REVIEW ARTICLE

The Impact of Quarantine, Isolation, and Social Distancing on COVID-19 Prevention: A Systematic Review

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Abstract

Background: The new Corona virus disease (COVID-19) appeared in Wuhan, China in December 2019. Methods, such as quarantine, isolation, and social distancing, if implemented properly, can help prevent the transmission of the disease. This study aimed to examine the effects of quarantine, isolation, and social distancing on the prevention of COVID-19.

Methods: In this systematic review, EMBASE (Elsevier, 2018), MEDLINE (National Library of Medicine, 2018), Scopus, ProQuest, Web of Science (Clarivate Analytics, 2018b), and Google Scholar databases were searched for the studies published prior to 10 April 2020. The search and data extraction were conducted by two authors and to check and control the quality of the articles, we used the Newcastle-Ottawa checklist.

Results: Based on the inclusion criteria, 24 out of the 768 primarily screened studies were finally assessed. Studies showed that the short-term negative psychological effects of quarantine included frustration, boredom, anger, and confusion. Nonetheless, extending the adult quarantine period to 18-21 days could be effective in preventing the spread of the virus and controlling the disease. Moreover, the decision to control the people's travels through restrictions on freedom of movement must be balanced regarding the estimated epidemiological impact and the expected economic outcome.

Conclusion: Although isolation, quarantine, and social distancing all have challenges, they are very useful methods for controlling the disease, which can be best used by knowing their duration of implementation.

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Introduction

Corona virus disease (COVID-19) appeared in Wuhan, China, in December 2019. The disease was quickly spread to Hobby province and has now spread to all Chinese provinces. It spread to 203 countries by 4 April 2020. At first, it was thought that the new corona virus was similar to Severe Acute Respiratory Syndrome (SARS), inhaled by droplets, with a similar incubation period and R0 value. SARS looked scary at the time, even scarier than the COVID-19,[1,2] due to the very severe progression to more serious diseases and death. The world was able to completely cut off human-to-human transmission and stop the epidemic, and now SARS has been eradicated. In the absence of vaccines and antivirals, this significant achievement was made possible by the strict implementation of traditional public health measures.[3] To date, we are faced with a viral outbreak that

currently has no specific treatment or vaccine. To control the epidemic of this respiratory disease, we must trust the classic measures of public health. The main purpose of these public health measures is to prevent the spread of the disease from person to person by isolating individuals to cut off the transmission chain. The measures that can be used in this regard include isolation, quarantine,[4] and social distancing.[5] In public health, 'quarantine' refers to the separation of individuals or communities who are at risk of an infectious disease. This method is one of the oldest and most effective measures for controlling the spread of infectious diseases.[6] In contrast, 'isolation' refers to a way to separate the people who are infected with the disease.[7] 'Social distancing' has also been widely used to reduce interaction between the society members, in which individuals may be infected but have not yet been identified and are, therefore, not yet separated. Because disease transmission through respiratory droplets requires special closeness, increasing the social distance can reduce the transmission.[8] All these measures are currently being used on an unprecedented scale in China.[3] Governments around the world have also implemented quarantines and travel bans on an unprecedented scale. China has quarantined the entire cities, and Italy has imposed severe restrictions across the country. There are also thousands of home quarantined people in the United States. Quarantine and travel bans have often been the first response to new infectious diseases.[9, 10] However, these old measures have been considered to be very limited for highly communicable diseases and, if not implemented properly, cannot help prevent the transmission of the disease. In the case of the SARS-CoV-2 virus, this method may not be useful enough.[7]

Considering what was mentioned above, the present study aimed to examine the effects of quarantine, isolation, and social distancing on reduction of the prevalence of COVID-19.

Methods

Search Strategy and Study Selection

This systematic review was conducted on the studies published prior to 10 April 2020 reporting the consequences of quarantine, isolation, and social distancing on COVID-19 by searching EMBASE (Elsevier, 2018), MEDLINE (National Library of Medicine, 2018), Scopus, ProQuest, Web of Science (Clarivate Analytics, 2018b), and Google Scholar databases using the search strategy presented in Supplement 1. The selected keywords for international databases included "Novel Coronavirus Pneumonia", "Quarantine", "Hospitals, Isolation", "Social Isolation", "Patient Isolation", and "Social Distancing". The collected data were entered into the EndNote X7 software, and duplicate articles were automatically deleted.

