Epidemiological Study of COVID-19 Modes of Disease Transmission: with Molecular Basis for SARS-CoV-2 Virulence

Thushara Galbadage  
*Biola University*

Brent M. Peterson  
*Biola University*

Richard S. Gunasekera  
*Biola University*

Follow this and additional works at: https://digitalcommons.biola.edu/faculty-articles

Part of the Epidemiology Commons, and the Virus Diseases Commons

**Recommended Citation**

Galbadage, Thushara; Peterson, Brent M.; and Gunasekera, Richard S., "Epidemiological Study of COVID-19 Modes of Disease Transmission: with Molecular Basis for SARS-CoV-2 Virulence" (2020).  
*Faculty Articles & Research*. 407.  
https://digitalcommons.biola.edu/faculty-articles/407

This Article Preprint is brought to you for free and open access by Digital Commons @ Biola. It has been accepted for inclusion in Faculty Articles & Research by an authorized administrator of Digital Commons @ Biola. For more information, please contact eileen.walraven@biola.edu.
An Epidemiological Study of COVID-19 Modes of Disease Transmission: with Molecular Basis for SARS-CoV-2 Virulence

Thushara Galbadage¹, Brent M. Peterson¹, and Richard S. Gunasekera² *

¹Department of Kinesiology and Health Science, ²Department of Chemistry, Physics, and Engineering, Biola University, La Mirada, California 90639, United States.

*Corresponding author

Richard S. Gunasekera

E-mail: richard.gunasekera@biola.edu

Author Emails:

Thushara Galbadage: don.galbadage@biola.edu
Brent M. Peterson: brent.peterson@biola.edu
Richard S. Gunasekera: richard.gunasekera@biola.edu

Keywords

Coronavirus, COVID-19, SARS-CoV-2, droplet, viral transmission, pandemic, outbreak, epidemic
Abstract

The world has been embroiled in a deadly and volatile public health crisis. The novel coronavirus disease 2019 (COVID-19), as a pandemic, has been rapidly affecting nations throughout the world with such ferocity that governments and their public health authorities have been forced to take drastic measures to contain the spread. Yet, despite the aggressive preventative measures in place, COVID-19 has propagated exponentially throughout the world. In response, we conducted an epidemiological study evaluating cumulative incidence, incidence rate, and mortality rate of COVID-19 to better understand the potential modes of disease transmission in select countries experiencing a high burden of the disease. Currently, the accepted mode of disease transmission is by respiratory droplets containing the virus. Here we provide epidemiological data in conjunction with molecular mechanisms of this Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) and explain the possible alternative modes of disease transmission for COVID-19. Results from this investigation showed that despite aggressive droplet precautionary measures in place the rate of COVID-19 transmission remains exponentially high. Our study indicates that COVID-19 has a high probability of transmission through other routes, such as indirect routes; viz, fomites and aerosols. In conclusion, additional preventative measures are needed to slow the spread of COVID-19.
Introduction

The world is in the middle of a historic public health crisis. As of March 30th, 2020, over a third of the population in the United States were under “stay at home” orders given by state governors to protect the vulnerable and the unexposed. Unprecedented steps have been taken by governments globally to contain the novel coronavirus disease 2019 (COVID-19), a rapidly spreading pandemic. This has resulted in more than 690,000 cases and over 33,000 deaths worldwide (Table 1). The index case of the disease, caused by the Severe Acute Respiratory Syndrome- Coronavirus-2 (SARS-CoV-2) was identified more than three months ago. Since then, public health authorities worldwide have taken aggressive measures to blunt the exponential spread of this coronavirus. Furthermore, several nations including Italy, Spain, and France have imposed nation-wide lockdown measures to enforce social distancing to further prevent the spread of COVID-19 in their respective countries.

While preventative measures have been imposed globally, the observed propagation of COVID-19 has noticeable differences among select nations. Epidemiologic data shows that some nations have exponential increases in disease incidence, while others seem to have “flattened the curve.” This raises the questions of whether a full scientific understanding of the modes of transmission of this disease has yet to be attained, and thus whether there are more effective ways to prevent its spread. This brings us to the fundamental question of whether COVID-19 spread through droplets alone.

