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Posted Date: 24 June 2024

doi: 10.20944/preprints202406.1647.v1

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Review

How Effective Were Isolation and Quarantine Strategies during the COVID-19 Pandemic: Challenges and Lessons Learned so Far?

Running Title: Isolation, quarantine & COVID-19 pandemic

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Highlights

- Quarantine, isolation, and social distancing measures are crucial non-pharmaceutical tools to control the pandemic of COVID-19.
- Isolation and quarantine would be effective only when adopted promptly. Early adoption can prevent disease transmission by 5-fold compared to late adoption of 2.6-fold is implemented as early as possible.
- Quarantine alone reduced the rate of new infection, death, and viral reproduction by 44-96%, 31-76%, and 37-88% respectively.
- Around 90% of outbreaks could have been managed if 80% of contacts were monitored, traced, and isolated within 4 days. For each new case of COVID-19, approximately 36 individuals should have been traced.
- When the percentage of people with no symptoms is more than 30%, isolation and contact tracing alone cannot contain the infection.
- Symptom-based isolation strategy alone should not be considered as a criterion for entry isolation. Both pre-symptomatic and asymptomatic contact should be quarantined.

Abstract: Isolation, quarantine, and contact tracing were some of the most critical and commonly employed non-pharmaceutical interventions to control the COVID-19 pandemic. However, the effectiveness of these strategies after their implementation depends upon many factors such as the country's population, availability of sufficient resources to diagnose and effectively isolate the infected individuals, and feasibility, and acceptability of isolation and quarantine policy by the public. This narrative review aims to appraise the current evidence on the correct implementation strategies and shortcomings made in the isolation and quarantine strategies during the COVID-19 pandemic. PubMed, SCOPUS, EMBASE, and Web of Science citation index with the following keywords were searched: Pandemic, COVID-19, Coronavirus, Quarantine, and Isolation. The results showed that quarantine and isolation of COVID-19 patients were more effective than late adoption (5-fold versus 2.6-fold). Around 90% of outbreaks could have been managed if 80% of contacts were monitored, traced, and isolated within 4 days. For each new case of COVID-19, around thirty-six individuals should have been traced. When the percentage of individuals without symptoms is greater than 30%, isolation and contact tracing alone cannot contain the infection. The delay between the onset of symptoms and isolation is the most important factor determining whether an outbreak is controllable. The ideal day for testing should start on the 6th of the quarantine. However, this evidence is mostly based on mathematical modeling studies, and evidence for its effectiveness in real scenarios is required. Symptom-based isolation strategy should not be considered the sole criterion for considering isolation.

Keywords: Coronavirus; COVID-19; Infection; Isolation; Pandemic; SARS-CoV-2; Quarantine

Introduction

The coronavirus infection of 2019 (COVID-19) was caused by a 'Severe Acute Respiratory Syndrome (SARS)' coronavirus-2 (SARS-CoV-2)' was one of the worst pandemics in the world [1]. To control the COVID-19 pandemic various infection control and prevention measures such as the use of personal protective measures, masking, social distancing, quarantine, isolation, and lockdown were advocated to control the spread of infection [2–4].

Isolation and quarantine were two of the most important and widely used non-pharmaceutical strategies for controlling COVID-19 infection [3–5]. Quarantine entails restricting activities or isolating individuals who were not infected, but may have acquired the contagion or the virus. On the contrary, isolation was done by separating the symptomatic and infected individuals from asymptomatic and non-infected individuals to prevent the transmission of infection or cross-contamination [4,5]. The history of quarantine can be dated to the year of the Bubonic plague in 1377 in Croatia when all ships were docked and their passengers were restricted from going ashore [6,7]. In 1423, a 'lazaretto or quarantine station' far from the central city with an intervening natural barrier like a river or sea was started in Venice to separate those with an infectious disease [8–11]. Bedloe's Island, currently known as 'Liberty Island,' was used as a quarantine center to protect New York from smallpox and other malignant fevers during that time [8,10]. In 2014, an entire village in Sierra Leone was kept under observation and quarantined for three weeks after the death of a woman due to the Ebola virus [11,12]. In 2003, around 8000 individuals were home-quarantined to control the SARS outbreak in Singapore [13]. The Centre for Disease Control (CDC) has listed the following diseases that require strict quarantine and isolation: small-pox, cholera, tuberculosis, plague, diphtheria, SARS, measles, pertussis, viral hemorrhagic fevers, meningococcal disease, yellow fever, and flu [1,2,13,14]. Recently, the Department of Health and Human Services USA has added COVID-19 to the list and stated that strict isolation and quarantine strategies are necessary to combat Coronavirus infection. Since the virus SARS-CoV-2, the whole world has been on a steep learning curve regarding its transmissibility, developing accurate tests, effective management and control, and dealing with a rapid and overwhelming influx of illness that affected everyone.