Data Extraction

The search and data extraction were conducted by two authors (MV and FG). Discrepancies and doubts about the relevance of the sources were solved through consultation with the corresponding author (HGh). The corresponding PRISMA flowchart has been depicted in Figure 1.

Eligibility Criteria

We included all published articles that reported the impact of Quarantine, Isolation, and Social Distancing on COVID-19 prevention prior to 10 April 2020. The records were excluded if they met the following

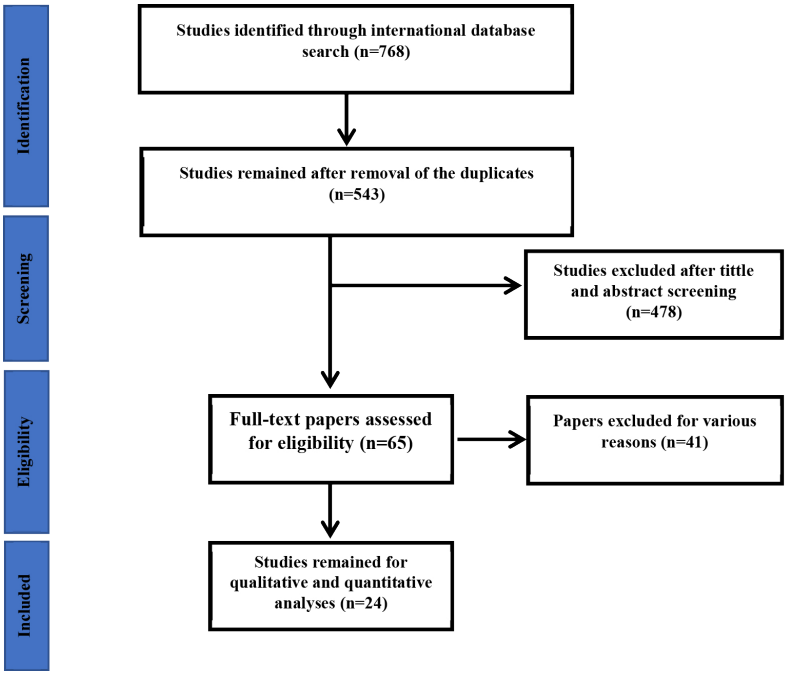

Figure 1: The process of deleting the articles obtained from the search in scientific bases and selecting the 24 articles in question

criteria established prior to the search: opinion pieces, reviews reporting no new data, studies investigating a single aspect of COVID-19, and those not available in English. The full text of all articles included in the study was available. The remaining studies were categorized as longitudinal or cross-sectional for qualitative synthesis (Table 1). It should be noted that the systematic review protocol was not registered due to the urgency of the issue and because limited available evidence on the topic was anticipated.

Quality Assessment

To check and control the quality of the articles, we used the Newcastle-Ottawa checklist. This tool consisted of three different parts, including selection (four questions), comparability (one question), and outcome (three questions). The final scores could be divided into three categories as follows: good (three or four stars in the selection domain, one or two stars in the comparability domain, and two or three stars in the outcome/exposure domain), fair (two stars in the selection domain, one or two stars in the comparability domain, and two or three stars in the outcome/exposure domain), and poor (zero or one star in the selection domain, zero stars in the comparability domain, or zero or one star in the outcome/exposure domain).[11] The results of quality assessment are presented in Table 1.

Results

Study Selection

A total of 768 studies were searched, among which 543 were reviewed and 225 duplicates were removed. After title and abstract screening, 478 articles were excluded. In the second screening also 41 articles were excluded because 25 articles had not reported the impact of Quarantine, Isolation, and Social Distancing on COVID-19, 9 articles were review, and 7 articles had reported the impact of Quarantine, Isolation, and Social Distancing on similar diseases COVID-19. On the other hand, six studies were included via a manual search; this left a total of 24 studies for analysis (Figure 1).

This study evaluated the impact of quarantine, isolation, and social distancing on COVID-19 prevention. The outcomes were divided into two groups, including 1- quarantine and isolation and 2- social distancing and travel restrictions, based on the final report proposed by the articles. All included studies are listed in detail in Table 2, and their results were compared in order to find the most qualified studies.

Unlike SARS that occurred in almost all subsequent transmissions following the onset of symptoms, COVID-19 transmission can occur before the onset of symptoms. The available information indicates that secondary transmission of COVID-19 is possible at least two days before the onset of the symptoms.[12] However, transmission efficiency is unclear, and seroprevalence studies are warranted.

