CHAPTER 10

A review of deciphering the successes and learning from the failures in preventive and health policies to stop the COVID-19 pandemic

Milad Mousazadeh[1,2]**, Zohreh Naghdali**[1,2]**,**
Zahra Mohammadi Goldar[1]**, Marjan Hashemi**[3]**,**
Alaa El Din Mahmoud[4,5]**, Zakaria Al-Qodah**[6]**, Miguel A. Sandoval**[7,8]**,**
Khalid S. Hashim[9]**, Mika Sillanpää**[10,11,12]**,**
Chaudhery Mustansar Hussain[13]**,**
Mohammad Mahdi Emamjomeh[14,*]

[1]Student Research Committee, Qazvin University of Medical Sciences, Qazvin, Iran; [2]Department of Environmental Health Engineering, School of Health, Qazvin University of Medical Sciences, Qazvin, Iran; [3]Environmental and Occupational Hazards Control Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran; [4]Environmental Sciences Department, Faculty of Science, Alexandria University, Alexandria, Egypt; [5]Green Technology Group, Faculty of Science, Alexandria University, Alexandria, Egypt; [6]Al-Balqa Applied University, Faculty of Engineering Technology, Department of Chemical Engineering, Amman, Jordan; [7]Universidad de Santiago de Chile USACH, Facultad de Química y Biología, Departamento de Química de los Materiales, Laboratorio de Electroquímica Medio Ambiental, LEQMA, Santiago, Chile; [8]Universidad de Guanajuato, División de Ciencias Naturales y Exactas, Departamento de Ingeniería Química, Guanajuato, Mexico; [9]Department of Civil Engineering, Liverpool John Moores University, Liverpool, United Kingdom; [10]Chemistry Department, College of Science, King Saud University, Riyadh, Saudi Arabia; [11]Faculty of Science and Technology, School of Applied Physics, University Kebangsaan Malaysia, Bangi, Selangor, Malaysia; [12]Department of Biological and Chemical Engineering, Aarhus University, Nørrebrogade 44, Aarhus C, Denmark; [13]Department of Chemistry and Environmental Science, New Jersey Institute of Technology, Newark, NJ, United States; [14]Social Determinants of Health Research Center, Research Institute for Prevention of Non-Communicable Diseases, Qazvin University of Medical Sciences, Qazvin, Iran

10.1 Introduction

Coronavirus disease 2019 (COVID-19) originated in the city of Wuhan, China, in December 2019. It is an infectious disease caused by a new type of coronavirus named severe acute respiratory syndrome coronavirus 2 (SARS–CoV–2), which can be potentially fatal. The virus has rapidly spread all over the world.[1] On March 12, 2020, the World Health Organization

* Corresponding author Email: m_emamjomeh@yahoo.com

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(WHO) declared the infection a pandemic. The COVID-19 pandemic seems to be a major global health threat due to the increasing number of cases and associated mortality. As of August 11, 2020, COVID-19 had affected 213 countries and territories around the world, infecting 20,394,035 human beings and, unfortunately, 741,807 deaths confirmed worldwide.[2,3] The rate of virus spread and people-to-people transmission is high, and as a newly emerging virus still much remains to be understood about its transmission.[4,5]

Although there are reports of using different medicines and efforts to develop a successful vaccine, at this moment there is continuously research novel approaches to developing proven treatment for COVID-19. The vaccines for COVID-19 have been developed using novel methods intended to increase the volume and speed of production and bring about strong immune responses.[5−7] The disease spread is ongoing, with a rising death toll with various trajectories in countries with a different population (see Fig. 10.1). Since there is neither a confirmed vaccine nor effective pharmaceutical treatment, the best way to reduce the transmission rate of the disease seems to be nonpharmaceutical interventions (NPIs) as preventive measures.[4,6,8,9]

Different countries are at different stages of the pandemic, so governments and health departments have chosen different strategies to contain the spread of the virus. For example, social distancing and movement restrictions, commonly known as lockdown in China, Italy, India, and the UK[1]; massive testing to identify new and asymptomatic cases in South Korea[1,11]; and mass masking policies as a preventive measure even long before WHO recommendations in many Asian countries such as China, South Korea, and Japan.[11−13] The main idea behind all these implementations was to reduce the transmission rate to flatten the epidemic curve and distribute medical treatment demand over time. This last point allows health systems to deal with a larger number of patients at the same time. Fig. 10.2 shows the impact of five public health interventions implemented individually and in combination to suppress infection transmission and health care demand based on epidemiological modeling in the UK.[3,4,14] Data show that countries, which implemented such containment and preventive measures, experienced lower infection rates and fewer deaths.[3,8,15] Since wide testing would not be affordable and feasible in many low and middle-income countries, and poor countries such as Brazil and Ghana cannot tolerate lockdown consequences, herd immunity might be chosen as an alternative solution in this pandemic. However, the duration of such immunity is not known and might offer serious risks and
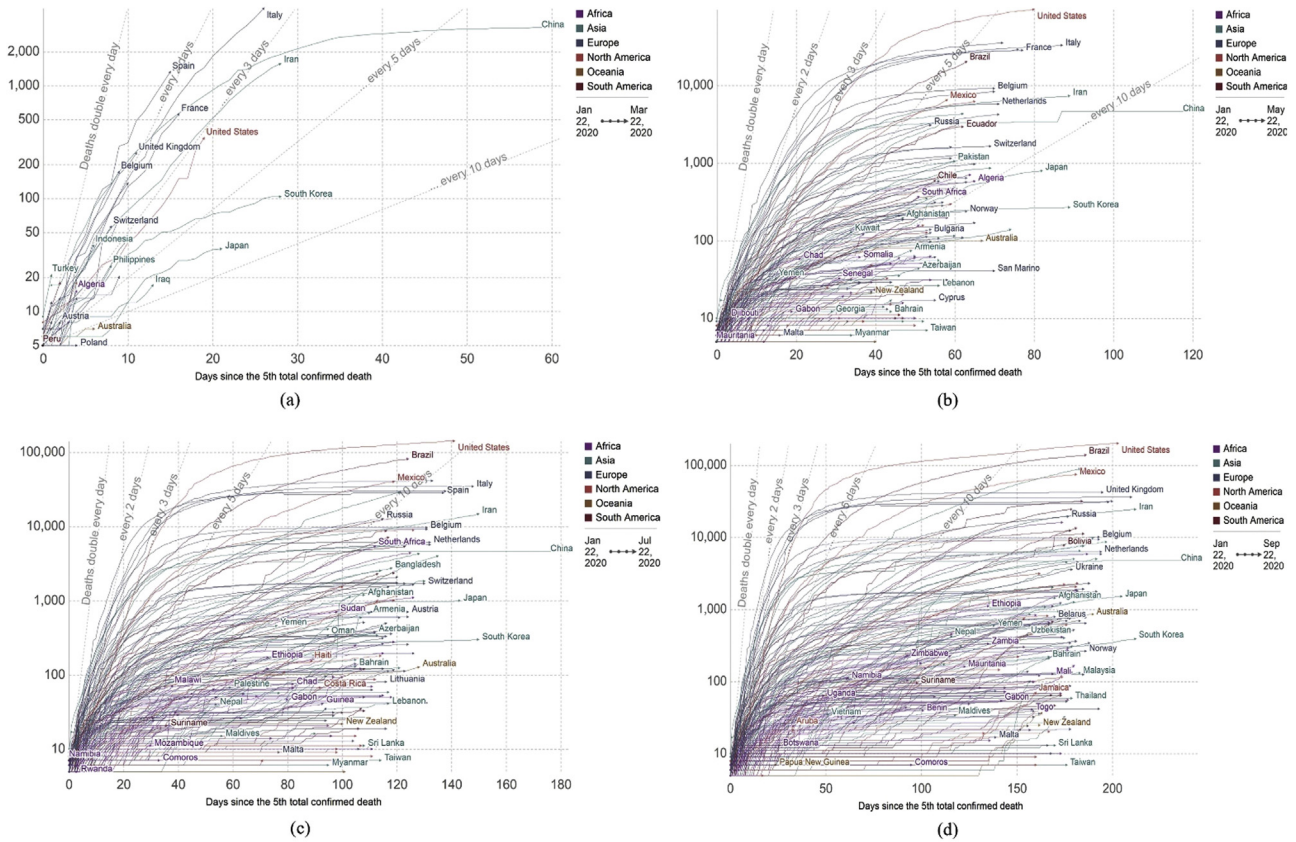
Figure 10.1 Total confirmed COVID-19 deaths in two-month periods from January 22 to September 22, 2020. (A) From January 22 to March 22; (B) from March 22 to May 22; (C) from May 22 to July 22; and (D) from July 22 to September 22. (*Modified after* Our World in Data.[10])
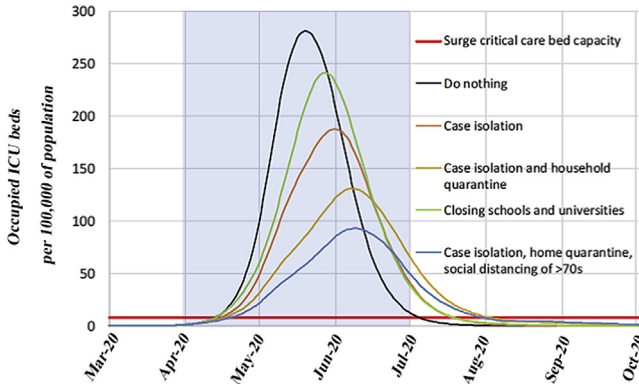
Figure 10.2 Intensive care unit (ICU) bed requirements in Britain with and without mitigation strategies. Modified after Ferguson et al. [4]