To answer this question we performed an epidemiological study evaluating at total numbers of COVID-19 cases, incidence rates, total mortality, and mortality rates in countries that were considered epicenters for COVID-19. Our Current epidemiological data in conjunction with molecular characteristics of SARS-CoV-2 suggests that it may spread through indirect
transmission modes as well. In addition, these data presented herein demonstrate the increased virulence characteristics and the ability of this novel coronavirus to remain viable on various environmental surfaces from hours to days compared to the previous SARS-CoV-1. These molecular properties and data presented herein, likely explain how this novel coronavirus may also be transmissible by indirect methods of transmission including fomites and aerosols, in addition to respiratory droplets.

Public health agencies and authorities play a significant role in controlling and mitigating the effects of pandemics such as this one. Public health leaders develop and implement aggressive interventions to reduce the exponential rise in incidence rates of disease transmission. Policy regarding these reduction measures has been guided by observations in health outcomes following the 1918 influenza pandemic. Importantly, during this pandemic, some U.S. cities chose more effective measures to address the spread of the disease, resulting in observable differences in mortality rates across the nation [1]. One example of this was the quarantining of people within homes. Another was the deliberate reduction in space between persons; a practice now known as social distancing. Social distancing is an evidence-based practice to help prevent the transmission of pathogens that are known to spread from person to person within a 3 to 6 feet distance through respiratory droplets [2, 3]. This practice requires individuals in a community to choose behaviors that increase the distance between themselves and others (infected, asymptomatic carriers, or non-infected). This helps reduce the transmission of respiratory droplets containing SARS-CoV-2 and slows the incidence of the disease by reducing the opportunities for potential viral exposures.

Documented responses such as the previous provide great examples of how integral the public health system and policies are to the proper function of medical and healthcare systems. Acting swiftly and mobilizing precautionary measures, can substantially aid in flattening the
disease incidence curve. Thereby reducing the number of critically ill patients who will need medical treatment—all at the same time. This, in turn, reduces the burden on the healthcare system that takes care of patients presenting with the most feared complication of COVID-19, i.e.; severe bilateral pneumonia [4]. This concept now widely referred to as “flattening the curve” gives critically ill patients a fighting chance to survive by obtaining life-saving supportive therapy in hospitals. This, therefore, significantly reduces the mortality rate [1]. If the number of critically ill patients is greater than what can be accommodated in hospitals, many more patients will die due to the lack of life-saving medical attention.

Methods

Epidemiological study design

This was a cross-sectional study looking at the cumulative incidence of COVID-19 on a daily interval from the 20th of January to the 30th of March. Incidence data for COVID-19 cases and deaths were obtained from the COVID-19 Situation Reports provided by the WHO (https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports). For this study COVID-19 Situation Reports, 1 to 70, published from the 20th of January to the 30th of March were used. These data sets included the number of cumulative cases and the number of cumulative deaths attributed to COVID-19, reported each day. Cases and deaths were stratified according to countries and different regions of the world. For this study we look at countries most affected by the COVID-19 pandemic, also referred to as disease epicenters.

Cumulative Incidence and Incidence Rate of COVID-19

Cumulative incidence of COVID-19 was calculated using the case total data from WHO COVID-19 Situation Reports 1 to 70. Each of these reports provided the cumulative incidence of
COVID-19 stratified according to countries and the cumulative incidence worldwide. To calculate the daily incidence rate of COVID-19 from the 20th of January to the 30th of March, the case total corresponding that day was subtracted by the case total from the previous day. The incidence rates are presented over 24 hours in this study. The population at risk was considered to be the total population of the respective country, as COVID-19 is a new disease with no prior immunity.

Total number of deaths and Mortality Rate of COVID-19

The total number of deaths due to COVID-19 was obtained from WHO COVID-19 Situation Reports 1 to 70. Each of these reports provided the total number of deaths caused by COVID-19 stratified according to countries and the total number of deaths worldwide. To calculate the mortality rate of COVID-19 from the 20th of January to the 30th of March, the ratio of the total number of death and the case total of COVID-19 corresponding that day was taken. The mortality rates are reported for the period from the 20th of January to the 30th of March (Table 1). Mortality rates of COVID-19 are reported worldwide and for select countries from various regions as designated by the WHO.