Transmission by people without symptoms or with mild symptoms can reduce the strength of the isolation strategy by reducing the likelihood of separation of all cases and tracking all contacts.[13]

Table 1: Newcastle-Ottawa Quality Assessment Form for Cohort Studies

Author (year)	Selection	Comparability	Outcome	Total	Quality
Michele Acton, March/April 2020	3	1	2	6	Good
Siqi Ai, February 5, 2020	3	1	2	6	Good
Asami Anzai, 24 February 2020	3	1	2	6	Good
Matteo Chinazzi, 24 April 2020	3	1	2	6	Good
Zhanwei Du, 5, May 2020	2	1	2	5	Fair
Joel Hellewell, April 2020	3	1	2	6	Good
Xue Jiang, March 18, 2020	4	1	1	6	Good
Joel R Koo, March 23, 2020	3	1	2	6	Good
Jean Christophe Lagier, 12 March 2020	2	1	2	5	Fair
Qianying Lin, 27 February 2020	3	1	2	6	Good
Zhihua Liu, 8 March 2020	4	1	1	6	Good
Andrea Lombardi, 2 March 2020	1	1	3	5	Fair
Elisabeth Mahase, 17 March 2020	2	1	2	5	Fair
Benjamin F. Maier, February 19 ,2020	3	1	2	6	Good
Sandip Mandal, February & March 2020	3	1	2	6	Good
Kenji Mizumoto, 29 February 2020	3	1	2	6	Good
Yixiang Ng, March 13, 2020	3	1	2	6	Good
Ginger E. Nicol, 2020	3	1	2	6	Good
Jinhua Pan, February 23, 2020	4	1	1	6	Good
Rocklöv J, 2020	3	1	2	6	Good
Franz-Josef Schmitt, 25 Mar 2020	3	1	2	6	Good
BiaoTang, 7 February 2020	4	1	1	6	Good
Biao Tang, 6 March 2020	3	1	2	6	Good
Xinkai Zhou, May 8, 2020	4	1	1	6	Good

Table 2: The list of the features of the articles obtained

Number	Authors	Year	Country	Type of prevention	Study duration	Aim of study	Findings	Population	Type of study
1	Michele Acton	March/ April 2020	United Kingdom	Quarantine	On the 26th February 2020	Reducing the impact of quarantine in the Coronavirus	Studies show that the short-term negative psychological impact of quarantine includes frustration, boredom, anger and confusion. Some smaller studies also show that long-term impacts, such as PTSD symptoms, can be a result of quarantine - although they do not always necessarily meet criteria for PTSD diagnosis.	General population	Meeting report
2	Siqi Ai	February 5, 2020	China	City closure policy	January 31, 2020	We examined the effects of population outflow from Wuhan on the 2019-nCoV transmission in other provinces and cities of China, as well as the impacts of the city closure in Wuhan.	Our findings suggest that population movement might be one important trigger of the 2019-nCoV infection transmission in China, and the policy of city closure is effective to prevent the epidemic.	Number of 2019-nCoV cases per unit outflow population	Ecologic
3	Asami Anzai	24 February 2020	Japan	Reduction in travel volume	January and February 2020	Assessing the Impact of Reduced Travel on Exportation Dynamics of Novel Coronavirus Infection (COVID-19)	From 28 January to 7 February2020, we estimated that 226 exported cases (95% confidence interval: 86,449) were prevented, corresponding to a 70.4% reduction in incidence compared to the counterfactual scenario.	confirmed cases with COVID-19 infection diagnosed outside China	Modeling
4	Matteo Chinazzi	24 April 2020	China	Travel restrictions	23 January 2020	The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak	Modeling results indicate that sustained 90% travel restrictions to and from mainland China only modestly affect the epidemic trajectory unless combined with a 50% or higher reduction of transmission in the community.	Cases with COVID-19 infection diagnosed	Modeling
5	Zhanwei Du	5, May 2020	China	Quarantine	January 23, 2020	Risk for Transportation of Coronavirus Disease from Wuhan to Other Cities in China	On January 23, 2020, China quarantined Wuhan to contain coronavirus disease (COVID-19). We estimated the probability of transportation of COVID-19 from Wuhan to 369 other cities in China before the quarantine. Expected COVID-19 risk is >50% in 130 (95% CI 89–190) cities and >99% in the 4 largest metropolitan areas.	Cases with COVID-19 infection diagnosed	Ecologic
6	Joel Hellewell	April 2020	United Kingdom	Isolation of cases and contacts	2020	Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts	The delay between symptom onset and isolation had the largest role in determining whether an outbreak was controllable when R0 was 1·5. For R0 values of 2·5 or 3·5, if there were 40 initial cases, contact tracing and isolation were only potentially feasible when less than 1% of transmission occurred before symptom onset. In Hellewell and colleagues' model, transmission before symptoms, even when the percentage is moderate, at 15–30%, had a marked effect on probability to control	cases with COVID-19 infection diagnosed	Modeling