Numerous studies observed that quarantine and isolation along with effective contact tracing were some of the commonly implemented measures to minimize the number of diseased and dead individuals during the pandemic [6–15]. Quarantine is the preliminary step for breaking chains of transmission dynamics of the infection within a community [16]. Sarkar et al. performed a modeling study to explain the transmission of COVID-19 infection in the Indian subcontinent and found that eliminating the SARS-CoV-2 is probable if strict social distancing measures like isolation and quarantine are attempted along with effective methods of contact tracing [17,18]. Additionally, there are numerous questions regarding when the individual should enter and exit quarantine, whether symptom-based strategies are effective in deciding if quarantine is required or not, and when should one be tested for COVID-19. A recent editorial in the British Medical Journal (2020) stated that 'countries failed to control COVID-19 at an initial stage, due to a lack of awareness and inadequate knowledge about the key difference between quarantine and isolation protocol and the right implementation strategies to be adopted both at home and in hospital settings [2]. With more than two years since the initiation of COVID-19, it is prudent to look back and explore the efficacy and problems associated with isolation and quarantine in controlling COVID-19. Although the individual evidence discusses the effectiveness of isolation and quarantine during COVID-19, this narrative review comprehensively provides an update on the role of quarantine and isolation strategies during the COVID-19 pandemic. The review discusses the different types of isolation and quarantine protocols; how they could have been implemented to extract the maximum benefits and what were pitfalls in isolation and quarantine strategies during the pandemic. The review would help the public, government officials, policymakers, healthcare professionals, epidemiologists, and data scientists to understand the intricate details about what went wrong during the implementation of isolation and

quarantine strategy, what could have been done better, and how these strategies should have been implemented in the future.

2. Method

Keyword, Search Strategy, and Data Collection Process

Electronic searches were conducted in PubMed, Web of Science, EMBASE, and SCOPUS on 12th April 2021 and updated on 10th May 2023. The search terms include controlled terms (MeSH terms) and free-text terms e.g., Pandemic, Covid-19, quarantine, isolation, home quarantine, social distancing, non-pharmacological interventions, and non-pharmaceutical intervention. The search strategy was used for data collection in PubMed and adapted for others was: (((((((("Covid 19"[Supplementary Concept]) OR ("SARS-CoV-2"[MeSH Terms])) OR ('Covid-19'[Title/Abstract])) OR ('Covid 19'[Title/Abstract])) OR ('Corona'[Title/Abstract])) OR ('Novel Corona'[Title/Abstract])) AND (((((((((((((((((((("quarantine"[MeSH Terms]) OR (hospital, isolation[MeSH Terms])) OR ("contact tracing"[MeSH Terms])) OR ("social distance"[MeSH Terms])) OR ("Cordon sanitaire"[MeSH Terms])) OR ("Contact surveillance"[MeSH Terms])) OR (quarantine[Title/Abstract])) OR (hospital isolation[Title/Abstract])) OR (contact tracing[Title/Abstract])) OR ("social distance"[Title/Abstract])) OR ("Cordon sanitaire"[Title/Abstract])) OR ("Contact surveillance"[Title/Abstract])). Additionally, hand searching and snowballing were performed to get relevant articles. Only English-language articles were included.

criteria for inclusion and exclusion: We considered all observational studies (cohort, case-control, and cross-sectional studies), mathematical modeling studies, systematic and narrative review articles conducted from any geographic area in the adult global population, and any setting modeling (mathematical and/or epidemiological) that explained any of following were considered: 1) Effectiveness, implementation strategy, timing, and duration of isolation and quarantine to control the SARS-CoV-2 transmission during the COVID-19 2). Effectiveness of contact tracing along with quarantine and isolation to control the spread of SARS-CoV-2 infection 3) The infection control protocol to be followed during the isolation and quarantine period to prevent the SARS-CoV-2 was also included 4) Modelling studies that predict the advantage of isolation and quarantine to control the COVID-19 pandemic 5) Studies that compared the effects of timing of quarantine/isolation in controlling the coronavirus infection. The articles were searched till May 2023 with no lower bar for the year.

