-CoV-2 RNA in the majority of public areas were undetectable except in two areas prone to crowding, possibly due to infected carriers in the crowd. Some medical staff areas (e.g. protective equipment removal rooms) initially had high concentrations of viral RNA, but these levels were reduced to undetectable levels after implementation of rigorous sanitization procedures. Overall, in the positive samples, viral RNA copies were quantified as up to 113 copies per square metre per hour for deposition surfaces in intensive care units, and up to 42 copies per cubic metre for aerosol samples.

It is important to note that these studies concern healthcare settings where symptomatic cases are present, The Ministry of Health advice for Alert Level 3 continues to be: “Physical distancing of two metres outside home (including on public transport), or one metre in controlled environments like schools and workplaces.”

6.3.3. Effect of temperature on coronavirus infectivity

The stability of SARS-CoV-2 in virus transport media was tested at different temperatures (4, 22, 37, 56 and 70°C) for up to 14 days [74]. The starting concentration of infectious SARS-CoV-2 was 6.8 log₁₀ of TCID₅₀ per ml. Full inactivation (undetectable by the cell culture assay) of SARS-CoV-2 was reported after 5 min at 70°C, 30 min at 56°C, day 2 at 37°C and day 14 at 22°C. SARS-CoV-2 was highly stable at 4°C with only a ~0.7 log reduction of infectious titre by day 14.

Temperature is also known to affect the persistence of 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 [81]. 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 [82, 83]. Indeed, freezing is used to preserve viruses in laboratories. 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 [84].
6.3.4. Inactivation treatments for coronaviruses

Chemical treatments:

A new study evaluated the virucidal effects of common disinfectants against SARS-CoV-2 [74]. A 15 μl volume of SARS-CoV-2 culture (~7-8 log unit of TCID_{50} per ml) was added to 135 μl of various disinfectants at working concentration, and levels of infectious virus were assayed after incubation at 22°C for 5, 15 and 30 min. No infectious virus was detected after 5 min incubation in household bleach (active ingredient sodium hypochlorite; 1:49 and 1:99 dilution\textsuperscript{27}), ethanol (70%), povidone-iodine (7.6%), chloroxylene (0.05%), chlorhexidine (0.05%) or benzalkonium chloride (0.1%).

The reported efficacy of common biocidal agents used in surface disinfectants against other coronaviruses using suspension tests has been reviewed [70]. 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 using suspension tests, coronavirus infectivity was reduced by ≥4 log_{10} 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 exposure times (2-5 min) were needed for equivalent inactivation in glutardialdehyde (0.5-2.5%). Concentrations of sodium hypochlorite of 0.21% resulted in >4-log reduction after 30 seconds, while 10 min was needed for ~1-3-log reduction in infectivity using 0.01%. 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. Chlorhexidine digluconate (0.02%) was not effective. Benzalkonium chloride results were conflicting; no reduction in HCoV infectivity was seen when exposed to a 2.0% concentration for 10 min, while the infectivity of other coronaviruses reduced >3.7 log_{10} when exposed to lower concentrations (0.05%). 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 \textsuperscript{28}. The database lists active

\begin{itemize}
\item The concentration of the sodium hypochlorite in household bleach was not given, but depending on the purpose, can range from 2-12%; concentrations in US bleach products are typically 6%. Assuming a 6% concentration, concentrations of sodium hypochlorite used in the study would be 0.12 and 0.06%. https://www.cdc.gov/vhf/ebola/clinicians/non-us-healthcare-settings/chlorine-use.html; accessed 19 May 2020.
\item https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2; accessed 27 March 2020
\end{itemize}
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).

**Hand sanitisers:**

Proper hand hygiene and sanitation has been recognised as critical to mitigate the transmission of SARS-CoV-2. The WHO has released guidance for general hand hygiene against a range of pathogens for the healthcare setting, which includes two recommended hand sanitiser formulations. Formulation guidelines were later updated to include higher alcohol concentrations (measured by mass instead of volume percentage, see below) and lower glycerol concentrations (because glycerol was thought to reduce efficacy) [85].