7	Xue Jiang	March 18, 2020	China	Quarantine	January 1 and February 25, 2020	Is a 14-day quarantine period optimal for effectively controlling coronavirus disease 2019 (COVID-19)?	Data modeling suggested that if adults take an extra 4-day or 7-day of isolation (i.e., a quarantine period of 18 or 21 days), 96.2% or 98.3%, respectively, of the people who are developing symptoms will be more effectively quarantined. Patients transmitted via lunch/dinner parties (i.e., gastrointestinal tract infection through oral transmission) had a significantly longer incubation period (9-day) than other adults transmitted via respiratory droplets or contaminated surfaces and objects (P<0.004).	2015 Covid-19 cases	Modeling
8	Joel R Koo	March 23, 2020	Singapore	Isolation measures for infected individuals and quarantining of family members; quarantine plus school closure; quarantine plus workplace distancing; and quarantine, school closure, and workplace distancing	2020	Interventions to mitigate early spread of SARS-CoV-2 in Singapore	Implementing the combined intervention of quarantining infected individuals and their family members, workplace distancing, and school closure once community transmission has been detected could substantially reduce the number of SARS-CoV-2 infections.	Cases with COVID-19 infection diagnosed	Modeling
9	Jean Christophe Lagier	12 March 2020	France	Quarantine	2020	Testing the repatriated for SARS-Cov2: Should laboratory-based quarantine replace traditional quarantine?	Optimising our procedures reduces anxiety and reassures the population and decision makers.	337 passengers	Epidemiology study
10	Qianying Lin	27 February 2020	China	Travel restriction	24 February 2020	A conceptual model for the coronavirus disease 2019 (COVID -19) outbreak in Wuhan, China with individual reaction and governmental action	We propose conceptual models for the COVID-19 outbreak in Wuhan with the consideration of individual behavioural reaction and governmental actions, e.g., holiday extension, travel restriction, hospitalisation and quarantine.	General population	Modeling
11	Zhihua Liu	8 March 2020	France	Isolation, quarantine, and public closings	31 January2020	Understanding Unreported Cases in the COVID-19 Epidemic Outbreak in Wuhan, China, and the Importance of Major Public Health Interventions	We observe that public health measures, such as isolation, quarantine, and public closings, greatly reduce the final size of the epidemic, and make the turning point much earlier than without these measures.	Confirmed cases and Mortality cases for Wuhan COVID-19	Modeling

12	Andrea Lombardi	2 March 2020	Italy	Isolation and quarantine	2020	Duration of quarantine in hospitalized patients with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection	Isolation of those affected and the use of personal protective equipment (PPE) are the mainstay to block transmission of this pathogen, which is presumed through respiratory droplets. A 14 days quarantine is applied to subjects coming from endemic areas or who had contact with confirmed cases. It is assumed that, if in this period the subject does not develop any sign or symptoms compatible with COVID 19, he is not infected and thus the quarantine can be removed, and the subject returned to the community. Domiciliary quarantine of 14 days since a positive test is applied also for patients with a diagnosed mild disease who did not need medical support.	Confirmed cases COVID-19	answer to question
13	Elisabeth Mahase	17 March 2020	United Kingdom	Social distancing	2020	social distancing after new model points to 260 000 potential deaths in Covid-19	The researchers found that the first plan—combining home isolation of cases and social distancing of people over 70—would lead to a peak over a three to four month period during the spring and summer and would reduce healthcare demand and deaths, but it would still result in 260 000 deaths and a health system unable to cope.	Entire population	NEWS
14	Benjamin F. Maier	February 19 ,2020	China	Isolation and quarantine	20 January 2020 to 10 March 2020	Effectivecontainmentexplainssub-exponentialgrowthinconfirmedcasesofrecent COVID-19 outbreakinMainlandChina	We show that the observed scaling law is a direct consequence of containment policies that effectively deplete the susceptible population. To this end we introduce a parsimonious model that captures both, quarantine of symptomatic infected individuals as well as population wide isolation in response to mitigation policies or behavioral changes. For a wide range of parameters, the model reproduces the observed scaling law in confirmed cases and explains the observed exponents.	confirmed cases of COVID-19	Modeling
15	Sandip Mandal	February & March 2020	India	Restrictions on travel & quarantine	2020	The objectives of this study were to find out if it was possible to prevent, or delay, the local outbreaks of COVID-19 through restrictions on travel from abroad and if the virus has already established in-country transmission, to what extent would its impact be mitigated through quarantine of symptomatic patients?	Port-of-entry-based entry screening of travellers with suggestive clinical features and from COVID-19-affected countries, would achieve modest delays in the introduction of the virus into the community. Acting alone, however, such measures would be insufficient to delay the outbreak by weeks or longer. Once the virus establishes transmission within the community, quarantine of symptomatics may have a meaningful impact on disease burden. Model projections are subject to substantial uncertainty and can be further refined as more is understood about the natural history of infection of this novel virus. As a public health measure, health system and community preparedness would be critical to control any impending spread of COVID-19 in the country.	coronavirus disease 2019 transmission in India	Modeling

16	Kenji Mizumoto	29 February 2020	The Diamond Princess Ship	Quarantine	January and February 2020	Transmission potential of the novel coronavirus onboard the diamond Princess Cruises Ship	Our findings suggest that R t decreased substantially compared to values during the early phase after the Japanese government implemented an enhanced quarantine control. Most recent estimates of Rt reached values largely below the epidemic threshold, indicating that a secondary outbreak of the novel coronavirus was unlikely to occur aboard the Diamond Princess Ship.	Passenger of the Diamond Princess Ship	Epidemiology study
17	Yixiang Ng	March 13, 2020	Singapore	patient isolation and quarantine, active monitoring of contacts, border controls, and community education and precautions	January 2–February 29, 2020	Evaluation of the Effectiveness of Surveillance and Containment Measures for the First 100 Patients with COVID-19 in Singapore	Rapid identification and isolation of cases, quarantine of close contacts, and active monitoring of other contacts have been effective in suppressing expansion of the outbreak and have implications for other countries experiencing outbreaks.	The first 100 cases in Singapore	Report
18	Ginger E. Nicol	2020	Canada	Social isolation	2020	Action at a Distance: Geriatric Research during a Pandemic	Leverage our relationships with participants and rapidly deploy novel clinical engagement techniques such as digital tools to intervene remotely and reduce the negative effects of social isolation on our participants. Equip research staff with tangible resources, and provide timely population-specific health information to support patients and healthcare providers.	Older patients	Report
19	Jinhua Pan	February 23, 2020	China	Quarantine, strict isolation measures AND closure of Wuhan city	19 January to 16 February 2020	Effectiveness of intervention strategies for Coronavirus Disease 2019 and an estimation of its peak time	China's prevention and control measures have made significant inroads into controlling the epidemic of COVID-19, but the complete control has not yet to be achieved. This study found self-quarantine at home should be strictly observed in the future, and that the quarantine level to be maintained at a relatively high level to prevent the possibility of a second outbreak of the epidemic.	Confirmed cases COVID-19	Modeling
20	Rocklöv J	2020	Diamond Princess cruise ship	Isolation and quarantine	21 January to 19 February 2020	COVID-19 outbreak on the Diamond Princess cruise ship: estimating the epidemic potential and effectiveness of public health countermeasures	The cruise ship conditions clearly amplified an already highly transmissible disease. The public health measures prevented more than 2000 additional cases compared to no interventions. However, evacuating all passengers and crew early on in the outbreak would have prevented many more passengers and crew from infection.	Cruise ships passenger	Modeling

21	Franz-Josef Schmitt	25 Mar 2020	Germany and United states	Closed any public events, schools and universities and social distancing	March 10 – March 23	A simplified model for expected development of the SARS-CoV-2 (Corona) spread in Germany and US after social distancing	a reduction in the actual daily new infection rate (actual daily growth rate of reported cases, in short: infection rate) from the current value of 30-35% in the US to 10% would be extremely effective in stopping the spread of the virus. The severe restrictions in Germany which closed any public events, schools and universities a week ago might already have contributed to a reduction of the growth rate of reported cases below 30%.	Germany and US population	Modeling
22	BiaoTang	7 February 2020	China	Travel restriction and quarantine and isolation	10 to 15 January 2020	Estimation of the Transmission Risk of the 2019-nCoV and Its Implication for Public Health Intervention	Under the most restrictive measures, the outbreak is expected to peak within two weeks (since 23 January 2020) with a significant low peak value. With travel restriction (no imported exposed individuals to Beijing), the number of infected individuals in seven days will decrease by 91.14% in Beijing, compared with the scenario of no travel restriction.	laboratory-confirmed 2019-nCoV cases	Modeling
23	Biao Tang	6 March 2020	China	Quarantine and isolation	Since January 23rd 2020	The effectiveness of quarantine and isolation determine the trend of the COVID-19 epidemics in the final phase of the current outbreak in China	The uncertainty analyses reveal that the epidemics is still uncertain and it is important to continue enhancing the quarantine and isolation strategy and improving the detection rate in mainland China.	Quarantined and suspected cases	Modeling
24	Xinkai Zhou	May 8, 2020	China	Quarantine and travel ban	Jan 13rd to Feb 29th 2020	Modelling-based evaluation of the effect of quarantine control by the Chinese government in the coronavirus disease 2019 outbreak	Our simulation results with different degrees of government control suggest that the strictly enforced quarantine and travel ban have significantly decreased the otherwise uncontrollable spread of the disease. Our results suggest similar measures should be considered by other countries that are of high risk of COVID-19 outbreak.	Confirmed cases COVID-19	Modeling

Another important challenge in the completion of isolation is that the nucleic acid test, as the main means for identifying the cases, has a variable rate of false-negative results. Therefore, even symptomatic cases can be released and, as a result, the possibility of controlling the prevalence of COVID-19 is weakened.[14] Consequently, developing better tests is a priority for international research. With more research groups joining the fight, some progress may occur in tracking the patients. In this fight against COVID-19, control measures such as isolation and contact tracing may gain more power, thanks to the modern technology[13] (Figure 2).

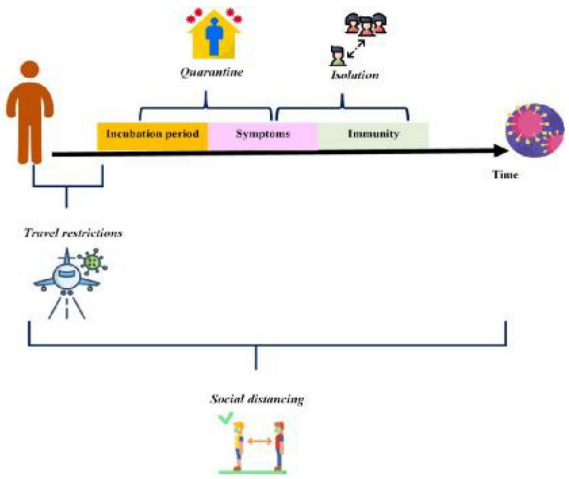

Figure 2: Quarantine, isolation, social distancing, and travel restrictions are the prevention methods for COVID-19 and all can be useful in controlling the disease.

Quarantine and Isolation

Studies have shown that the short-term negative psychological effects of quarantine included frustration, boredom, anger, and confusion. On the other hand, some smaller studies have demonstrated the long-term effects of quarantine, such as Post-Traumatic Stress Disorder (PTSD). Generally, the main factors affecting quarantine include its duration, understanding the risks, frustration and boredom, availability of resources and activities, clarity and availability of information, financial loss, unequal financial effects among people (e.g. those who can work from home versus those who cannot), and social stigma (how people react to those who have completed their quarantine period).[15-17]

A previous study estimated that COVID-19 could be transferred from Wuhan to 369 other Chinese cities before quarantine. The risk of COVID-19 was expected to be >50% in 130 cities (95% CI: 89-190) and >99% in four major metropolitan areas.[18]

Data modeling has suggested that four- and seven-day isolation periods (i.e. a quarantine period of 18-21 days) would be effective by 96.2% and 98.3%, respectively, among symptomatic people. Moreover, the incubation period has been reported to be significantly longer (nine days) among the patients infected in lunch/dinner parties (e.g. gastrointestinal infections through oral transmission) compared to those infected through respiratory droplets and contaminated surfaces and objects ($p<0.004$). Hence, extending the quarantine period to 18-21 days could be effective in preventing the spread of the virus and controlling the disease.[19]