All editorials, guidelines, and letters from the Centre for Disease Control (CDC) and WHO were also considered. Studies not related to COVID-19 were excluded. All single case reports and case series were excluded. Articles on other non-pharmaceutical interventions except on isolation, quarantine, and contact tracing were excluded. All data was transferred to Mendeley after removing duplicates from the search results. Three team members (A.C, S.D, K.S) performed the title/abstract for articles as per the eligibility criteria in a Microsoft Excel spreadsheet. The disagreement was discussed with an expert (SG) and mutual consensus was achieved. A total of 10033 articles were obtained from the PubMed database by removing the duplicates. After screening these articles, 110 articles were in the review, of which 25 were mathematical modelling studies. The results of the review are described as a narrative synthesis

Results

How and When Should Quarantine and Isolation Be Implemented?

Quarantine can be implemented voluntarily or legally for the entire community, group of people, or individual depending upon the incubation period of the contagion. Additionally, quarantine should be implemented only when an individual is exposed to an infectious agent to prevent the non-infected ones from contracting the disease. As per the definition, a contact is an individual who has come in direct contact or was within one meter for at least 15 minutes with a COVID-19-positive person, even if the infected individual is asymptomatic [16]. The individual

should be quarantined even if the individual does not have any symptoms at the time of quarantine, but is exposed to an infectious agent/ an infected person. Asymptomatic cases should be quarantined and tested repeatedly to reduce the risk of onward transmission [16–23]. Since patients with coronavirus infection shed their viral RNA even after 8-10 days of symptoms onset, both symptomatic and asymptomatic individuals should be monitored and quarantined until proven to be non-infective by a negative RT-PCR report. Many countries discharged their COVID-19 patients without any symptoms after ten days, whereas others demanded 21 days of isolation [8–13]. The quarantine period for asymptomatic individuals exposed to infected people was initially kept for 14 days, however, later asymptomatic individuals were quarantined for a week or till the test was found to be negative. This led to many asymptomatic patients and individuals who have false-negative reports escaping the quarantine and becoming a potential source of infection. Along with isolation/quarantine, maintaining social distancing and termination of public transport; restriction of public and social gatherings; and closure of schools, colleges, gymnasiums, malls, shopping centers, offices, and religious places are required immediately [8,9]. When the risk of disease transmission is high, all domestic and international travel should be restricted immediately, especially from a country, state, or district with the foci of infection [24–27]. Different types of quarantine can be implemented based on the nature of residence; nature of work; time of quarantine; the number of individuals in the house, and the age of the family members (Table 1). Quarantine for the community should be implemented as a “snow day” or “sheltering in place” scenario, whereby the schools, colleges, workplaces, sites of public gathering, and public transportation are closed, restricted, or prohibited initially only for a few days. This allows the public to get accustomed to isolation and quarantine policies. [15,16].

Table 1. Different Strategies of Isolation and Quarantine.