raising mortality.[16] Therefore, it is of utmost importance to evaluate the accurate time and duration of social distancing policy to be effective; further, the use of multiple interventions is required to diminish the transmission rate. In addition, the effectiveness of different strategies critically depends on society's response and acceptance, which varies in different countries.[4,14] COVID-19 has had a profound impact on different socio-economic aspects and posed the fundamental question of what the most effective and sustainable policies are to contain its spread.

The Swiss cheese model of COVID-19 prevention called "Swiss Cheese Respiratory Pandemic Defense" sketched by the Australian virologist, Ian MacKay, is very effective in analyzing the reasons for countries' failure and success in controlling COVID-19. According to this model (as shown in Fig. 10.3), COVID-19 prevention is based on several principles as layers including social distancing, mask wearing, regular hand washing, rapid and accurate testing to diagnose people infected with COVID-19, ventilation, quarantine, proper information, government funding, and ultimately vaccination. These layers are complementary to each other and must exist together to help control and prevent COVID-19 because none of these methods of prevention is absolute and certain.[17,18] Based on this important model, the strategic role of herd immunity, quarantine, social distancing, and masking was challenged by various governments.

This chapter reviews the experiences of different countries, including successes and failures, in preventive and health policies against the COVID-19 pandemic to compare their effectiveness, feasibility, and affordability.
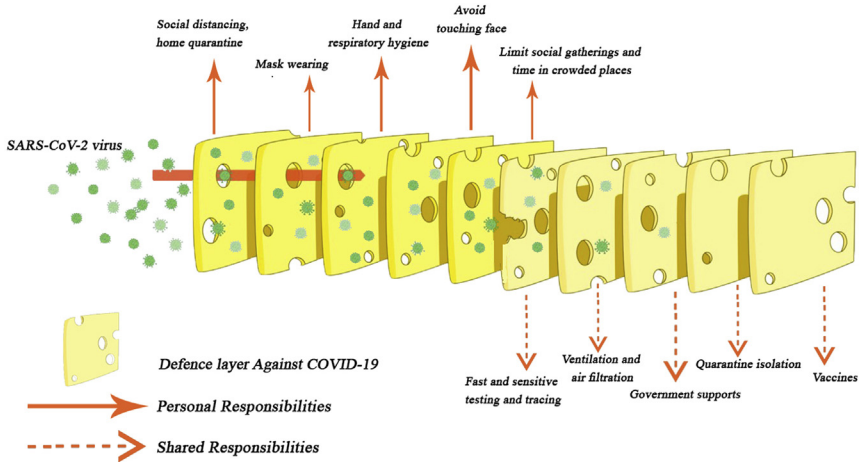
Figure 10.3 Multiple layers of Swiss Cheese Respiratory Pandemic Defense developed by Ian MacKay. (*Modified after Roberts.[17]*)

10.2 Herd immunity approach

The story of herd immunity seems to go back to the work of American veterinarians who observed contagious abortion in cattle and sheep. As a result, ranchers slaughtered and sold affected cows, but George Potter, an American veterinarian, realized in 1916 that this was the wrong solution and proposed the theory of herd immunity. He had the idea that by keeping the cattle immune, raising the calves, and preventing new cows from entering, the herd would be protected. In the same way, further work was done until the researchers achieved the concept of herd immunity. In 1919, Topley created an epidemic in the mice population and found that the growing prevalence of immune individuals would put an end to an epidemic if there was no continued influx of susceptible mice. In 1923, Topley and Wilson defined the phenomenon as "herd immunity."[19] In 1924, Dudley established herd immunity to humans. Dudley prefaced his report in 1934 entitled "Active Immunization against Diphtheria" with photos of "the human herd" and "bacterial herds." Finally, in 1935, Topley stated a broader concept of herd immunity.[19] Topley explained that herd immunity, in addition to involving safety distribution, also determines the social factors that affect herd exposure.[19]

The concept of "herd immunity" increased after 1990 when health officials sought to achieve acceptable levels of universal vaccine coverage. As the world tackles with the COVID-19 pandemic, some countries are

urging people to follow the wrong herd immunity policy to get sick or killed in pursuit of herd immunity. Herd immunity is a key concept for pandemic control in that only part of the population should be immune to an infectious agent to prevent the spread of the disease from person to person. As a result, not only those who are immune but also the whole community are protected against the disease. According to Marc Lipsitch,[20] the fundamental principle of herd immunity is how many safety people are needed in the population and how many people are immune to the infection. Usually, a percentage of people should be susceptible to the disease, which is called the herd immunity threshold. The number of susceptible individuals in a community should be low; otherwise, if the portion of vulnerable persons in a population is too high, herd immunity cannot be achieved. Therefore, the pathogen spreads and its prevalence increases.[20] In conclusion, herd immunity occurs when immune individuals are above the threshold; consequently, the susceptible individuals receive indirect protection against infection. In this regard, the herd immunity threshold relies on a factor, namely the basic reproduction number (R_0) or the effective reproduction number (R_e or R_t).[21] R_0 relates to the average number of secondary infections caused by only one infected person entering a highly susceptible population. Herd immunity threshold (P_{crit}) is mathematically expressed as $1 - 1/R_0$. It can be found that for instance, if $R_0 = 4$, the herd immunity threshold is 0.75.[22] This means that more than two–thirds of the population need to be immune.