A study in Singapore found that performing quarantine combined with interventions for the infected individuals and their family members, workplace distancing, and school closure after community transfer detection could significantly reduce the number of SARS-CoV-2 infections. At higher asymptomatic ratios, the effectiveness of the interventions might significantly reduce, requiring effective management and treatment as well as preventive measures such as vaccines.[20]

Andrea Lombardi et al. stated that isolation of the infected individuals and use of Personal Protective Equipment (PPE) were the main bases for preventing the transmission of this pathogen through respiratory droplets. Accordingly, a 14-day quarantine was recommended for the people from endemic areas or those who had contact with confirmed cases. In case an individual does not show any signs and symptoms that are compatible with COVID-19 during this period, one will be found not be infected with the disease and, as a result, quarantine will be eliminated and the individual will be able to return to the community. Home quarantine is also available 14 days after a positive test for patients with mild symptoms who do not need medical attention.[21] However, acting alone is not enough to delay the onset of the disease for weeks or longer. After the transmission of the virus in the community, the quarantine of symptomatic patients may have a significant effect on the burden of the disease.[22] The findings of a prior study revealed a significant decline in the R value after the implementation of advanced quarantine control by the Japanese government compared to the early stages.[23]

Singapore has implemented a multilateral surveillance and containment strategy that will further secure the case and slow down the spread. According to a review of the first 100 cases, the mean distance from the onset of symptoms to isolation was 5.6 days, which decreased after approximately one month. Rapid identification and segregation of the cases, quarantine of close contacts, and active monitoring of other contacts have been effective in suppressing the spread of the disease and its consequences in other countries that have experienced its prevalence.[24] A study in China found that self-quarantine at home should be strictly adhered to and that quarantine should be maintained at a relatively high level to

prevent a second outbreak.[25] In the same line, Rocklöv et al. stated that separation and quarantine prevented 2307 cases from infection and reduced *R* to 1.78. They showed that the initial examination of all passengers on the 3rd of February 2020 revealed 76 infected individuals during the incubation period. Examination of all passengers and crew at the beginning of the outbreak also prevented the passengers and the crew from further contamination. In fact, public health measures prevented more than 2,000 additional cases compared to interventions.[26] Yet, studies have indicated that interventions, such as intensive contact tracing followed by quarantine and isolation, could effectively reduce the number of controlled reproductions as well as the risk of transmission.[27]

The results of another study in China showed that the trend of epidemics mainly depended on the quarantine and suspected cases. It was also reported that the epidemics were still unresolved and that it was important to continue strengthening the quarantine strategies and improve tracking in China's mainland.[28] Moreover, Xinkai Zhou et al. believed that without governmental control, the number of infected cases in Wuhan would have risen to 7.78 million (70% of the total population) and the number of deaths to 319,000 based on the current death rate (4.1%). Their findings showed that severe quarantine and travel bans significantly reduced the prevalence of this uncontrollable disease. Thus, similar measures should be considered by other countries at risk of COVID-19 outbreak.[29]

Delays between the onset of symptoms and segregation have played a major role in determining whether the prevalence is controllable at R0=1.5. For R0 values of 2.5 or 3.5, if there are 40 initial cases, tracking and distancing are only possible when less than 1% of the transmission has occurred before the onset of symptoms. In most scenarios, contact detection and isolation are very effective in controlling the new COVID-19 outbreak within three months. According to the model proposed by Helol et al., pre-symptomatic transmission, even at moderate percentages (15-30%), has a significant effect on the likelihood of control.[30]

Social Distancing and Travel Restrictions

It was important for Chinese authorities to assess how long it would take to prevent and control COVID-19 and how costly it would be. With the most limited measures, the prevalence of the disease was expected to peak in two weeks (from January 23, 2020). Nonetheless, by imposing travel restrictions to Beijing, the number of infected people in this city decreased by 91.14% within seven days.[27]

Siqi Ai et al. observed a significant relationship between the population movement and the number of COVID-19 cases. Further analysis showed that if the city closure policy had been implemented two days earlier, it would have been possible to prevent 1420 cases (95% CI: 1059-1833). On the other hand, if it had been implemented two days later, 1462 more cases would have been infected (95% CI: 1090-1886). Hence, population movement might be one of the main drivers of COVID-19 transmission in China, and the city closure policy has been effective in preventing the epidemic.[31]

Asami Anzai et al. estimated that 226 cases expired (95% CI: 86-449) from 28 January to 7 February 2020, representing a 70.4% decrease compared to the incorrect scenario. Therefore, the decision to control the volume of travels through restrictions on the freedom of movement must be balanced regarding the estimated epidemiological impact and the expected economic outcome [32].