The virucidal activity against SARS-CoV-2 of four WHO–recommended hand rub formulations (two original formulations and two modified formulations), and of their active ingredients, has also recently been assessed [86]. A suspension of SARS-CoV-2 was exposed for 30 seconds to the active ingredients or formulations, used at full strength or diluted, and infectivity was determined using cell culture. First, the active ingredients ethanol and 2-propanol (isopropyl alcohol), reduced viral titres to background levels in 30 s with reduction factors of between 4.8 and ≥5.9; a concentration of >30% (vol/vol) ethanol or 2-propanol was sufficient for complete viral inactivation. Formulations tested included: original formulation I (vol/vol: 80% ethanol, 1.45% glycerol, 0.125% hydrogen peroxide), original formulation II (vol/vol: 75% 2-propanol, 1.45% glycerol, 0.125% hydrogen peroxide), modified formulation I (wt/wt: 80% ethanol; vol/vol: 0.725% glycerol, and 0.125% hydrogen peroxide) and modified formulation II (wt/wt: 75% 2-propanol; vol/vol: 0.725% glycerol, and 0.125% hydrogen peroxide). All four formulations inactivated SARS-CoV-2 after 30 seconds, although it was noted that this may be a longer period than used in practice. The ethanol-based formulations were effective down to a dilution of >40%, and the 2-propanol-based formulations down to >30%.

The virucidal efficacy of a hand soap solution (1:49 dilution) was also assessed against SARS-CoV-2 [74]. Infectious virus was still detected after incubation at room temperature (22°C) for 5 min (only 1/3 of the triplicate reactions was positive), but not after 15 min. Note that the hot water and physical agitation used in handwashing will increase the virucidal effect.

**Ozone:**

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) [87, 88]. 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 [88-92]. No information was found on the efficacy of ozone on SARS-CoV-2 or other coronaviruses. However, ozone treatment has been found to

---

29 [https://apps.who.int/iris/bitstream/handle/10665/44102/9789241597906_eng.pdf](https://apps.who.int/iris/bitstream/handle/10665/44102/9789241597906_eng.pdf); accessed 6 May 2020
be effective against a range of other viruses, and is more effective against enveloped than non-enveloped viruses [87]. 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 [88, 93].

**Ultraviolet light:**

Considerable interest has been raised recently around the potential for ultraviolet-C (UV-C) light for the decontamination of SARS-CoV-2 from surfaces, hospital equipment, N95 respirators and other PPE [94-96]. The germicidal effectiveness of UV radiation is in the 180-320 nm range, with a peak at 265 nm. At this range, protein and nucleic acids adsorption and damage occurs [97]. However, this is also harmful to human skin, so any germicidal treatment should not be used to sterilise human skin, and must be carried out in areas where no one is present at the time of disinfection.

To our knowledge, no studies have yet examined the efficacy of UV-C for inactivating SARS-CoV-2. However, various studies have demonstrated inactivation by UV-C of the closely-related virus SARS-CoV, MERS-CoV and other respiratory viruses [98-103]. The studies demonstrate efficacy over a range of different virus presentation formats such as in solution, aerosol, on surfaces, and in blood products. The UV-C equipment, wavelength, emission intensity and exposure times differed depending on the experiment.

Although there is no current consensus on the amount of UV-C radiation required to inactivate SARS-CoV-2, the UV dose required to inactivate 90% of another single stranded RNA virus (MS2 bacteriophage) on the surface of gelatin media has been estimated to be 1.32-3.20 mJ cm\(^{-2}\) [103].

Card *et al.* 2020 [94] investigated the potential for using typical Biosafety Cabinets for sterilising N95 respirators and face shields using the UV-C function. One difficulty they discovered is that these cabinets do not deliver consistent UV levels throughout the internal space, and each cabinet performs differently. Elevating PPE closer to the UV light shortened the calculated time required for sterilisation. For example, under the conditions investigated, they conservatively estimated the time to sterilise N95 respirators for SARS-CoV-2 was one hour per side when in an elevated position, but over four hours when placed on the bottom of the Biosafety Cabinet. Effective decontamination of face shields likely requires a much lower UV-C dose, and may be achieved by placing the face shields at the bottom of the Biosafety Cabinet for 20 minutes per side. The calculations were based on a target dose of 1 J/cm\(^2\), which is considerably higher than previously reported inactivation doses (1.32–3.20 mJ/cm\(^2\)).

A wide range of UV-C germicidal irradiation (UVGI) facilities and equipment are available, such as UVG1 Rooms, lamps, and biosafety cabinets. The time taken to decontaminate a particular

---


surface or product for SARS-CoV-2 will depend on the light source wavelength, degree of emission and distance from the surface requiring decontamination. Based on the light source employed, such devices can be calibrated via radiometry to deliver a measured amount of ultraviolet radiation energy per unit surface area (Joules per square centimetre) for a time period deemed sufficient for decontamination.