Type of quarantine/isolation	Description	Advantage/disadvantage
Home quarantine/isolation	Quarantine imposed at an individual level, enforced at the individual's residence is referred to as home quarantine. Can be implemented for small households. For large family sizes (>), institutional / hospital isolation should be implemented.	1. Easy to implement and cost-effective [2] 2. Not effective for large families, cramped households, and households with elderly with co-morbidities [18–24] 3. Social distancing may not be effective [26] 4. The risk of transmission among family members is high [27,37]
Shelter-in-place	Is a modification of home quarantine where individuals “are sheltered in isolation where they are residing, like a hostel, ship, ward, or hospital. Shelter-in-place is employed for individuals who are at risk of getting infected by the virus as they share a common residence.	Allow individuals to stay in familiar home settings; May be associated with psychological stress [40,41]
Working quarantine	An example of shelter-in-place quarantine is where healthcare professionals such as doctors, nurses, and paramedical staff are quarantined in hotels or hospitals to treat COVID-19 after their working hours.	Working quarantine ensures that the disease is not transmitted to the community from the hospital setting. However, this may involve a psychological burden and poor quality of life [48].
Mass isolation/cohort isolation	If separate rooms are unavailable or difficult to arrange due to lack of space, people infected with the same contagion can be isolated. Mass isolation can be implemented for hospital staff, who are	Mass isolation allows access to the infected individuals at the same by the clinician and allows the clinician to deliver treatment to all isolated individuals at one time.

	isolated in specific wards or hotels and are forbidden from visiting regular patients after visiting infected ones.	Positive social outcomes of community-based quarantine were discovered to include emotional distress, increased communication disparities, food insecurity, economic difficulties, decreased access to health care, alternative methods of education, and gender-based assault in six infectious disease, including the current COVID-19 pandemic.
Cordon sanitaire (sanitary cordon)	Implemented when the disease has spread to the community. When cordon sanitaire is implemented, the borders of the affected area are sealed, and the movement of people across the borders is prohibited. Cordon sanitaire should be implemented only when: 1) the infectious agent is highly virulent and contagious; 2) there is a high mortality rate; 3) the cure is not available 4) it is difficult to access the area; 4) no vaccine is available to immunize a large group of people	Cordon sanitaire helps the essential commerce of the community to function uninterrupted within the country or district that has been quarantined [56]
Protective sequestration	During protective sequestration, an unaffected community isolates or separates itself voluntarily till the possibility of an epidemic diminishes. Age-restricted isolation is one example of protective sequestration adopted in New Zealand	The local community's economy is affected adversely, and ensuring social distancing within the community becomes challenging [66]
Reverse quarantine	The vulnerable individuals are prohibited from attending public gatherings and are separated from their family members, who are at risk of being infected. Developed for a population that includes the elderly, pregnant women, obese people, infants and small children, people with medical conditions such as diabetes, hypertension, kidney, lung and heart disease, cancer, immunocompromised people, post-transplant patients, and people taking immunosuppressive drugs. Can also be used for children and adolescents in the family who may contact the sick or old regularly. This can be reduced by living in a separate residence until the danger of infection has been reduced.	Although there may be a risk to psychological tissues, reverse quarantine lowers the frequency of severe cases that necessitate hospitalization, morbidity, and mortality in society [67]
Contact Surveillance	The monitoring or surveillance during isolation and quarantine can be done either actively or passively to note the development of any signs and symptoms of the disease. During passive surveillance, the infected individual is instructed to inform the authorities if any symptoms develop. During active surveillance, a regular follow-up, either	Active surveillance was found to be more effective than passive surveillance as with passive surveillance many asymptomatic individuals did not report their illness and breached in isolation resulting in the spread of infection. Additionally, social stigma, psychological issues (stress,

	by telecommunication aids or direct visits, to the suspected is made. Therefore, active contact surveillance for both infected and non-infected is preferred over passive surveillance	loneliness, and anxiety during quarantine and isolation), and financial and work-related constraints may prevent individuals from disclosing their symptoms. This may lead to a breach of isolation and quarantine policy and preclude effective infection control [19–33]
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Effective quarantine need not be perfect. A partially effective quarantine, also known as leaky quarantine, can decrease the risk of disease transmission, provided the public is cooperative and voluntary measures are absolute. Partial quarantine and strict infection control protocol can be initiated, once the vaccines are available [17–20]. However, it is crucial to ensure that essential services such as food, water, suitable lodging, sanitation, appropriate medical care, means of communication, and monetary help are provided to all individuals in quarantine both private and institutional settings. An individual under quarantine or isolation should abide by the government’s rules and follow all necessary precautions [17,18] (Table 2: describes the infection control protocol for home isolation). Studies have shown that many misconceptions, lack of awareness, and knowledge about how quarantine/ isolation measures result in poor infection control measures. Mistree et al. (2021) showed that explaining fact along with concept provides better infection control and self-reported COVID-19-related preventive behavior compared to public education by fact alone [7]. All isolated or quarantined travelers should be informed about the underlying reasons along with a written order within 72 hours and the required duration of quarantine [20].