Representation of Study Results

The case and death number and data obtained from the WHO COVID-19 Situation Reports 1 to 70 were analyzed and graphed using Microsoft Excel software. The case totals and cumulative deaths are represented as scatter plots. The number of new cases and deaths due to COVID-19 each day are represented as bar graphs. These results are organized according to country and regions of the world. The four regions analyzed in this study are the Western Pacific region, European region, East-Asian region and the Mediterranean region.
Results and Discussion

Transmission of COVID-19 and Preventative Measures in Place

The current consensus regarding the transmission of SARS-CoV-2 is that it spreads person to person through respiratory droplets [5, 6]. Precautions to prevent the spread by droplets as recommended by both the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) are to (1) wash hands with soap, (2) avoid touching viral entry points, such as eyes, nose, and mouth, (3) cover the mouth when coughing or sneezing, (4) wear a facemask to cover both the mouth and nose if sick and (5) practice social distancing by putting 6 feet of distance between individuals. In addition to these precautions, government-mandated social distancing measures such as (6) state lockdowns and (7) “stay at home” orders are effective ways to minimize the spread of SARS-CoV-2 through droplet transmission. Despite all these aggressive precautionary measures, SARS-CoV-2 has succeeded to establish an exponentially growing pandemic that has spread to almost every nation in the world (Figure 1). The United States and Italy have already passed China in the number of cases and deaths caused by COVID-19 while Spain was not far behind (Figure 2).
Figure 1. The number of COVID-19 Cases and Deaths Worldwide. The global cumulative case total of COVID-19 (SARS-CoV-2) as reported by the World Health Organization (WHO) daily COVID-19 Situation Reports (1 – 63). This includes cases reported from the 21st of January to the 30th of March 2020. (a) The total number of COVID-19 cases. (b) The number of new cases confirmed each 24 h period. (c) The total number of deaths associated with COVID-19. (d) The number of new deaths reported each 24 h period.

The outbreak on the Diamond Princess Cruise Ship

Certain epidemiological observations may provide evidence to suspect that the spread of SARS-CoV-2 may not be limited to respiratory droplets alone. For example, on the 4th of February 2020, the Diamond Princess Cruise ship carrying 3711 passengers and crew members reported 10 cases testing positive for COVID-19 after their 14-day voyage. As a response to this, the ship was quarantined for 14 days while docked off the coast of Japan. Following this quarantine period, a total of 634 cases reportedly tested positive for COVID-19, despite droplet precautions and social
distancing principles practiced on board [7]. In retrospect, public health officials acknowledge this was not the best practice implemented to contain COVID-19. Additionally, public health officials responded differently to the Grand Princess Cruise ship off the coast of Oakland California, based on suspicions that the dramatically widespread transmission of fomites or COVID-19 aerosols may have been exacerbated by interconnected central ventilation between ship cabins [8]. Public health officials removed all susceptible and unexposed passengers from this cruise ship, which resulted in a significantly lower number of COVID-19 cases [8].

![Graphs showing COVID-19 cases and deaths in the United States, Italy, Spain, and China.](image)

**Figure 2. The number of COVID-19 Cases and Deaths in the United States, Italy, Spain, and China.** The cumulative case total of COVID-19 (SARS-CoV-2) for each country as reported by the World Health Organization (WHO) daily COVID-19 Situation Reports (1 – 63). This includes cases reported from the 21st of January to the 30th of March 2020. (a) The total number of COVID-19 cases. (b) The number of new cases confirmed each 24 h period. (c) The total number of deaths associated with COVID-19. (d) The number of new deaths reported each 24 h period.
The Outbreak in Italy and Other European Countries

Tragically, another story that is unfolding in the COVID-19 pandemic has been occurring within the country of Italy, which currently maintains a mortality rate of 11.0% (Table 1). Once the number of COVID-19 positive cases surpassed 5000, the government of Italy imposed a nationwide lockdown measure on the 9th of March (Figure 3 a and b, black solid arrow). However, even after these measures were in place for over two weeks (Figure 3 a and b, black dotted arrow), the number of cases of COVID-19 continued to rise exponentially, nearing 100,000 cases by the 30th of March (Table 1 and Figure 3). This may suggest that Italy responded far too late to implement preventative measures that could have flattened the curve. Or, this example may suggest that even amidst the aggressive precautionary measures taken to reduce droplet transmission, that aerosol transmission may have also occurred, which may more effectively explain this outcome.

These observations are not limited to just Italy. Most of the European nations are currently experiencing an exponential increase in the incidence rate of COVID-19 despite many stringent precautionary measures employed over the past several weeks (Figure 3). These epidemiological observations in the rapid spread of the disease across nations practicing droplet precautions strongly suggest the premise of this investigation that other alternative modes of disease transmission are adding to the number of diagnosed cases worldwide.
Figure 3. The number of COVID-19 Cases and Deaths in 19 in Select Countries in the European Region. The cumulative case total of COVID-19 (SARS-CoV-2) for each country as reported by the World Health Organization (WHO) daily COVID-19 Situation Reports (1 – 63). This includes cases reported from the 21st of January to the 30th of March 2020. (a) The total number of COVID-19 cases. (b) The number of new cases confirmed each 24 h period. (c) The total number of deaths associated with COVID-19. (d) The number of new deaths reported each 24 h period. The black solid arrow represents the day Italy entered a nationwide lock down. The black dotted line represents two weeks since the start of the lockdown measures, which overlaps with the incubation period of SARS-CoV-2.

The Outbreak in Western Pacific Region

Despite having many of the early cases of COVID-19 in East Asian countries in the Western Pacific Region, the rate of spread of SARS-CoV-2 has been controlled for the most part (Figure 4). Apart from mainland China, where the index case of COVID-19 was identified, South
Korea (Republic of Korea) had the highest number of confirmed cases (Figure 4a). This was largely due to the expanded screen measures and laboratory tests to confirm COVID-19 cases. This is also reflected in the relatively low mortality rate observed in South Korea (1.6% mortality rate) (Table 1 and Figure 4 c and d). Other countries in this region have had relatively low incidence rates of the disease and indicate possible successful preventative measures in place.

Figure 4. The number of COVID-19 Cases and Deaths in 19 in Select Countries in the Western Pacific Region. The cumulative case total of COVID-19 (SARS-CoV-2) for each country as reported by the World Health Organization (WHO) daily COVID-19 Situation Reports (1 – 63). This includes cases reported from the 21st of January to the 30th of March 2020. (a) The total number of COVID-19 cases. (b) The number of new cases confirmed each 24 h period. (c) The total number of deaths associated with COVID-19. (d) The number of new deaths reported each 24 h period.
The Outbreak in South East Asia and Mediterranean Regions

Apart from Iran, the COVID-19 pandemic has not been widespread across South East Asia and the Mediterranean region (Figure 5). There are many population dense countries in these two regions, with India having a population of over 1.3 billion residents. At the current moment, it is not completely clear as to why disparities exist in the transmission rates of COVID-19 among different countries. However, the disease seems to be spreading globally with moving epicenters for the disease. If Iran is any representation of how COVID-19 can spread in South East Asia and Mediterranean regions, the next few months will be crucial for public health authorities to take the necessary measures to mitigate the public health impact of COVID-19.

Figure 5. The number of COVID-19 Cases and Deaths in 19 in Select Countries in South-East Asia and the Eastern Mediterranean Regions. The cumulative case total of COVID-19 (SARS-CoV-2) for each country as reported by the World Health Organization (WHO) daily COVID-19 Situation Reports (1 – 63). This includes cases reported from the 21st of January to the
30th of March 2020. (a) The total number of COVID-19 cases. (b) The number of new cases confirmed each 24 h period. (c) The total number of deaths associated with COVID-19. (d) The number of new deaths reported each 24 h period.

**Molecular Basis of SARS-CoV-2 Virulence**

Recent studies have indicated that SARS-CoV-2 demonstrated 10-20 times greater affinity to angiotensin-converting enzyme 2 (ACE2) receptors compared to SARS-CoV-1, making it a much more virulent virus [9, 10]. This means fewer SARS-CoV-2 virions are necessary to establish an infection in humans. This in part, could explain the rapid spread of the disease worldwide compared to the 2002-2003 SARS outbreak that infected approximately 8,100 individuals. The primary mode of transmission of SARS-CoV-1 in the 2002-2003 outbreak was by respiratory droplets up to a distance of about 6 feet [3, 11]. However, SARS-CoV-1 has also shown to be viable on a variety of common surfaces under environmental conditions up to 96 h post-exposure [12, 13]. SARS-CoV-2 was recently shown to remain viable on average for about 6.8 h on plastic surfaces and about 5.6 h on stainless steel surfaces, and viable virions were detected up to 72 h post-exposure [14]. These studies have demonstrated that SARS-CoV-2 can remain viable in the environment much longer than most other viruses transmitted through respiratory droplets.

The ability of SARS-CoV-2 to remain viable longer on surfaces taken together with its higher virulence in establishing an infection makes it very likely that this coronavirus uses other modes of transmission in addition to respiratory droplets (Figure 6). Remaining longer in the environment may mean this coronavirus can easily transmit through indirect contact. This is can be either a certain level of airborne spread or vehicle-borne (fomites) transmission. Pathogens like
influenza virus and rhinovirus that are usually spread through respiratory droplets have some airborne transmission properties making it plausible that SARS-CoV-2 may have such characteristics as well [2, 15, 16]. Such additional modes of transmission can help further explain the observations made on the Diamond Princess Cruise ship, in Italy and other European nations. On the cruise ship, contaminated surfaces and utensils (fomites), and aerosolized viral particles traveling beyond 6 feet could have exacerbated the volatile spread of COVID-19. In Italy having houses or other domiciles in close proximity to one another may have transmitted the disease even with a limited level of aerosolization. This example may also greater explain the current exponential spread of SARS-CoV-2 in many European nations and in the United States that are aggressively practicing social distancing.

Figure 6. COVID-19 Potential Modes of Transmission. This illustration shows three potential ways SARS-CoV-2 can spread from an infected host to a susceptible host. First, it is transmitted person to person (direct contact) through respiratory droplets. These droplets can travel for distances 6 feet or less in air. Second, SARS-CoV-2 is likely transmitted through fomites (indirect
contact) for the duration it is viable on environmental surfaces. Third, it is also likely transmitted through aerosols (indirect contact) for distances longer than 6 feet in the air. To establish an infection, SARS-CoV-2 needs to first reach an entry point (eyes, nose or mouth) on a susceptible host.

**Widened Measures to Help Better Prevent the Spread of SARS-CoV-2**

Today, the world is facing a certain deadly disease to which there is no cure currently nor a vaccine. Based on the aforementioned findings, if SARS-CoV-2 is also transmitted through indirect contact, greater and additional, yet practical methods of precaution must be taken. There are ways to help prevent such spread. (1) First, it is important to follow all droplet precautions including washing hands with soap or using an alcohol-based hand sanitizer for 20 to 40 seconds, (2) protecting viral entry points, (3) covering one’s mouth when coughing or sneezing, and (4) appropriate social/physical distancing. In addition, (5) constantly disinfecting contact surfaces can eliminate the risk of fomite-based transmission. (6) Furthermore, to prevent the possible spread of aerosolized SARS-CoV-2 infections, we will need to reevaluate; (i) the current recommendations of 6 feet of physical separation between individuals but possibly increase it further, and (ii) recommend the use of personal facemasks in areas where there is a high level of social activity. Finally, in areas of increased risk of COVID-19 transmission such as hospitals and patient care facilities, (7) an appropriately fitted N95 respiratory (facemask), with other personal protective equipment (PPE) (e.g. eye shields, gowns and glows) and (8) expanded use of special air handling and ventilation systems (e.g. AIIRs) that can appropriately purify circulating air in hospitals. This can help contain and safely remove SARS-CoV-2 likely transmitted through aerosolization [17, 18].
Acknowledgments:

The work of Drs. Richard Gunasekera and Thushara Galbadage was supported by the Discovery Institute and the Peter & Carla Roth Family. We acknowledge research students, Joseph Awada and Danny Ramirez. Jr. for their discussions on this research topic.
References


### Table Legend

#### Table 1. Mortality Rates of COVID-19 as of March 23\textsuperscript{rd}, 2020 in Select Regions and Countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of Cases\textsuperscript{1}</th>
<th>Mortality Rate (%)\textsuperscript{2}</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Western Pacific Region</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>82447</td>
<td>4.0</td>
</tr>
<tr>
<td>South Korea</td>
<td>9661</td>
<td>1.6</td>
</tr>
<tr>
<td>Japan</td>
<td>1866</td>
<td>2.9</td>
</tr>
<tr>
<td>Malaysia</td>
<td>2470</td>
<td>1.4</td>
</tr>
<tr>
<td>Singapore</td>
<td>844</td>
<td>0.4</td>
</tr>
<tr>
<td>Philippines</td>
<td>1418</td>
<td>5.0</td>
</tr>
<tr>
<td>Australia</td>
<td>3966</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>European Region</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>97689</td>
<td>11.0</td>
</tr>
<tr>
<td>Spain</td>
<td>78797</td>
<td>8.3</td>
</tr>
<tr>
<td>France</td>
<td>39642</td>
<td>6.6</td>
</tr>
<tr>
<td>Germany</td>
<td>57298</td>
<td>0.8</td>
</tr>
<tr>
<td>Switzerland</td>
<td>14274</td>
<td>1.8</td>
</tr>
<tr>
<td>Netherlands</td>
<td>10866</td>
<td>7.1</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>19526</td>
<td>6.3</td>
</tr>
<tr>
<td><strong>South-East Asia Region</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>1524</td>
<td>0.6</td>
</tr>
<tr>
<td>India</td>
<td>1071</td>
<td>2.7</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>120</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Eastern Mediterranean Region</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iran</td>
<td>38309</td>
<td>6.9</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>570</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>North American Region</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States of America</td>
<td>122653</td>
<td>1.7</td>
</tr>
<tr>
<td>Canada</td>
<td>5655</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>Worldwide (All Cases Globally)</strong></td>
<td>693224</td>
<td>4.8</td>
</tr>
</tbody>
</table>

\textsuperscript{1} Number of cases of COVID-19 as reported by the World Health Organization (WHO) in their Coronavirus disease 2019 (COVID-19) Situation Report – 70, published on March 30\textsuperscript{th}, 2020.

\textsuperscript{2} Mortality rate (%) calculated by taking the ratio of the total number of deaths and the total number of cases reported by the WHO for each country in their Coronavirus disease 2019 (COVID-19) Situation Report - 70 published on March 30\textsuperscript{th}, 2020.
Figure Legend

Figure 1. The number of COVID-19 Cases and Deaths Worldwide. The global cumulative case total of COVID-19 (SARS-CoV-2) as reported by the World Health Organization (WHO) daily COVID-19 Situation Reports (1 – 63). This includes cases reported from the 21st of January to the 30th of March 2020. (a) The total number of COVID-19 cases. (b) The number of new cases confirmed each 24 h period. (c) The total number of deaths associated with COVID-19. (d) The number of new deaths reported each 24 h period.

Figure 2. The number of COVID-19 Cases and Deaths in the United States, Italy, Spain, and China. The cumulative case total of COVID-19 (SARS-CoV-2) for each country as reported by the World Health Organization (WHO) daily COVID-19 Situation Reports (1 – 63). This includes cases reported from the 21st of January to the 30th of March 2020. (a) The total number of COVID-19 cases. (b) The number of new cases confirmed each 24 h period. (c) The total number of deaths associated with COVID-19. (d) The number of new deaths reported each 24 h period.

Figure 3. The number of COVID-19 Cases and Deaths in 19 in Select Countries in the European Region. The cumulative case total of COVID-19 (SARS-CoV-2) for each country as reported by the World Health Organization (WHO) daily COVID-19 Situation Reports (1 – 63). This includes cases reported from the 21st of January to the 30th of March 2020. (a) The total number of COVID-19 cases. (b) The number of new cases confirmed each 24 h period. (c) The total number of deaths associated with COVID-19. (d) The number of new deaths reported each 24 h period. The black solid arrow represents the day Italy entered a nationwide lockdown. The black dotted line represents two weeks since the start of the lockdown measures, which overlaps with the incubation period of SARS-CoV-2.
Figure 4. The number of COVID-19 Cases and Deaths in 19 in Select Countries in the Western Pacific Region. The cumulative case total of COVID-19 (SARS-CoV-2) for each country as reported by the World Health Organization (WHO) daily COVID-19 Situation Reports (1 – 63). This includes cases reported from the 21st of January to the 30th of March 2020. (a) The total number of COVID-19 cases. (b) The number of new cases confirmed each 24 h period. (c) The total number of deaths associated with COVID-19. (d) The number of new deaths reported each 24 h period.

Figure 5. The number of COVID-19 Cases and Deaths in 19 in Select Countries in South-East Asia and the Eastern Mediterranean Regions. The cumulative case total of COVID-19 (SARS-CoV-2) for each country as reported by the World Health Organization (WHO) daily COVID-19 Situation Reports (1 – 63). This includes cases reported from the 21st of January to the 30th of March 2020. (a) The total number of COVID-19 cases. (b) The number of new cases confirmed each 24 h period. (c) The total number of deaths associated with COVID-19. (d) The number of new deaths reported each 24 h period.

Figure 6. COVID-19 Potential Modes of Transmission. This illustration shows three potential ways SARS-CoV-2 can spread from an infected host to a susceptible host. First, it is transmitted person to person (direct contact) through respiratory droplets. These droplets can travel for distances 6 feet or less in air. Second, SARS-CoV-2 is likely transmitted through fomites (indirect contact) for the duration it is viable on environmental surfaces. Third, it is also likely transmitted through aerosols (indirect contact) for distances longer than 6 feet in the air. To establish an infection, SARS-CoV-2 needs to first reach an entry point (eyes, nose or mouth) on a susceptible host.