**Gamma irradiation:**

Gamma irradiation has been proposed as a means of inactivating SARS-CoV-2, particularly for PPE. A study of the irradiation doses required to inactivate a target dose of $1 \times 10^6$ TCID₅₀/mL of various viruses, including SARS-COV has been published [104]. It found that a comparatively low dose was required to inactivate SARS-COV (1 Mrad) compared with other types of virus (up to 5 Mrad).

A study of the effect of Cobalt-60 gamma irradiation on N95 masks used these irradiation doses that had been shown to inactivate viruses, including SARS-CoV [105]. The ability of the masks to filter 0.3 um particles was found to be significantly reduced by this treatment.

**pH:**

Coronaviruses are sensitive to low and high pH levels. One study showed no detection of HCoV-229E virus infectivity after 6 hours incubation in foetal calf serum/saline solution at pH ≥9 or ≤4 at 33°C [84]. The virus was less pH-sensitive at 4°C, with loss of infectivity at pH ≥11 or ≤3. As discussed in Section 9, MERS-CoV was inactivated in gastric fluid (pH 2) after two hours [106]. However, a new study has reported that SARS-CoV-2 remained infectious following incubation for 60 min at 22°C in solutions that covered a range of pH values from pH 3 to 10 [74]. pH values higher or lower than this range, and incubation for longer time periods, were not tested. The pH of gastric acid is 1.5 to 3.5 in the human stomach lumen.

**Washing produce:**

It has been suggested that washing fruit and vegetables with soap and water in the home should be conducted as a protection against COVID-19. A commentary from various US food safety scientists recommends against this idea, on the basis of adverse effects from consuming soap residues.³³

---

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 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 [107]. 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 22°C. 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.34
8. WHAT IS THE INTERNATIONAL CONSENSUS ON SURVIVAL RATES FOR SARS-COV-2 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) [67].

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 log₁₀ 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. No valid results could not be determined for coronavirus persistence on strawberries as no virus could be recovered following initial inoculation. Reductions of 1.97 log₁₀ and 2.38 log₁₀ of HAdV-2 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 [108]. 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 23°C 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.

International organisations, including but not limited to the WHO\textsuperscript{35}, US CDC\textsuperscript{36}, US FDA\textsuperscript{37} and EFSA\textsuperscript{38}, have all indicated that there is currently no evidence and highly unlikely that food or food packaging are sources or routes of transmission of SARS-CoV-2. EFSA links to a FAQ on the topic published by the German Federal Institute for Risk Assessment\textsuperscript{39}, which links general advice about avoiding foodborne infections in private households.\textsuperscript{40}

The minimum infectious dose is not known but there is always a possibility that infection of the tongue or possibly the pharynx could occur as the food passes through to the oesophagus. However, this possibility is considered very remote as the virus would be mixed (diluted) with food and the transit time is relatively quick.(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. Coronavirus 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 [106]. 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.

\textsuperscript{36} https://www.cdc.gov/foodsafety/newsletter/food-safety-and-Coronavirus.html; accessed 6 May 2020
\textsuperscript{39} 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
\textsuperscript{40} https://www.bfr.bund.de/cm/364/protection-against-foodborne-infections.pdf accessed 25 March 2020
ANSES convened an expert group to assess the potential for foodborne transmission.\textsuperscript{41} The following is from their report.

\textbf{“Potential transmission of the virus via food”}

“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. \textbf{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, \textbf{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, \textbf{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. \textbf{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. \textbf{Good hygiene practices, when properly applied, are an effective way to prevent food from being contaminated with the SARS-CoV-2 virus}”

\textsuperscript{41} https://www.anses.fr/en/content/covid-19-cannot-be-transmitted-either-farm-animals-or-domestic-animals-0

accessed 29 April 2020
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 first 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 and has been updated since the previous report:

**“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?”**

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

Instruct sick employees to stay home and to follow the CDC’s “What to do if you are sick with coronavirus disease 2019 (COVID-19)”\(^{43}\). Clean and disinfect surfaces in the employee’s workspace\(^{44}\). Inform fellow employees of their possible exposure to COVID-19 while maintaining confidentiality. Instruct employees who are well, but have been exposed to COVID-19, to notify their supervisor and follow CDC’s Interim Guidance for Implementing Safety Practices for Critical Infrastructure Workers Who May Have Had Exposure to a Person with Suspected or Confirmed COVID-19.