Matteo Chinazzi maintained that at the beginning of the travel ban on Wuhan on 23 January 2020, most Chinese cities had already received many infected travellers. Travel quarantine delayed the overall progression of the disease for only three to five days in China's mainland, but it had a more significant impact on an international scale where imports fell by nearly 80% by mid-February. The results of the modelling also showed that the 90% sustainable travel restriction within the country and from China's mainland only moderately affected the epidemic pathway unless it was accompanied by a 50% or higher reduction in the community transmission.[33] Researchers have found that the combination of home quarantine and social distancing among the people aged above 70 years for a three to four-month period would reduce mortality and demand for healthcare services during spring and summer. However, it would still result in 260,000 deaths and a health system's inability to cope.[34]

Reducing the actual rate of new daily contaminations (actual daily growth rate of the reported cases; infection rate in short) from the current value of 30-35% in the US to 10% can be very effective in preventing the spread of the virus. In Germany, severe restrictions for closing any public events, schools, and universities might have helped reduce the growth rate of the reported cases to below 30%. Yet, reduction in the infection rate from 30% to 15% does not imply the elimination of social distancing. Since the routes of infection are not known in details, it is likely that such a significant reduction in the infection rate will only be achieved if social distancing is fully achieved because there are other cases in addition to personal contacts. For instance, smear infections (e.g. in shops or other places) cannot be easily affected by social distancing.[35]

Discussion

This study aimed to examine the impacts of quarantine, isolation, and social distancing on reduction of

COVID-19 disease.

Quarantine and Isolation

Due to the fact that the secondary transmission of COVID-19 occurs at least two days before the onset of symptoms, challenges such as virus transmission by asymptomatic people or those with false-negative results can decrease the efficacy of isolation. These results were consistent with the findings of the studies conducted by Glasser and Niud.[36, 37]

The results of this study showed that the short- and long-term adverse effects of quarantine included frustration, boredom, anger, confusion, financial loss, unequal financial effects among people, social stigma, and PTSD. These results were in agreement with those obtained by Acto.[38]

Undergoing four- and seven-day isolation periods (18-21 days of quarantine) could be effective by 96.2% and 98.3%, respectively among the symptomatic individuals. Thus, various studies have shown that extending the quarantine period to 18-21 days would be effective in preventing the spread of the virus and controlling the disease. However, a longer quarantine period would be necessary for the diseases transmitted through the gastrointestinal tract compared to respiratory diseases.[39, 40] Furthermore, quarantining the infected individuals and their family members, workplace distancing, and school closure have been identified to be effective in the prevention of SARS-CoV-2 infection.[40, 41]

Overall, isolation and quarantine have been reported to be very effective in preventing the transmission of infectious diseases, especially those transmitted by respiratory droplets (COVID-19), showing a considerable decline in the value of R.[24, 42-46] Self-quarantine at home was also found to be effective in prevention of the second outbreak in China.[44]

Social Distancing and Travel Restrictions

Social distancing and travel restriction have been expressed as cost-effective methods for controlling COVID-19. In case social distancing and travel restriction are not followed, it will take about a week for the infection to reach its peak. By implementing travel restrictions, however, the infection rate would be reduced by 91.14%. These results were in line with those of the studies performed by Tang and Bikbov.[47, 48]

Overall, various studies have shown that population movements were one of the main reasons for the transmission of 2019-nCoV infection in China. In this regard, school closure policy and social distancing were effective in preventing the epidemic.[34, 49-53]

Conclusion

One of the limitations of our study was the non-English language of some articles, which of course were few cases, and we tried to reduce this limitation by examining the English abstract. Another limitation of our study was the inclusion of different types of studies, which according to the strengths and weaknesses of each type of study can affect the outcome of the work, which is inevitable.

In conclusion, although quarantine, isolation, and social distancing have challenges, all the three methods of prevention have been reported to be very effective in preventing the transmission of infectious diseases, especially those transmitted by respiratory droplets, and they are very useful and cost-effective methods for controlling the disease, which can be best used by knowing their duration of implementation.

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