According to a published study by the Italian Institute for International Political Studies (ISPI) (Fig. 10.4), as of May 4, 2020, 12 countries concentrated the highest mortality rates, while the prevalence of COVID–19 remained quite low and certainly far from the required share for herd immunity (between 70% and 80%). The results showed that Belgium, which tops the list, had only 84% (with 6.2% of R_t) of its population needed to be immune, while in Sweden—without mandatory lockdown measures—was even 60% (with 2.5% of R_t) of the population. In the major EU countries including Italy, UK, France, and Spain, 70%–80% (with 3%–4% of R_t) of population needed to be immune. Related to Germany and Portugal with R_t of less than 1% was utterly different and the whole population needed to be immune. According to ISPI estimates, acceptable emissions in the 12 countries affected by the virus can never exceed 7%, and in almost all cases remain below the 5% threshold.[23]

The three developed countries, Britain and the Netherlands, and especially Sweden, have dealt with the pandemic COVID–19 with a soft
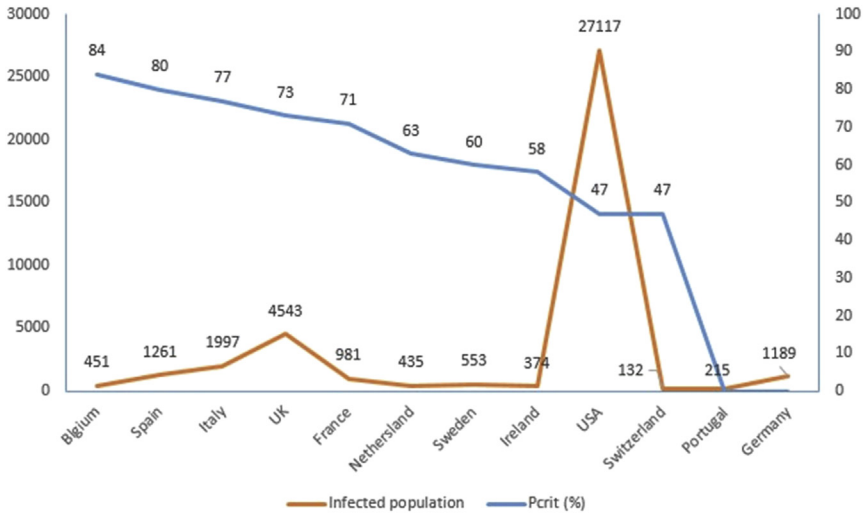
Figure 10.4 As of May 4, 2020, the countries with the highest P$_{crit}$. Belgium (84%), Spain (80%), Italy (77%), UK (73%), France (71%), the Netherlands (63%), Sweden (60%), Ireland (58%), USA (47%), Switzerland (47%), Portugal (0%), and Germany (0%).[23]

approach and had no lockdown. In contrast, these countries had voluntary compliance and the use of masks. Though the COVID-19 strategy was risky, the government of Sweden believed that with a herd immunity approach it could curb the current pandemic. Britain and the Netherlands, after observing the rapidly increasing trend of deaths, the delayed countrywide lockdown was adopted.[24] However, Sweden was faithful to its method of implementation and continued it. In late March 2020, Sweden abandoned the herd immunity policy and decided to take active interventions to control the infection. Most educational centers were closed to learners, travel limitations were enforced, remote working was urged, and prohibitions on parties of more than 50 were endorsed. Contrary to herd immunity, the prevalence in Stockholm, Sweden in April 2020 was reported to be less than 8%.[25] As of May 2020, the rate of positive antibody testing in Sweden was estimated about 15%, which did not reach public safety at all, while the death rate was more than 556 deaths per million. This was 4.5 times more deaths than its Nordic neighbors (e.g., Denmark).[26,27] Iran, as the first country of COVID-19 confirmed in the Middle East, also used a herd immunity strategy due to the poor economic conditions resulting from US sanctions and internal mismanagement. The Institute for Health Metrics and Evaluation (IHME) predicts that if a herd immunity

strategy is pursued in Iran, around 110,000 deaths in the country will be estimated by February 1, 2021.[28] Currently (as of December 13, 2020), the death toll is 51,949.[2]

Hunter and Pankhania[29] still believe that other European countries should not pursue Sweden's pattern because risk remains a major factor. Pankhania stated, "Because the new virus is circulating and we do not know what it does, we cannot test the herd immunity."[29] Herd immunity is only possible when people can be safely vaccinated, thus ensuring that a large number of people are protected.[30] However, the researchers said that this strategy failed in Britain and other European countries but could be successful in poor countries such as India due to the disproportionate population of young people would face less risk of hospitalization and death. They also acknowledged that by spreading the virus compared to European countries such as Italy, it could limit the coronavirus death toll, as 93.5% of the Indian population is under 65 years old. Herd (population) immunity strategy in less developed countries, due to the impossibility of social distancing in crowded environments, the lack of test kits to detect contagions, and the human suffering that occurs in lockdowns, indicates that in these regions a different route is needed.[31]

In a recent correspondence published in The Lancet, more than 80 researchers warned that herd immunity is a dangerous and erroneous method that is not supported by scientific evidence.[32] Studies conducted in June and July 2020 showed that herd immunity is a questioned methodology. Antibody studies performed in Spain and Switzerland showed a low seroprevalence of less than 10%.[33] Critics have unanimously argued in light of recent findings that any proposed method of herd immunity through natural infection is both immoral and unfeasible. However, advocates of herd immunity have remained. Some researchers believe that antibodies are not necessary because of durable T-cell immunity by the SARS–CoV-2 virus.[34] Others think that if the most vulnerable people in a communal are infected first, they will be able to achieve herd immunity after encountering only 20% of the population. While only a few months remain until possible vaccination as the main hope for controlling the pandemic, there are currently no ideal options other than social distancing, hand hygiene, and the use of masks, as well as quarantine. However, it is well known that these containment measures can harm both the public's physical and mental health and long-term economic disruption.[35] Bhopal[16] examined herd immunity from another perspective and encouraged the use of population immunity.

Bhopal believes that 40%—50% of the population immunity is enough to eradicate the COVID-19 pandemic. Bhopal explicitly thinks that confirmed immunity is crucial, particularly in young people or children.

Vaccines cannot be the only hope as they may be effective only for a short period, particularly if new strains of the virus develop. However, this is just a change of concept and does not eliminate the essence of the problem.[16] In conclusion, Adhanom, the WHO director, finally acknowledged on October 22, 2020 that the population (herd) immunity approach that some countries have taken to combat the COVID-19 epidemic is completely immoral. Adhanom also stated that population immunity is achieved by protecting people from the virus, not by exposure.[36]

Contrary to the herd immunity perspective, Kenyon[37] achieved a herd immunity strategy called "flattening the curve." After analyzing 65 countries, Kenyon proposed the current solution to control the spread of infection through the community. The flattening-the-curve strategy is a kind of gradual affliction of people that can cause reduction of the burden in hospitals and help the economic situation and, subsequently, prevent further complications and mortality. This plan requires the observance of principles such as mask wearing, physical distancing, hand washing, and avoiding mass gatherings.[37]

As a result, by the time a vaccine is available worldwide, many people will die from COVID-19 before they can reach immunity. Overall, instead of having faith in herd immunity, governments should rely on extensive testing, tracking, and treatment of the disease, along with strict rules of social distancing, mask wearing, and quarantine of patients—an experience that has already had a successful impact in several countries.

10.3 Lockdown and quarantine

As COVID-19 can reach and infect any age group at any place and time, strict restrictions should be applied, and one of the forefront of these restrictions is lockdown.[38] Many countries applied and adopted lockdown policies because of the lack of vaccination.[39] He et al.[40] defined the lockdown city when all the following preventive measures were enforced: (I) ban of reopening of unnecessary commercial activities at the community level; (II) prohibition of excessive gatherings by city dwellers; (III) restrictions on the movement of personal vehicles and public transport.

WHO recommended strict lockdown to diminish the reproduction rate of infection.[41] Therefore, "Complete Lockdown" has been adopted by many governments across the world as a measurement to prevent COVID-19 spreading.[42] Lockdown was implemented in Europe, and the well-known example is Italy, being the first country executing a nationwide lockdown.[43] The whole Italian territory was under lockdown restrictions in February 20, 2020.[44] Table 10.1 illustrates the measurement of the quarantine levels by the spent hours per person in the public/day. The Italian government also considered different average household sizes, including large average households of six persons, medium average households of three persons, small average households of two persons, and single-person households. Their model predicted 43 new infections within two weeks for a large household (six persons) and zero secondary cases for a single-person household over the same period.

New Zealand reacted swiftly to the COVID-19 epidemic, which included a severe lockdown that effectively disrupted COVID-19 transmission by the community. However, this success has had significant economic and social effects (e.g., psychological distress).[45] Spain is one of the most affected countries, which announced the national lockdown on March 14, 2020. According to the results of an ecological study, the lockdown period in Spain showed that it took approximately 18.33 days to reduce the mortality rates. Even with the national lockdown, some communities such as Catalonia and Aragon experienced an increase in the daily mortality rate of more than 20%, reaching a maximum value of 34% in the daily death rate in Catalonia. Higher rates in these communities were probably associated with higher population density and by the higher mobility before lockdown.[46] In April 2020, almost all schools, universities,

Table 10.1 The effectiveness of quarantine based on the degree of adherence to quarantine.

Quarantine level	Definition	Hours/day
Complete noncompliance	Individuals do their every-day outdoor activities (i.e., working, shopping, etc.) without restrictions.	10
Medium quarantine	Restricts every-day out-of-household activities to 50% of normal.	5
Complete quarantine	No out-of-household activities at all.	0

industries, and activities were prohibited in Milan. This lockdown was also extended to Germany, Spain, and France to prevent the rapid spread of COVID-19.[47] Some countries had to use excessive force and teargas against the violators of lockdown law as happened in Kenya.[48] Recently, Systems Dynamics models were used to simulate and evaluate different quarantine periods. This model was applied for a population of 100,000 inhabitants to simulate three different scenarios as illustrated in Table 10.2.[49] It was found that the three types of quarantine were effective in lessening infection numbers compared to no quarantine. Nevertheless, scenario II and scenario III could be the best approaches because these scenarios will not negatively affect the capacity of available hospitals.

The stress on the health and administration sections is a major problem for accommodating a large number of patients in a short period with the symptoms of COVID-19.[50] Following social distancing and lockdown restrictions as the major factors in reducing the spread of COVID-19,[51] Ambikapathy and Krishnamurthy[52] assessed the lockdowns for 4, 14, 21, 42, and 60 days as intervention strategies in India. They observed that reductions in the transmission of COVID-19 were detected in 21 days and more significant reductions for 42 days. Extending further to 16 days might not result in the positive effect on transmission. The success of lockdown can be measured on certain parameters. Table 10.3 illustrates these major parameters according to Krishnan et al.[53]

Singapore recorded its first case on January 23, 2020, almost at the same time as the US. Outside of China, Singapore had the strongest contact with Wuhan, China, so it could have been the most threatened by COVID-19, however, the outbreak of COVID-19 in Singapore has been one of the slowest in the world. In the early days of the COVID-19 outbreak,

Table 10.2 Different quarantine scenarios implemented by the Italian government.

Scenario	Initial day	Final day	The initial day of the second lockdown	Final second lockdown
I. Long lockdown	25	85	—	—
II. Two shorts lockdown and one smart	25	55	85	115
III. One medium lockdown and one smart	25	65	66	106

Table 10.3 Parameters of lockdown measurements according to Krishnan et al.[53]

Parameters	Explanation
1. Flattening the curve	• Means that fewer people need treatment at any time. • Guarantees that the infected cases who need to be hospitalized remain below the capacity of the health care system.
2. Reducing the growth rate of new cases	• Helps decision-makers evaluate the effectiveness of containment by making sure it reaches its peak or the number of new items in a downtrend. • Indicate a negative growth rate.
3. Containing the spread of COVID-19	• Prohibiting spread to newer and rural areas during lockdown.
4. Improving health care capacity	• The lockdown period assists to ease the burden on the health care system and provides an opportunity for the government to use the time to build the additional capacity needed to reopen.

Singapore conducted simulations that highlighted the combined efforts of quarantine, social distance from school, and work stoppages to slow down COVID-19. However, Singapore did not immediately implement a national lockdown, and continued to recommend a social distance, which was easily enforceable. Almost four months after the first case was recorded, Singapore was experiencing a second wave of SARS-CoV-2 infections, leading to an official nationwide lockdown that took place on April 28, 2020. The key to Singapore's success in controlling the COVID-19 epidemic, in addition to timely action, can be attributed to its dynamic and strong economy.[54] The economic situation and management in Singapore are not comparable to poor and low-income countries like African countries. In a study, Kuguyo et al.[54] found that lockdown in African countries during the COVID-19 period should not be an option. Poverty has been a major barrier to being affected by the national lockdown in South Africa, a situation that is reflected in most other African economies. The lockdown period slows down the transmission of society and leads to the identification of infection clusters. Unfortunately, this containment policy was not possible for Africa's ailing economy.[54]

As the outbreak of COVID-19 started in Wuhan city, China, the Chinese government locked down one-third of its cities. The government

did not enforce a complete lockdown but implemented tailored measures such as the closure of schools and factory shutdowns.[42] A recent study found that Wanzhou, China succeeded in effectively controlling the spread of COVID-19 to disrupt the transmission chain by including social distancing, extensive contact tracing, mask wearing, extensive testing, and strict quarantine. If these containment measures had not been implemented, the number of infections per day could have reached a peak of about 39,000 by January 30, 2020, leading to about 560,000 infected people in the city.[55] During the lockdown in Scotland, they adapted the strategy of "Test and Protect." This approach included: (1) testing people, (2) tracing contacts, and (3) quarantining infected people or those exposed to the virus.[35] Another successful story took place in Germany where a protocol of systematic contact tracing was developed. They could keep the mortality rate low and control COVID-19 spreading.[56] A latest research compared the spreading of COVID-19 between the complete lockdown countries and bordering countries applying social distancing procedures only.[57] It confirmed the absence of any effects of COVID-19.

Sweden (in Europe) and Taiwan (in Asia) are examples of countries that managed the outbreak of COVID-19 without enforcing a lockdown. However, two completely different stories emerged, one successful and the other almost defeated by negligence. For instance, in Sweden, the government relied on the awareness of the citizens. Hence, the citizens are asked to keep social distancing in public places and stay at home if they were sick. As mentioned in the previous section, the Swedish government followed a deadly soft COVID-19 strategy. Sweden's strategy of not implementing quarantine has not been as effective. Anders Tegnell, a chief epidemiologist for the Swedish public health authority who architected the herd immunity strategy, admitted that many people died by urging his country not to pursue a severe lockdown policy.[58] On the other hand, Taiwan, or Chinese Taipei, an island attached to China, achieved a significant victory over COVID-19. Taiwan, unlike most of the countries that undertook strict lockdown, was able to prevent severe lockdown throughout the country with basic measures. Nevertheless, the keys to Taiwan's great success can be traced back to: (1) quick preparation, timely action; (2) border control, travel restrictions, and finding suspicious items: enforcing strict rules in the first few days for travelers, especially the Chinese; (3) timely allocation of resources, which led to the cessation of exports of masks and medical equipment, so increased production of masks in the country; and (4) communication and policy-making measures,

including timely and accurate information and prevention of rumors. The key to Taiwan's success is the government's "rapid preparedness and timely action," which is the result of the country's previous experience in fighting the 2002−2004 SARS outbreak. There is also a centralized command center for crisis management called the National Health Command Center (NHCC) that provides data and information seamlessly to officials and experts. On the other hand, the very special feature of the Taiwanese people is to follow the government regulations as the main factor that complemented the decisions and timely actions of the NHCC. Surprisingly, Taiwan has not had any deaths from COVID-19 in the last 200 days, and has recorded a total of 733 cases and 7 deaths so far (as of December 13, 2020). As a result, Taiwan has shown how to learn well from past experience and quickly overcome the crisis. Taiwan became the most successful country in the confrontation of COVID-19 by taking timely, fast, and principled measures and employing skilled and experienced teams of officials.[59,60]

It is noteworthy to highlight that lockdown cannot be imposed forever. The factories cannot be closed and the vehicular movement cannot be restricted for a long time.[61] As the number of infected COVID-19 cases starts to decrease, governments decided to finish the lockdown. Therefore, governments and policy–makers should plan sustainable strategies to continue regular lifestyle after the COVID-19 period. The criteria that governments should follow to lift lockdown include: (1) controlling the transmission of infection; (2) accessing the health system to identify, test, isolate, and ultimately treat the infection; (3) minimizing the risk of vulnerable areas such as nursing homes; and (4) protective measures for essential places such as workplaces and educational institutions, and control of the potential risk of newly imported infections.[62]

Extended periods of lockdown are not recommended because it will increase economic and social issues.[63] However, it was noticeable that lockdown had a positive effect on the environment.[64] During the lockdown across the world, people started to observe a clear blue sky and seas. The effect of lockdown restrictions has been studied and evaluated on the quality of water and air. Fig. 10.5 summarizes the positive impact of lockdown due to COVID-19 on the environment. The first study to demonstrate this positive impact on surface water quality in India was performed by Yunus et al.[65] They found that suspended particulate matter (SPM) in the Vembanad Lake in India decreased by 15.9%, which reflected the enhancement of surface water quality. Mandal and Pal[66] detected an improvement in the water quality of the Ganga River during
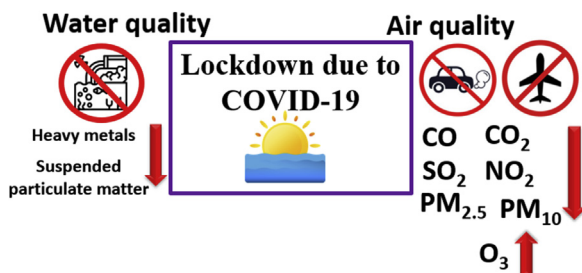
Figure 10.5 Lockdown effects owing to COVID-19 on water and air quality.

the lockdown by 40%−50%. Total dissolved solids (TDS) concentration was reduced from 2457 to 987 mg/L and biological oxygen demand (BOD) was <2 mg/L. Depellegrin et al.[67] evaluated the effect of lockdown by studying the human–marine environment interactions and design innovative approaches that can enrich ecosystem-based management of marine resources.

In 2016, WHO reported that air pollution is responsible for around 8% of total death in the world.[68] Air Quality Index (AQI) is usually used to express the magnitude of air pollution of a region according to $PM_{2.5}$, PM_{10}, CO, SO_2, NO_2, and O_3. It categorizes the air quality into six categories from Good (0−50) to Severe (more than 401).[61,69] A recent article estimated the air pollution concentrations through the lockdown in 34 countries using satellite data and a network of more than 10,000 air quality stations.[70] It was found that NO_2 and $PM_{2.5}$ concentrations were reduced by 60% and 31%, respectively. He et al.[40] estimated the effect of lockdown on AQI across China's cities which decreased 19.84 points. It was found that $PM_{2.5}$ was lowered by 14.07 $\mu g/m^3$ in the locked-down cities. The same behavior was detected in other cities without lockdown due to preventive measures. Wang et al.[71] recorded the average of AQI was decreased from 89.6 points to 71.6 points with 20% reductions after the breakout of COVID-19 with imposing some restriction measures. Dantas et al.[72] found that CO emission levels reduced during the partial lockdown with 30.3%−48.5% in Rio de Janeiro, Brazil. Berman and Ebisu[73] indicated a 25.5% reduction of NO_2 compared to historical data and also an 11.3% reduction in fine particulate matter ($PM_{2.5}$). In Italy, the lockdown led to a significant drop in SO_2 levels only in the city of Milan.[74] In India, the most polluted megacities were based on the environmental performance index in Delhi. Since 2011, $PM_{2.5}$ and PM_{10} concentrations are very high and they are beyond the tolerable limits followed by NO_2, SO_2, and CO.[69]

With the onset of the second wave of COVID-19 in Europe, possibly driven by Belgium and the Czech Republic, as of October 30, 2020, European countries have been forced to reimplement quarantine laws to combat COVID-19.[75] The following are some cases: Ireland became the first European Union country to impose a quarantine that allowed people to travel only 5 km from their place of residence. Restrictions imposed in Ireland are among the most severe restrictions in Europe.[76] France announced a general quarantine until December 1, 2020, which might be extended until January. Schools and universities continue to operate under these restrictions, but family members cannot accommodate more than one person. Quarantine was reintroduced in Germany with less intensity than in the spring, as well as the current situation in France.[77] Belgium was the last country to join the convoy of European countries that imposed a national quarantine for the second time. During the new quarantine, which was almost identical to that in France with a duration of 45 days, citizens were not allowed to invite more than one family member to their home and were allowed to leave the house only in groups of up to four people.[78]

In South America, Brazil had a sad story. President Jair Bolsonaro continued to pursue wrong policies, ignoring the danger of an epidemic, and false sense of immunity. At the beginning of COVID-19, Bolsonaro likened the virus to "little flu" and insisted that Brazilians were "immune" to it and had nothing to worry about. In April 2020, Bolsonaro fired the then Brazilian Minister of Health for supporting policies of physical distancing and social quarantine. Bolsonaro saw the damage to quarantine policies and social distancing as worse than COVID-19 and was concerned about the country's economy. The deteriorating situation in Brazil reached a point where in mid-June 2020 the number of COVID-19 cases passed 1 million.[79]

Iran was one of the failed countries at the beginning of the epidemic. Iranian officials identified the city of Qom as the outbreak of the disease, which was announced on February 19, 2020, but Iranian President Rouhani prevented it from being quarantined, calling it a relic of the pre−World War I era. Rouhani considered the recent sanctions imposed by the Trump administration as the main reason for not implementing the quarantine, which creates more fundamental problems for the Iranian economy by creating a quarantine. Rouhani stated that his government did not intend to impose a lock on the eve of the Iranian New Year holiday, March 20, 2020, and there was no such thing at all. Although Rouhani did not believe in quarantine, he attended all meetings in accordance with

health protocols and often by video conference.[80] After the virus spread to other cities, the government kept roads to the north of the country open despite requests from local authorities to restrict traffic. The armed forces took further action after many Iranians refused to follow official instructions to prevent the spread of the virus.[81] Finally, as of March 13, 2020, with the deteriorating situation and the increase in the COVID-19 confirmed to more than 11,300 cases, the first quarantine was officially announced by the Iranian government.[82] The quarantine did not last long and eased off after a while. Unplanned policies have led to an increase in the number of patients in recent months and the loss of health care workers. The IHME had predicted that daily mortality would increase in the coming months, peaking at around 825 daily in mid-December, forcing Iran to reapply quarantine.[28] Unsurprisingly, in the face of a new rise in the number of COVID-19, Iranian authorities have ordered hundreds of cities across the country to impose a variety of severe restrictions, again from November 21, 2020. In the month before the quarantine, about 400 deaths were reported daily.[83]

As a result, the decision to use the lockdown must be carefully considered in all respects to indicate a reduction of new COVID-19 cases considering its negative impact of the sudden removal of the lockdown without precautions. The findings presented here emphasize the importance of early and critical decision-making to control the epidemic by considering the negative side effects of lockdown.

10.4 Physical or social distancing

The respiratory viruses are usually transmitted via mucosalivary droplets produced during speech, sneezing, and exhalation.[84] In addition, the transmission of respiratory disease occurs via two routes, namely, droplet route, for large droplets, that assumes they fall on external surfaces and contaminate them, and aerosol or airborne route, for small droplets of less than five microns, that assumes their inhalation. For this reason, COVID-19 is assumed to spread by both direct contact and droplet transfer while the airborne transmission is still under debate.[85] Accordingly, keeping a suitable physical distance between different persons is assumed to effectively reduce COVID-19 transfer by both airborne and droplet transmission. This physical distance, or what is called "social distancing rules," is being now applied in many countries to decrease or prevent the risk of COVID-19 spread.[86−88]

COVID-19 outbreaks in environment are most common when people are outdoors, traveling, in restaurants and catered events, schools and institutional settings, as well as health care facilities settings. Several socio-environmental measures like social distancing and stay-at-home rules has already been taken to manage this crisis and have shown positive results.[89] It means to keep physical distance of at least about two arm's length among individuals which is established as a safe space between individuals. Exact measure of social distancing designate of staying at least 6 feet away from each other, in every aspect of public and professional domains. With respect to environmental health, social distancing offers a very strong and powerful preventive measure against transmission of COVID-19 virus in near vicinity, which ultimately lowers down the possibility of its transmission.[90] The main reason to enforce social distancing is to prevent the contact with infected people and contaminated surfaces. A recent study by researchers at the University of Texas at Austin of COVID-19 outbreaks in 58 Chinese cities found that places that took longer to implement social distancing spent more time with the rapidly expanding virus. The results of the analysis showed that every day that a city is delayed in social distancing measures after the onset of the first case, the duration of the outbreak is increased by 2.4 days.[91]

The droplet size concept could be useful to differentiate the large droplets and small airborne fine particles. It is known that respiratory system infections are caused by exhaled air containing a wide range of droplet sizes. This interval of droplets sizes varies from visible (millimeters) to invisible ones (microns). However, social distancing rules refer to the risk of droplet spread to isolated comparatively large droplet releases only. Accordingly, if COVID-19 is only transferred by large droplets, this would indicate that the risk will be reduced by applying shorter physical distancing. It has been reported that infected peoples with COVID-19 caused high rates of secondary infection to people of close contact with them. This infection was likely to occur within 1—2 m.[92−95] According to the previous assumptions, the WHO has suggested the policy of 1-m social distance.[85] Nonetheless, other countries have applied their own policies. For example, Spain and Canada are now implementing a 2 m distance rule. Similarly, the UK recommended the 2 m rule but it is still under review.[96] The social distance should be appropriate and flexible since too short distance increases the risks, whereas too long distance could be disruptive to society.

10.4.1 Origins of two-meter rule

Studies concerning the transmission of droplets while speaking or when sneezing or coughing have started since in the 19th century by using air samples cultured on agar or glass plates.[84,97] Flugge assumed that approximately 2 m distance is safe based on the fact that samples over this distance usually contain droplets with pathogens.[98] Turner et al.[99] presented some visual representations of these emissions. Subsequently, Hamburger and Robertson[100] reported that 65% of the total participants (48 people) produced large droplets, and only <10% of these droplets traveled about 1.7 m. In contrast, in 10% of participants, the "hemolytic streptococci" bacteria were collected 2.9 m away. These findings reveal the scientific basis of the rule of 1–2 m distance.[101]

However, different distances were used by different studies. A meta-regression conducted by Chu et al.[102] who found that as the distance increases the strength of association becomes larger. It should be noted that 172 studies were analyzed in this systematic review and 44 studies of them are considered as comparative studies with about 25,697 patients, with COVID-19, SARS, and MERS. The main results indicate that a large reduction in infection was associated with social distancing of at least 1 m. On the other hand, it was clear that distances of 2 m might be more effective.

The main conclusions that can be withdrawn from these studies are:
- The 2 m social distancing rule assumes that large droplets falling on surfaces are the dominant routes of transmission of COVID-19.
- Smaller droplets (airborne) contaminated with COVID-19 could spread up to 8 m. These small droplets are concentrated in the exhaled air resulted from infected individuals.
- The risk of COVID-19 transmission increases as the physical distance between people decreases, so for indoor settings, even 2 m might be too close.[103]

Consequently, social distancing should be used in conjunction with other approaches to reduce transmission. These strategies include adapting ventilation to indoor spaces, air hygiene, regular surface cleaning, effective hand washing, and using face masks in addition to fast isolation of affected individuals. It is now familiar that COVID-19 transmission occurs primarily by people having symptoms as well as those who have not yet developed symptoms. This transmission occurs when infected and noninfected people

are very close together for long periods. However, since persons who never develop symptoms can transfer the virus to others, more studies are needed in this area.

10.4.2 COVID-19 transmission prevention

The main aim of the "Strategic Preparedness and Response Plan" is to control COVID-19 by preventing or reducing its transmission and the associated illness and consequently death.[104] WHO recommends a comprehensive set of measures to prevent COVID-19 transmission. These measures include:

*   Identify of all suspect, test, and isolate all cases of infected people as quickly as possible using appropriate facilities.
*   Identify and quarantine all infected individuals in close contact. Then testing the people who develop the symptoms and isolating them in case of infection and needing more care.
*   Use face masks in public places where physical distancing is not possible.
*   Health workers caring for COVID-19 patients should use all precaution including the use of a medical mask to prevent their infection.
*   The frequent use of hand hygiene, keeping suitable physical distancing, and respiratory etiquette should be always practiced. In addition, people should avoid close–contact surroundings and crowded enclosed spaces with poor aeration. Finally, proper ventilation in all enclosed environments and the use of appropriate cleaning and disinfection for the environment should be always applied.[105]

The main conclusions of the above discussion support the application of physical distancing of 1 m or more. In addition, the optimum use of face masks, respirators, and eye protection in public and health care settings should be applied. Moreover, accurate and randomized trials are needed to better inform the evidence for these interventions.