**Federal Government Resources** Businesses should consult the CDC’s Interim Guidance for Business and Employers to Plan and Respond to Coronavirus Disease 2019, which is frequently updated.\(^{45}\)

The Occupational Safety and Health Administration (OSHA) also 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).\(^{46}\)

**Additional Resources** The Food and Beverage Issues Alliance has developed protocols for (1) when an employee of a firm is a confirmed or presumptive case of COVID-19 and (2) when a facility employee/facility visitor/customer has been in close contact with an individual with COVID-19. This protocol is specific to food manufacturing facilities, distribution centers, and wholesale and retail outlets.\(^{47}\)

**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?**

---


\(^{46}\) [https://www.osha.gov/Publications/OSHA3990.pdf](https://www.osha.gov/Publications/OSHA3990.pdf), accessed 5 May 2020

\(^{47}\) [https://static1.squarespace.com/static/5e7d1107dac6b0a6b3e3f098d/t/5e8fe0311087511091ceeb577/1586487346649/FBIA+COVID19%2BCase+Recommended+Protocols_9Apr2020_Version4+ja_SIGNED.pdf](https://static1.squarespace.com/static/5e7d1107dac6b0a6b3e3f098d/t/5e8fe0311087511091ceeb577/1586487346649/FBIA+COVID19%2BCase+Recommended+Protocols_9Apr2020_Version4+ja_SIGNED.pdf), accessed 5 May 2020
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 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. 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, 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.
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 the Food Safety Authority of 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.”
NZFSSRC have also produced a guide for New Zealand food producers, processors and distributors to better understand the current situation with regards to testing requirements in the workplace for SARS-CoV-2\textsuperscript{50}. Information provided pertinent to this section is as follows:

\textit{Is there a requirement to test for SARS-CoV-2 in food production and processing areas?}

Currently in New Zealand there is no regulatory requirement to test for the presence of SARS-CoV-2 in commercial food preparation areas or food products. Further, we are not aware of any regulation requiring testing of food surfaces or products in any international jurisdiction. The United States Food and Drug Administration (FDA) currently state that environmental testing is not recommended\textsuperscript{51}.

\textit{If a food production or processing worker becomes sick with COVID-19, should environmental testing or testing of food for SARS-CoV-2 be carried out?}

If hygiene standards commensurate with established Risk Management Plans are being followed, the probability of food or food preparation surfaces becoming contaminated with the virus is considered to be low. Normal food industry cleaning and sanitising regimes for food preparation surfaces will inactivate any virus that may be present. Note, it may be prudent to increase the frequency of sanitation. The United States Environmental Protection Agency (EPA) has collated a list of cleaners/sanitizers which claim to inactivate SARS-CoV-2. According to a recent study, the longest time that the virus can remain infectious on a surface is three days \cite{73}. Currently, authorities have not recommended environmental testing for SARS-CoV-2.

\textit{If I want to perform environmental testing in my factory or in food products, what are my options?}

The availability of kits that can test for the presence of SARS-CoV-2 has expanded dramatically worldwide \cite{52}. However, almost all these tests are intended for clinical diagnosis (i.e., to test for the presence of SARS-CoV-2 in human samples). Kits optimised for environmental testing for SARS-CoV-2 are being developed but are not yet commercially available in New Zealand, and their validation status is uncertain. To our knowledge, kits optimised for testing of SARS-CoV-2 in food matrices are also not yet commercially available. The current demand for clinical testing has created a world-wide shortage of some test components\textsuperscript{53}. There is real concern that testing for environmental contamination will further impact on the limited availability of clinical test kits."

\begin{thebibliography}{99}
\bibitem{50}https://mcusercontent.com/ac7d10ed90f765f0df9b564b7/files/39af8e-efd5-4706-bf31-2123c757edd6/Questions_and_Answers_for_the_New_Zealand_food_industry_on_testing_for_the_SARS_CoV_2_virus.docx.pdf; accessed 18 May 2020
\bibitem{52}https://www.finddx.org/covid-19/pipeline/; accessed 18 May 2020
\bibitem{53}https://cen.acs.org/analytical-chemistry/diagnostics/Shortage-RNA-extraction-kits-hampers/98/web/2020/03; accessed 18 May 2020
\end{thebibliography}
11. REFERENCES


82. Bozkurt, H., et al., *Outbreaks, occurrence, and control of norovirus and hepatitis a virus contamination in berries: A review*. Critical Reviews in Food Science and Nutrition, 2020:


