Review Article

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Epidemiology of COVID-19

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Abstract:

Acknowledging the epidemiological parameters is essential in the control of coronavirus disease 2019, which has been declared a pandemic by the World Health Organization. To define the macroscopic behavior and control of the disease in the society, the incubation period, serial interval, reproductive coefficient, doubling time of the infection, growth rate, curve flattening index, case fatality rate, and the rate of asymptomatic cases should be well known.

Keywords:

Coronavirus disease 2019, epidemiology, pandemic

Introduction

The world faced its first international threat to the health of the 21st century in 2003 with the outbreak of the disease named severe acute respiratory syndrome (SARS). SARS, which emerged first in China but then spread rapidly to Asia, North America, and Europe, caused 800 deaths in around 30 countries. On December 31, 2019, cases of pneumonia with an unknown etiology were reported in the city of Wuhan in the Hubei province of China.[1] On January 7, 2020, the causative agent of the disease was defined as a new coronavirus (2019-nCoV) that was previously unknown in humans. The disease was subsequently named coronavirus disease 2019 (COVID-19) and the agent as SARS-CoV-2 due to its similarity to SARS-CoV.[2]

The World Health Organization (WHO) declared an "international public health state of emergency" on January 30, 2020,[3] and a global pandemic on March 11, 2020, following the spread of COVID-19-113 countries other than China and due to the wide dissemination and severity of the outbreak.[4]

Infection chain in coronavirus disease 2019

Origin of infection

SARS-CoV-2, the agent underlying the disease, has the typical characteristics of the coronavirus family and is from the Betacoronavirus 2b lineage. It is a single-stranded enveloped RNA virus with positive polarity.[5]

The infection origin of the disease is currently unclear. According to the first epidemiological research in Wuhan, the majority of patients in the early stages of the disease were found to have a history of visiting or working at a market selling seafood and live animals. The obtained data pointed to wild animals being sold illegally at the Huanan Seafood Wholesale Market.[6]

Routes of transmission

Following the first cases, the main route of transmission was through direct human-to-human contact. The route of transmission of SARS-CoV-2 resembles that of influenza, being spread mainly by droplets. When an infected person coughs, sneezes, or speaks, the virus can transmit to another person if the virus in the respiratory secretions of the first person comes into direct contact with the mucosa of the latter. A person can also contract the disease if they

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touch their mouth, nose, or eye mucosa after coming into hand contact with droplets spread by an infected person through coughing or sneezing. It is estimated that the droplets can reach a distance of up to 2 m.[5,7]

Information on a transplacental transmission is insufficient. In a study of a small sample of women in the third trimester of pregnancy with a confirmed coronavirus infection, no evidence was found of transmission from the mother to the child. All of the women in the study gave birth by cesarean section, hence the lack of information on transplacental transmission.[8] In another study, maternal viremia was observed to be around 1%, and no SARS-CoV-2 was detected in cord blood.[9]

The RNA of SARS-CoV-2 was detected in the blood and feces samples of the patients.[10-12] No significant fecal-oral transmission of the infection can be demonstrated, although live virus samples have been isolated from fecal cultures.[13]

SARS-CoV-2 has been demonstrated to be viable in experimentally produced aerosols for at least 3 h, although the effect of this on the epidemiology and clinical results of COVID-19 is indeterminate.[14,15]

The transmission of SARS-CoV-2 infection varies according to some individual factors, such as the type and duration of contact with a person carrying the virus, the use of protective measures, and the amount of the virus in the respiratory secretions of the carrier.[7] There are some important unknown factors that are yet to understand related to transmission, including the duration of incubation and transmission, the viral load, the incidence and transmission capacity of asymptomatic cases, the transmission routes other than via droplets, and the duration of virus infectivity outside the body.[5,7]

Most secondary infections occur as a result of household contact and in health-care workers.[16,17] Other high-risk groups are those living in institutions providing long-term care.[18] The results of COVID-19 epidemic research involving the 3700 passengers and crew aboard a ship leaving the Yokohama Port of Japan revealed that the infection spread quickly in closed environments.[19] Nevertheless, nonhousehold transmission risk through close contact has been emphasized in case clusters reported after attending social gatherings or business meetings.[6]

The follow-up of contacts in the early phases of the diseases in various locations revealed that secondary infections were mostly attributable to household contacts with a secondary attack rate of around 10%.[20-22] The second wave rate of COVID-19 in various environments has been reported to be 1%–5% in China in a common report of the WHO and China. Most of these occurred among those with household contacts, with a secondary attack rate of 3%–10% in those with household contact.[23] The symptomatic secondary attack rate in the United States was found to be 0.45% and 10.5% among 445 people who came into close contact with 10 confirmed cases and among household contacts, respectively.[19] In a similar study performed in South Korea, the secondary attack rate was reported to be 0.55% and 7.6% among all contacts and household contacts, respectively.[21] Clusters of cases have been reported after family, business, or social gatherings where close personal contact was possible.[22,24]

The risks of more distant transmission through indirect contact (such as in encounters with an infected person on the street and using items belonging to an infected person) are not well established and possibly very low.[6]

The transfer of the virus from a sick person who is asymptomatic to another person is seen in COVID-19. This situation is defined as transmission during the presymptomatic phase.[25]

Viral load is also emphasized in transmission, knowledge of which is increasing. Viral load was found to increase immediately after the onset of symptoms in a study of symptomatic patients. Viral load is suspected to be higher in the nose than in the throat. It is very rare to see a viral load in asymptomatic patients in the amounts found in symptomatic patients.[26]

Environmental SARS-CoV-2 contamination was declared to be excessive in the hospital rooms of patients with COVID-19.[27] In a study in Singapore, viral RNA was detected on almost all surfaces (doorknobs, light switches, bed and safety rails, inside doors and windows, toilet bowl, and washbasins) tested in the infection isolation room of a mildly symptomatic COVID-19 patient. Based on data from studies of other coronaviruses, the duration of viral persistence on surfaces is likely to be dependent on the ambient temperature, relative humidity, and dimension of contagion.[28]

Host

Everybody who has not had the disease should be considered sensitive. The spectrum of infection is broad and varies between asymptomatic cases to severe respiratory and other organ failures. Severe cases were more common among patients of advanced age and with high comorbidities.[5,6,29]

The rate of the presence of known risks in individuals aged <10 years and 10 years or above was 6.7% and 13.7%, respectively, in a screening study evaluating the

presence of symptoms, travel history, and history of contact with a patient carried out in Iceland, where the disease first emerged at the end of February amid the present pandemic of COVID-19. The seropositivity rate was found to be 0.8% in the group aged 10 years and above, while no seropositivity was encountered in the younger age group. In the same population screening study, women were found to be positive for the risks mentioned above less commonly than men (11% and 16.7%, respectively). Similarly, the rate of seropositivity was found to be 0.6% and 0.9%, respectively.[30]

Epidemiological parameters of the disease

The challenges faced in the control of COVID-19 originate from the epidemiological parameters of the disease, being the duration of incubation, and the fact that carriers can transmit the disease to others without presenting with any symptoms, or even knowing that they have the disease. The rate of asymptomatic cases is also important.[31]

The incubation period, serial interval, reproduction coefficient, infection doubling time, growth rate, curve flattening index, case fatality rate (CFR), and the rate of asymptomatic cases should be well known in order to define the macroscopic behavior of the disease in society and to take it under control.

Incubation period

The incubation period is relatively long in COVID-19, being generally 5–6 days, and longer in some studies.[31-34] The incubation period of the disease has been reported to vary between 4.8 (2.2–7.4) and 6.5 (5.9–7.9) days in the studies.[32,33] In a meta-analysis including 57 of 1675 studies due to repetitions, the mean incubation period was calculated to be 5.84 (99% confidence interval: 4.83–6.85) days.[34]

Serial interval of the infection

This refers to the time between successive cases, starting from the first case, and is lesser than the incubation period. The serial interval was determined to be 4–8 days in the study mentioned above. The duration of the contagiousness of the infection was reported to be 7.5 days.[34]

Reproductive rate

This is defined as the spread rate of an infectious disease to the society. The reproductive coefficient (R_0 coefficient), which is an important epidemiological parameter that is used to define the contagiousness or the ability of transmission of the disease, was 1.95 in Hubei in the first calculation of the WHO.[35] The highest rate of R_0 reported to date is 14.8 on the Ruby Princess cruise ship outbreak before protective measures.[36] The R_0 of the disease is generally considered to be between 2.0 and 2.8, although variable reproduction rates have been reported.[37]

Doubling time of the patient number

The doubling time of the patient number has been obtained from three studies published to date and is estimated to be between 6.4 and 7.4 days and between 2.6 days and 4.6 days according to two preliminary studies.[34] It is possible to see the effects of protective measures on the doubling time of the patient number. The doubling time is short in Italy, the United Kingdom, and the United States but is quite long in South Korea and Japan [Figure 1].

Growth rate

This term indicates the growth rate of the number of cases. A positive growth rate is bad, and a negative rate is good. A continuous drop in growth rate over time and keeping the rate in this negative area indicates controlled progression. Growth rate is calculated using the following formula:[38]

$$Gt=(At-At-1)/At-1$$

A (number of active cases) = cumulative case – death – cumulative treated case; t: day.

Curve flattening index

The curve flattening index is a measurement of how well a country has flattened the pandemic curve over time. It is an index showing changes in the growth rate over time. A curve in the positive area means that the growth rate dropped during that period. This index is calculated using a formula. This index covers the entire timeframe of the pandemic. Positive values are interpreted as good and negative values as bad in this index.[38]

Case fatality rate

Different formulae have been used for the evaluation of the fatality rate. The most commonly used formula for the evaluation of fatalities is case fatality. Case fatality is calculated as follows:

CFR = current total deaths/current confirmed cases.

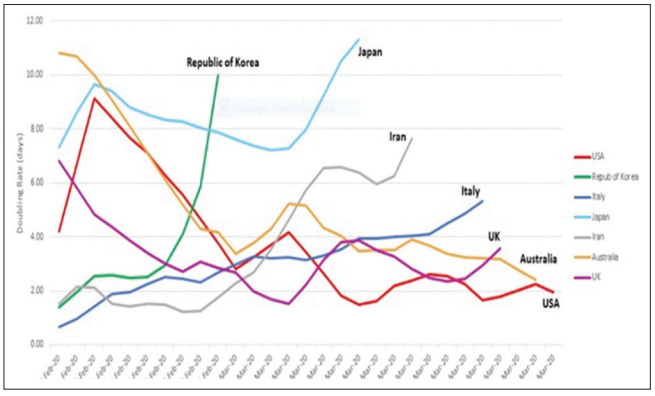

Figure 1: Doubling time of the infection in various countries (from the World Health Organization data)

One criticism of this formula is that it is insufficient, since the number of deaths and cases is unclear in an ongoing pandemic.

The diagnosis of a viral infection occurs days to weeks before recovery or death, and so the number of deaths should be compared to the previous number of cases. There is an alternative formula that takes into account this delay and estimated CFR. The alternative formula (since the pandemic is continuing) is as follows:

CFR: Number of deaths on day X/number of cases on day X-T, T = mean duration from confirmation of the case to death; this cannot be zero.[38]

Significant differences have been demonstrated between countries in fatality rates. The raw fatality rate of COVID-19 varied between 2% and 15% in China.[29]

The total CFR was reported to be 11% and 15% in the first analyses performed on a relatively small number of confirmed cases by a laboratory in Wuhan in January.[6] Most recently, a review of 44,672 patients revealed a total case fatality of 2.3%,[38] which is very low when compared to the results of previous analyses. The CFR is 8% among the 70–79 years' age group, 14.8% among the 80 years and above age group, and 49% in critically ill patients.

CFR has been reported to be higher among those with chronic diseases (10.5% in cardiovascular disease, 7.3% in diabetes, and 6.3% in chronic respiratory diseases) compared to 0.9% in those with no chronic disease. The majority of children with COVID-19 have been reported to develop mild symptoms such as fever and cough, and the outcome was generally recovery in another study involving children.[39]

The real results of these issues will be learned after the end of the outbreak.

A comparison of the epidemiological characteristics of COVID-19 and other viral infections with a similar clinical picture is presented in Table 1.[40]

Trends of manifestations of coronavirus disease 2019 in the world and in Turkey

These numbers related to the disease will change since the pandemic is ongoing. The latest figures released by the WHO were 1,991,562 diagnosed cases and 130,885 deaths in 206 countries, reported on April 15, 2019. The countries with no reported cases are North Korea, Lesotho, Tajikistan, Turkmenistan, and Yemen (https://covid19.who.int/). The countries where the disease is seen the most are the United States (395,090), Spain (146,690), Italy (139,422), Germany (108,202), China (83,095), France (81,095), Iran (66,220), the United Kingdom (60,737), and Turkey (83,117). The cumulative daily number of cases and deaths from COVID-19 released by WHO regions is presented in Table 2.[41] An epidemiological map demonstrating the incidence rate in the last 7 days is presented in Figure 2.