10.5 Mask wearing

Historically, using face masks by people in public places has been a common action for controlling the pandemic of respiratory diseases. For instance, the 1918 H1N1 influenza pandemic,[106,107] 2002, and 2003 SARS epidemic in Asia, and the COVID-19 pandemic in Taiwan.[108] Wearing a mask by a susceptible person is led to infection prevention. Furthermore, if an infected person wears a mask, the face mask prevents the transmission of infection to susceptible people.[109,110] To prevent COVID-19 transmission,

the WHO has recommended wearing a mask, according to published guidelines on June 5, 2020. In this recommendation, the governments should encourage people to mask wearing in public places where social distancing is not achieved, as a plenary approach to stop COVID-19 transmission. Many Asian countries have used a face mask much before the guideline setting, while most European countries have reserved face masks for COVID-19 patients, and health care staff.[13]

Using surgical masks assist in decreasing the risk of COVID-19 transmission. In general, face mask wearing has less effect on the control of seasonal respiratory infections. Although, in such a severe pandemic in which there is no definite antiviral drug, face masks can significantly prevent pandemic transmission.[111] Wearing a face mask and observing social distancing can be more impressive in control of COVID-19. Face mask wearing in combination with social distancing with an efficiency of around 50% and observing by just 30% of the population can lead to a decreasing of COVID-19 load considerably. According to a mathematical modeling, the physical distancing processes should carry on to the elimination of COVID-19 in late 2021. Otherwise, the second devastating wave will occur.[112] In a study, three factors were investigated in masks, including rate of aerosol reduction, public coverage, and availability to evaluate the influence of wearing ordinary medical masks in community through combination of mathematical modeling and existing scientific data to struggle over the COVID-19 pandemic. It shows that mask wearing in addition to social distancing has a positive effect to reduce the epidemic.[113]

Due to the beginning of the COVID-19 pandemic and increasing the information on transmission, everyone recognizes the importance of mask wearing in the prevention of transmission and considers it a strong cover against the spread of SARS-CoV-2. Some masks work better than others to help slow the spread of the virus that causes COVID-19. This last depends on the fabrics used and, most important, how the mask is made (such as the type of fabric, the number of layers of fabric, and how well the mask fits). Is there a strong reason why using multiple layers of a face mask is more effective in preventing transmission than a simple layer face mask? To clarify this, more research is needed in the upcoming. However, face shields also may be considered an alternative to mask. Wearing a mask with social distancing and frequent hand washing are effective in prevention of transmission, not alone. The efficiency of several commonly used face masks was studied by laser light and simulation of cough. This study showed that two-layer homemade face masks prevent the respiratory drops.

Therefore, they are recommended for the public. However, the medical staff should wear surgical or N95 masks. Well-fitting is an important issue in using face masks to leach the respiratory droplets form around the face. Multilayered masks with waterproof outer layer have the best efficiency in minimizing virus spread. However, the most urgent and important act in COVID-19 pandemic control is wearing a mask beside hand washing and social distancing.[114,115] A modeling study showed that even face masks with 20% efficiency are useful. Wearing a mask in public has a significant effect on limiting transmission of the pandemic. The universal approval of face mask wearing besides the physical distancing has community-wide benefits.[116] It should be noted that people think mask wearing protects them, but the main objective is to protect others from respiratory droplets because of asymptomatic transmission of the coronavirus.[117] Airborne transmission in the spread of COVID-19 is reduced significantly using mask wearing. For instance, in Italy and New York City 78,000 fewer in a month and 66,000 fewer infections within three weeks, respectively.[118]

Three things determine in the effect of mask wearing: the duplication of the virus in a society, the efficiency of masks in blocking, and the number of wearers. If masks with an efficiency of 60% wear by 80% of people, the reproduction rate of the virus gets to less than 1. In Hong Kong, 80% of people wear a mask in public places, in Israel, Singapore, and the Czech Republic wearing masks in public places has been legally regulated.[119] Face mask wearing rate by Hong Kong Special Administrative Region (HKSAR) population was 96.6%. Hence, the COVID-19 prevalence in HKSAR (129 per million person) was lower compared to some other countries from December 31, 2019 to April 8, 2020.[11] Fig. 10.6 shows shares of Singapore's citizens who have worn masks in public places from February to September 2020 during the COVID-19 pandemic.[120]

The centers for Disease Control and Prevention (CDC) issued new guidance to wearing face masks where close contact is unavoidable between people in public places. Italy, Germany, France, South Korea, Spain, and China have enacted laws to enforce face mask rules in public areas.[121,122] China, because it is the world's largest manufacturer of personal protective equipment (PPE), made it relatively easy for them to make masks. It was also very good for the Chinese to readily adopt mask wearing because of their experience in the previous epidemic.[123] By contrast, the United States refused to wear masks even in June and July, when it was on the rise. Even in late September 2020, President Trump ridiculed Joe Biden's mask wearing as a weakness.[123] However, between April 8 and May 15, 2020,
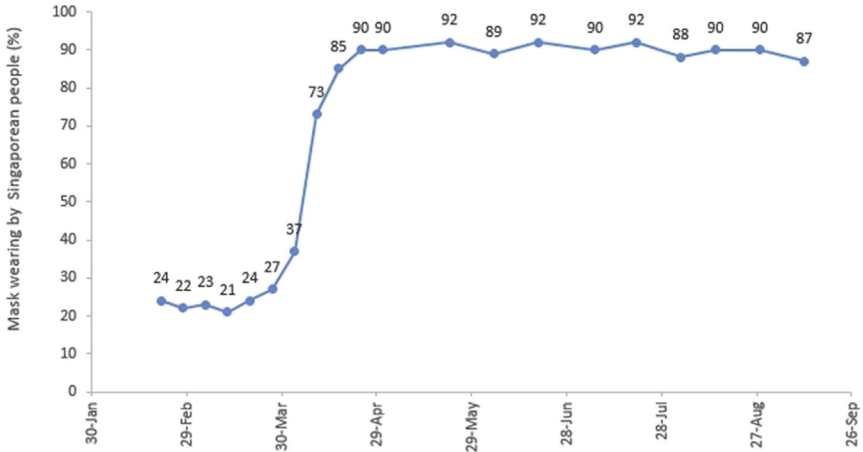
Figure 10.6 From February to September 2020, the participation of Singaporean who used face masks in public places during the COVID-19 pandemic. *(Modified after Statista.[120])*

mask wearing had been mandated in public places where possible social distancing may not be observed in 15 states in the US. The effect of mandating mask wearing in public place showed a significant decline in the COVID-19 growth rate.[124] In Hong Kong, only four deaths have been reported within the COVID-19 pandemic period. Notwithstanding high density, mass transportation, and closeness to Wuhan city. Taiwan reported only six deaths as well due to mandating the population to wear a mask in public places. The country could control the pandemic, and schools have been opened since late February 2020.[119] An observational cohort study by Salvatore et al.[125] examined the possibility of intrauterine mother-to-child transmission as well as breastfeeding during the COVID-19 epidemic at three Presbyterian Hospitals in New York City, United States. In this study, mothers used surgical masks and practiced proper hand hygiene. One hundred sixteen mothers were tested positive for SARS–CoV–2 and 120 neonates were examined. All neonates were tested in the first 24 h and it was observed that none were infected. Eighty-two (68%) neonates were followed for five to seven days of life, of which 68 (83%) neonates were in the same room with breastfeeding mothers, and the test was repeated for 79 (96%) neonates, all of whom were negative. Seventy-two (88%) neonates were tested after 14 days of life, all of which were negative. None of the neonates had COVID-19 symptoms. This study demonstrated the potential role of mask wearing for mothers when near their neonate.[125]

According to the Ipsos survey of 28,000 participants in early April 2020 found that 81% of respondents used a face mask because of COVID-19 epidemic. Data revealed that Vietnam had the highest number of people wearing masks due to the COVID-19 (91%). The survey indicated that people in Asian countries, including Vietnam, China, Japan, and India, performed better than most European countries. Western authorities have been slower in advising to cover their faces to prevent the spread of the coronavirus. Facial masks became mandatory in some parts of Italy in early April, which also reduced the prevalence of the disease. However, in several German states, this practice was only mandatory in congested settings. According to the results, only 20% of Germans had used this kind of mask by April 12th, 2020. The use of the mask was mandatory in seven US states, and after the CDC recommendation in early April 2020, it was encouraged in many countries, and as a result, 50% of Americans have at least tried it. France also recommended the use of masks throughout the country, and 34% have tried them out.[126] The countries of the Eastern Mediterranean Region (EMR) had different knowledge and risk perception of COVID-19, so that the use of masks varied from 6% to 83%.[127] As of November 3, 2020, Iran (628,780), Iraq (478,701), Saudi Arabia (348,037), and Morocco (222,544) have the highest total number of confirmed COVID-19 cases in the EMR. In these countries, the use of masks has been around or even less than 50%. These countries used the wrong policy to create a culture of mask wearing in society. Not wearing enough masks in the whole population was an important reason for the substantial increase in the number of COVID-19 cases in such countries.[128] According to the IHME, if wearing mask in Iran increases to 95%, rendering to the pattern that existed in Singapore and several countries in Latin America, the number of predicted deaths will be close to 68,000 and can be about 13,900 people rescued. That is about a 29% drop in the number of deaths predicted from now until February 1, 2021.[28]