Table 2. Specific precautionary infection control/ hygiene measures to be followed during quarantine/isolation at home.

- The ideal patient setting would be a separate, well-ventilated room with a bathroom connected. The best ventilation is natural, therefore if at all possible, open the windows. Any system that operates in a recirculation mode, such as split air conditioning units, fan coils, or similar devices, should be avoided wherever feasible. To prevent the spread of droplets or aerosols, windows should be opened to enhance external air exchange, and air blowing straight from one person to another should be minimized.
- The infected person must wear a mask while interacting with family members; however, if alone in the room, he/she need not wear a mask. It is best to use a disposable mask, which is changed every 6 to 8 hrs. Worn masks should be discarded appropriately without being reused, either by burning or burial, as the infected masks are a potential source of infection.
- Sodium hypochlorite solution or 5% bleach solution can be used to disinfect the non-disposable masks worn by patients, and caregivers before disposal by burning or deep burial [36,37].
- If family members’ movement into the isolation room cannot be avoided, masks and gloves should be worn while entering the room. A minimum of 6 feet distance, in addition to a mask, is recommended if another member resides in the same room with the infected person or enters the isolating room. The infected person should, preferably, eat in isolation. It is better to use non-disposable cutlery for the infected patient to avoid the generation of biohazard waste. If disposable utensils and cutlery are used, they should be disinfected with soap or sodium hypochlorite before disposal. The infected individual should not interact with anyone during the isolating period, especially children, pregnant women, older people, and individuals suffering from other co-morbidities [36].
- The infected person should clean the washroom themselves. However, if it is not feasible, the person assigned to take care of the infected patient should take care. Personal items like cutlery, toothbrushes, and tongue cleaners should be kept separately. Gloves, eyewear, or face shields should be worn at all times while handling non-living objects and cleaning the isolating area. The used gloves should be discarded after use. If reusable gloves are used, they should be disinfected and not used for other purposes. It is also essential to wash hands

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- immediately after removing the gloves and protect the skin and eyes from potential splash hazards while cleaning.
- Cleaning should be initiated from the area that is minimally infected to the most infected areas. It should also start from the area that is higher to an area to the lower-level area so that debris falls on the floor and is removed in the end.
 - It is recommended to wash the cloth worn by the isolated person every day and not shake the soiled lining while washing to minimize the probability of dispersing the viral particles via mist, water droplets, aerosol or splatter [36,37].
 - Hands should be washed frequently, with water and soap, by all family members for at least 20 seconds, particularly after attending to the patient's needs. If hand washing using soap and water is unlikely, hand hygiene using an alcohol-based hand sanitizer is recommended. Avoid contact with fomites such as a doorknob, windows, beds, chairs, electronics, switchboards, and blankets. The non-dominant hand or knuckles should open and close the doors and windows, manage electronic items, and switch in the house.
 - Frequently touched surfaces/objects such as doorknobs, mobiles, remote controls for televisions, surfaces around the counters of shops, tabletops, bathroom fixtures, sinks, toilets, keyboards, laptops, touch screens, remote controls, and bedside tables) should be disinfected regularly using EPA-registered disinfectants [36,37].
 - The visible contamination, if present, on electronic items can be cleaned by using alcohol-based wet-wipes or alcohol sprays containing at least 70% alcohol. Ensure that proper dilution with a contact time of at least 1 minute is achieved with disinfectants. Additionally, mixing different chemical products and undiluted products (unless specified) is not recommended to avoid toxicity and potential hazards [37–39].
 - Spraying or fogging (fumigation/misting) of chemicals/ disinfectants is not recommended for COVID-19, as spraying is ineffective in removing contaminants that are not in the direct spray zones and can damage the eyes, respiratory system or cause skin irritation. Do not wipe or bathe animals with such items that are not approved for use on animals. For people with asthma, special precautions need to be taken since the scent of disinfectant can trigger breathlessness and asthma attacks [37–39].
 - Dedicate a separate waste disposal bin for the isolated person. While handling and disposing of trash, use gloves, and then wash your hands. If available, consider talking to the local health department about waste disposal guidelines. [12,13].
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Before advising quarantine, the patient's medical condition and quality of home care facility by a qualified state or local health department staff should be reviewed. Although home isolation is easy and more cost-effective, it is not recommended if there are individuals (aged ≥ 60 years) or any medically compromised person [10–18]. The compliance of the family members and the time an individual spends per day in public should be noted. If a family does not follow correct protocols, approximately 43 new infections could occur in 14 days. If there is a household with one person and the person does not spend any time outdoors, the secondary cases predicted over the 14 days were nil. Additionally, smaller homes or quarantine groups were found to have fewer secondary infections [20–24]. A study by Nash et al. (2020) evaluated the risk of children in the house and the nature of crowding in the household as some of the key factors for COVID-19 infection. The authors found that families where children are present are 4.99 times more likely to become infected or admitted to hospitals. No associations were observed between homes with more than four family members and hospital admissions for COVID-19 to houses with only one family member. Participants living in flats/ multiunit apartments have a 4.62 times higher risk of being hospitalized than those in a single unit [30]. A systematic review found that the 'secondary attack rate' in the household is around 16.6%. The rates of infection are highest from symptomatic index cases (18.0%) followed by asymptomatic cases (0.7%), adult contacts (28.3%), child contacts (16.8%), and spouses (37.8%). Other family contacts in the house are also vulnerable (17.8%). The rate of infection is higher in homes with a single contact (41.5%) than in homes with three or more contacts (22.8%) [31]

Early implementation of isolation and quarantine could control disease transmission and increase the time required for the virus to replicate (2 days to 4 days) [15,16,28–30]. Quarantine alone reduced the incidence of new infections, death, and viral reproduction rates by 44-96%, 31-76%, and

37-88%, respectively [32–41]. Studies from many countries Hong Kong, South Korea, Japan, and Singapore, indicated that implementing quarantine and isolation at an early stage can reduce the doubling time (Table 3: describes the various pieces of evidence that evaluated the effect of quarantine/isolation during the pandemic. A study by Lai et (2020) showed that if these interventions were implemented early the number of COVID-19 cases would have reduced. One-week earlier implementation would have reduced the pandemic by 66% and a three-week early intervention would have reduced the pandemic by 95% (IQR: 93–97%) respectively in China [4,5]. However, with a delay in implementing isolation and quarantine by one week, the cases would have increased by threefold. A three-week delay would have increased the cases by 18-fold [4–6]. A delay to implement isolation by just five days would have increased the epidemic size by three-fold and if these measures had been started five days before, there would have been 40,991 cases nationwide [4–6]. However, later modeling studies by Khajanchi et al. (2021) reported that COVID-19 would show an oscillatory dynamic and might become a seasonal disease. Thus, if mass gatherings are prohibited, effective social distancing is maintained, and extensive lockdowns can be done, COVID-19 transmission can be reduced. Isolation or hospitalization of people with Coronavirus symptoms, combined with strict hygiene precautions and social distancing, can help to control a community and even eliminate the disease. Our findings also indicate that the magnitude and duration of an epidemic can be significantly influenced by the timely implementation of a hospitalization or isolation program [36]. Samui et al. developed a mathematical model to predict COVID-19 transmission dynamics in the Indian subcontinent. To explore model simulations and predictions, the authors computed the basic reproduction number R_0 . If R_0 is less than one, the disease is likely to stop spreading. However, if R_0 is equal to one, an ill person can infect an average of one other person, showing stable disease transmission. If R_0 surpasses one, the disease has the potential to spread and become an epidemic. The scientists calculated a R_0 of 1.6632, indicating a substantial COVID-19 pandemic in India. The simulation model found that the transmission rate is more successful in reducing the basic reproduction number R_0 . Based on projected data, the model anticipated that COVID-19 in India would reach its highest level in around 60 days and then plateau, although the coronavirus sickness would remain for a long time [37].

Table 3. Epidemiological Studies on the role of isolation and quarantine in controlling the COVID-19 pandemic.

Author/ Year	Aim/objective	Study design/country	Results/ Conclusion
Keeling et al. 2020 [29]	To explore how effective contact tracing strategies to control Covid-19 infection.	Cross-sectional study/UK	8.7% of infected individuals showed more than 100 contacts. On average 36 contacts should be traced for every new case that was traced.
Hu et al. 2020 [40]	In Guangdong province, disease variations were predicted and simulated. The influence of quarantine policies and the input population on these variations is also investigated. This includes calculating the highest value of cumulative confirmed cases and raising the number of new cases.	SEIRQ model/China	The greater the percentage of the population entering the province, the shorter the illness extinction days and the percentage of exposed persons.
Shen et al. 2020 [18]	To determine the quarantine’s impact on the trend and transmission path of the SARS-CoV-2 epidemic.	Retrospective study/China	Quarantine prevents around 79% of deaths, 71.84%, and 87.08% of infections in households and public spaces.

Cheng et al. 2020 [42]	To understand the patterns of COVID-19 transmission and assess the risk before and after symptom development in an individual.	Taiwan/ Prospective study	The rate of infection was higher among contacts who were exposed to index/primary cases within less than 5 days of the onset of symptoms. The risk of transmissibility before and immediately after the onset of symptoms is high.
Wang et al. 2020 [10]	Examined the demographic and clinical features of patients infected with COVID-19 and how to most effectively manage the condition in Zhejiang province.	Retrospective study/ China	Preventing exposure of healthy to the infected individual provides the maximum benefit in controlling the pandemic
Lai et al. 2020 [4]	Explore the forms of contact tracing adopted by the Government of Singapore, including digital means	Review articles Singapore	Digital contact tracing will be used more extensively to complement manual contact tracing in the future. It, however, cannot replace manual contact tracing entirely due to its effective nature in Singapore.
Mayr et al. 2020 [26]	To assess the effectiveness of quarantine measures alone or in combination with other non-pharmaceutical intervention procedures on individuals who contract the disease from travelers to other countries or live in a place where the infection is high.	Rapid review	Isolating people exposed to COVID-19 can prevent approximately 81% of the cases respectively. Quarantine can prevent mortality by 31 to 63% compared to situations where no such measures were adopted.
Girum et al. 2020 [15]	To identify best practices, they carried out a methodical investigation into the function of COVID-19 preventive measures attained by contact tracing, screening, isolation, and quarantine.	Systematic review	Non-pharmaceutical measures such as quarantine, isolation, and contact tracking/screening of individuals for infections should be done concurrently to control the spread of infection. Quarantine should be implemented as soon as possible to maximize the effectiveness of infection prevention.
Kucirka et al. 2020 [39]	To estimate the false-negative rate with the progression of the infection.	Literature review and pooled analysis/ USA	The chance of a false-negative result in an infected person declines from 100% on day 1 to 67% on day 4. On the day of symptom onset, the median false-negative rate was 38% (range, 18% to 65%). This fell to 20% (CI, 12% to 30%) on day 8 (3 days following symptom onset) before rising again to 21% on day 9 and 66% on day 21. This showed that one must exercise caution when using these results to remove safeguards designed to prevent forward transmission. If clinical suspicion is strong, infection should not be ruled out only based on RT-PCR, and the clinical and

			epidemiological situation should be carefully assessed.
Jung et al. 2020 [43]	Implications of testing individuals before being released from 14-day quarantine.	Retrospective study South Korea	Out of 19,296 people in Korea who were self-quarantined, only 0.3% tested positive for COVID-19 on the first day. 35.7% were identified by evaluating the onset of symptoms during the quarantine period, and 57.1% were identified after mandatory pre-release RT-PCR.
Marcus et al. 2021 [46]	Examined the results of symptomatic COVID-19 testing for each recruit before they started Basic Military Training.	Retrospective cohort study / USA	Testing the individuals when they finish quarantine was higher than those tested upon arrival. Arrival quarantine had greater frequencies of concurrent influenza testing (74% vs. 38%, $P = .001$).
Auranen et al. 2023 [33]	Assessed the viability and effectiveness of isolating SARS-CoV-2-positive patients and quarantining their contacts during a modestly developing phase of COVID-19.		The estimation of the time interval between symptoms in the main and secondary cases, it was found that in situations where there is no isolation of cases or its contact, the transmission would have happened on the day of or after the start of symptoms. One-third of the original SARS-CoV-2 patients reported waiting 0.8 days before isolation (quarantine) to experience symptoms. The efficacy was reduced because to the late isolation (mean 2.6 days after symptoms). Two or twenty cases, respectively, were required for isolation or quarantine to prevent another case from arising.