The first case in Turkey in the COVID-19 pandemic was seen on March 11, considerably later than in some European countries and Iran. The total number of cases in Turkey as of April 15, 2020, was 69,392, and the total number of deaths was 1518. As of March 10–April 7, 2020, the cumulative and a daily number of cases and deaths between March 11 and April 7 in Turkey are presented in Figure 3.[41,42]

The growth rate in Turkey is still positive, although there is a declining trend [Figure 4]. A number of cases

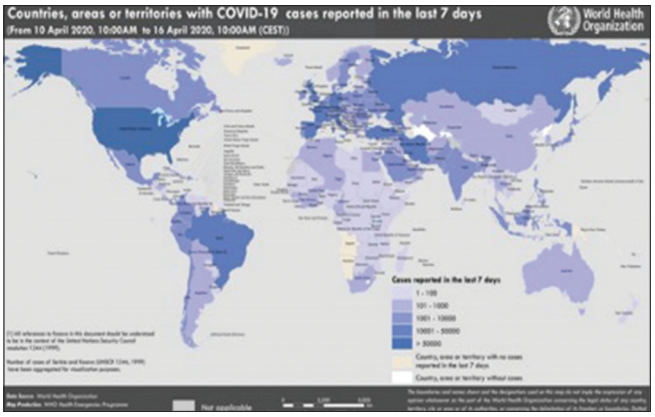

Figure 2: COVID-19 incidence rates of countries in the last 7 days (https://covid19.who.int/)

Table 1: Comparison of COVID-19 and other similar viral infections

	Disease			
	COVID-19	SARS	MERS	Flu
Pathogen	SARS-CoV-2	SARS-CoV	MERS-CoV	Influenza
Reproductive rate, R_0	2.0-2.5	3	0.3-0.8	1.3
Fatality rate (Case/death)	3.4%	9.6-11%	34.4%	0.05-0.1
Incubation period (days)	4-14	2-7	6	1-4
Possibility of transmission to others (%)	30-40	10-60	4-13	10-20
Hospitalization rate	19%	Most cases	Most cases	2%
Annual patients	Unknown	8098 (in 2013)	420	~1 billion

SARS-CoV: Severe acute respiratory syndrome-related coronavirus, MERS-CoV: Middle East respiratory syndrome-related coronavirus

Table 2: Cumulative and daily number of cases and deaths from COVID-19 by World Health Organization regions

	Cumulative case with diagnosis	Daily case*	Cumulative death	Daily death*
Europe	1,013,093	35,497	89,317	4710
America	707,121	33,760	30,245	2909
West Pacific	125,571	1367	4239	38
East Mediterranean	111,432	4043	5532	137
Southeast Asia	21,790	1503	990	54
Africa	11,843	477	550	27
Total	1,991,562	76,647	130,885	7875

*Data as of April 15, 2020

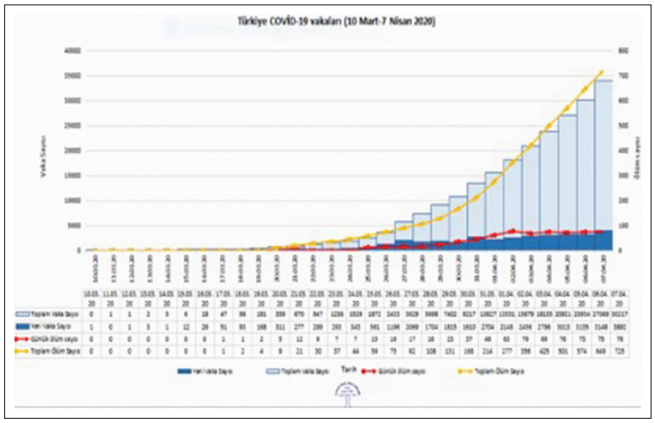

Figure 3: Cumulative and daily number of cases and deaths between March 11 and April 7 in Turkey[i]

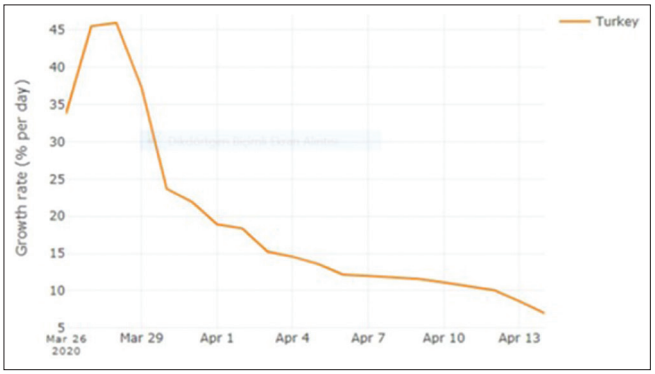

Figure 4: Growth rate of COVID-19 in Turkey between March 11 and April 13

have steadily increased; however, the continuous decline in the growth rate can be interpreted as controlled progression.[38]

Current data can be obtained from the https://www.who.int/emergencies/diseases/novelcoronavirus-2019 website of WHO and from the https://www.seyahatsagligi.gov.tr/Site/koronavirus website of the Turkish Health General Directorate of Borders and Coasts.

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Conflicts of interest
There are no conflicts of interest.

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