Although Japan is one of the first countries to be infected with COVID-19, it can be considered another strong model in reducing the number of people with COVID-19 infection. Despite Japan's large elderly population and premature infection, infection and death rates are among the lowest in the world. The main reason for this is Japan's strong mask culture, which reduces the COVID-19 to controllable levels.[129] Japan currently (as of September 22, 2020) has about 80,000 cases; in contrast, about 90% of them have recovered, indicating a high level of prevention and mask wearing by them nationwide.[2] Also recently, the Advanced

Telecommunications Research Institute International in Kyoto, Japan took a creative step to deal with the possible third wave of COVID-19 in the country, and by launching a robot called "Robovie" in stores which detected people who do not use a face mask and warn them of other COVID-19 guidelines.[130] In Czechia, which made it mandatory to wear a mask while in public, as of May 24, 2020, there were only 8932 confirmed COVID-19 cases and 315 deaths, making it one of the least infected countries in Europe. Czechia government, like most countries, faced a shortage of masks early in the epidemic, but people began to make masks with unprecedented collective effort, not just for hospitals but also for everyone. In some areas, people created "mask trees" where they would put available additional masks that were up for grabs for others. The order to use the mask—jointly with neighboring Slovakia—quickly became a symbol of the Czechia struggle against the epidemic.[131] As of September 22, 2020, the infection rate in Czechia has reached 55,000 cases and 555 deaths,[2] which shows the significant impact of mask use in this country. Table 10.4 shows countries with mask-wearing requirements in public places.

Table 10.4 Countries, which have required or recommended masks in public places.

Country	Mask requirement/Date
USA	Part of country
Germany	Full country/April 27, 2020
UK	Full country/June 15, 2020
France	Full country/May 11, 2020
Italy	Full country/May 4, 2020
Brazil	Part of country
Russia	Part of country
Mexico	Full country/May 20, 2020
Spain	Full country/May 2, 2020
China	Universal mask usage
Japan	Universal mask usage
India	Universal mask usage
South Korea	Universal mask usage
Switzerland	Recommends masks
Sweden	—
Norway	Recommends masks
Hong Kong	Universal mask usage
Finland	Recommends masks
New Zealand	Recommends masks
Netherland	Public transport/June 1, 2020
Denmark	Public transport

In Mongolia, one of the low-income countries with the outbreak of COVID-19, people have reacted widely with preventive measures by increasing health and safety behaviors, including the use of face masks. The use of face masks has been widely used and seen since February 2020 in most places such as streets, workplaces, and especially in markets and health centers. This led to the emergence of home fabric face masks as the demand for face masks increased. As of mid-February, the Mongolian government had required most organizations and businesses to wear masks. Mongolia, with a low number of infected cases—after 7 months after the pandemic, only 313 infected cases—showed that having strong prevention systems such as wearing a mask as a culture can effectively respond to an epidemic in a low-income or middle-income country.[132] In Inner Mongolia, drones equipped with echoing loudspeakers warned citizens who were not wearing a mask and told them not to talk or walk around without mask wearing.[123] A recent study by Mitze et al.[133] examined the effect of masks on the prevention of COVID-19 in Germany and found that after 20 days of becoming mandatory face masks, the number of new infections have reduced about 45% (between 15% and 75%). In addition, given that the mask has negligible economic costs compared to other public health measures, the mask is a cost-effective means of combating COVID-19. The importance of mask wearing is evident from the recent reports, which concluded that on the first day of COVID-19 infection, the probability of detecting the virus was zero. Even on the fifth day of infection, with symptoms and with a high load of the virus, no more than one-third of cases were diagnosed. As a result, mask wearing is a key parameter even with a negative test.[134]

In conclusion, wearing a mask can be an acceptable NPI to decrease efficiency of transmission for the viral respiratory diseases transmitted through aerosol and droplets, although masks should not be an alternative for social distancing and hand washing. Therefore, countries should introduce a compulsive policy and express the advantages of mask wearing.

10.6 Conclusion

Within a month or two of the onsets of COVID-19, it was often supposed that like other viruses (e.g., MERS and SARS), COVID-19 would have fewer deaths. The herd immunity approach often adopted by the Nordic countries (e.g., Sweden) failed because they did not achieve the expected immunity (above 60%) at all. On May 4, 2020, Belgium topped the list,

exposing only 6.2% of its population to COVID-19, which is not expected to exceed 7%. Similarly, in July it was observed that the prevalence in Spain and Switzerland is less than 10%. However, other researchers believe that applying this strategy to low-income countries (e.g., India) might be responsible due to its high youth population.

Enforced lockdown was one of the measures taken by most countries during this epidemic period. In February 2020, Italy became the first country in Europe to adopt a nationwide lockdown policy. They adopted quarantines based on the population of the household, which was effective in reducing the prevalence of the disease. Gradually, different scenarios including (1) long lockdown, (2) two short lockdowns and one smart, and (3) one medium lockdown and one smart were implemented in different countries. Social distancing of 1 m is another precautionary measure proposed by WHO guidelines, while governments have each adopted their own policies in this regard. Canada and Spain, for example, required a social distance of 2 m, which could be even higher in closed areas due to the faster transmission of infection. Currently, reports of deaths indicate that some Asian countries such as Japan, South Korea, Singapore, China, and Hong Kong are smarter than most European and American countries in taking measures such as testing and tracking individuals, lockdown hot spot areas, mask wearing, and social distancing. In most epidemics, mask wearing as a protector dramatically reduces the transmission of infection. Mask wearing will be about 50% effective if accompanied by social distancing. Hong Kong is one of the most successful countries in this field and almost 80% of people use masks in public places, so it is considered as a culture among the people. Taiwan with its ideal management has been a very successful example of how society responds quickly to crises and a protector worthy of the interests of its citizens. The low number of deaths and infected cases in this country compared to other countries shows their performance well.

At the same time, vaccines with high immunization efficiency are developed making COVID-19 vaccines available on a global scale requires the use of complex production techniques, scrupulous quality control and trustworthy distribution channels that ensure the vaccines are effective and accessible to all human kind. Based on experiences of the countries involved with COVID-19, this chapter suggests that current pandemic prevention policies are including isolating individuals, maintaining a social distancing of about 2 m in crowded places, and wearing masks to prevent transmission of infection is the best solution needed by all countries, which should be institutionalized as a culture among them. As of the writing of the

chapter (mid–December 2020), there are about 72.1 million cases and about 1.61 million deaths, bringing the epidemic level of the disease to the level of syndemic. Therefore, what scientists have learned so far from COVID-19 indicates that the story behind the disease is not as simple as other epidemics. This shows to protect the health of our communities, an even more subtle approach is needed. In a crisis, governments often make difficult decisions under hesitation and time constrictions. These decisions must be culturally appropriate and sensitive to the people, and the utmost important task that governments must have is to be honest with their people in providing information.

Acknowledgments

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