Moreover, if isolation, quarantine, and travel restrictions had not been implemented, the epidemic would have lasted for 477 days with over 800 million infected COVID-19 individuals [4–16]. Travel restrictions decreased the number of diseased individuals by 91.14% within a week [17–20]. Read et al. (2021) denied the efficacy of travel restrictions and showed that during the initial time of the epidemic in China, restricting travel by 99% can reduce the spread of the infection across the borders of the city of Wuhan by 24.9% [23]. Additionally, effective isolation, quarantine, and social distancing policies for elderly more than 70 years for four months were found to reduce the death rate by 49% ($R_0 = 2.4$ assumed). Studies also found that even when there is a dip in the incidence of cases, non-pharmaceutical interventions such as social distancing measures like quarantine, isolation, and contact tracing should be followed for several months [23–34]. Auranen et al. (2023) investigated the effectiveness of isolating patients with Coronavirus in Finland. The study found that without case isolation or quarantine, 40 transmissions would have occurred on or after the first day of symptom onset. One-third of SARS-CoV-2 cases ($N = 1521$) were originally quarantined, with a self-reported time to isolation (quarantine) of 0.8 days before symptom onset. This delay results in an effectiveness of 50 in preventing subsequent infections per quarantined case. Because of the later isolation (mean 2.6 days after symptoms), the effectiveness was lower in the two-thirds of individuals whose seclusion was motivated by their symptoms, rather than being previously isolated. Overall, the rate would have been at least twice as high without case isolation and quarantine. The numbers required to isolate or quarantine to prevent one secondary case were two and twenty, respectively [35]. Social media platforms were considered also an effective tool for combating the coronavirus outbreak in India. Rai et al. 2022 discovered that raising public knowledge changes people's attitudes and

behaviors, which can reduce the danger of transmission while increasing the rate of hospitalization for symptomatic persons. Additionally, the media can support asymptomatic people in adhering to health precautions including social distancing and self-isolation. Health authorities and government officials should routinely propagate knowledge through the internet and social media platforms to control the incidence of illness. This will allow them to hospitalize symptomatic persons and place asymptomatic ones under quarantine [36–38].

Criteria for Entering and Testing during Quarantine/Isolation

The time at which the tests are performed is a key factor in determining the rate of mortality and new cases during the pandemic. A symptom-based screening and single-time testing were the most commonly employed methods for deciding the need for quarantine and isolation. However, symptom-based strategies increased the probability of post-quarantine transmission. Since early detection and isolation are more effective compared to late detection (5-fold versus 2.6-fold) [30–38], many institutions rely on testing at the time of entry into quarantine. However, the rate of false-negative is high, if testing is done at an early stage of disease contraction due to the increased period of incubation for the virus. However, since the viral load is below the level of detection at an early stage, the chances of a false negative are high. This leads to many infected individuals not being quarantined/isolated. These individuals become potential sources of spreading the infection [38–40]. It should be noted that since the transmissibility of viral particles occurs much earlier than the onset of symptoms and lasts in the body at high levels, even after the person is infected, contact tracing and isolation of only the symptomatic patients are not enough to restrict the spread of infection. Contact tracing should be started four days before the symptoms start [41]. Studies have shown that testing and discharging an individual (with a negative report) immediately prevents only 35.2% of local transmission; whereas testing at the time of arrival and ending the quarantine period after two days can only prevent 54 % of local transmission (Table 3). Hence both symptomatic individuals and asymptomatic contacts should not be allowed to leave the isolation unless proven negative by an RT-PCR at the time of exit after three to seven days. However, one should not rely on the symptom-based isolation strategy and testing alone, and strict contact tracing and repeated testing of asymptomatic and pre-symptomatic individuals after seven days is crucial to identify and quarantine asymptomatic and isolate symptomatic individuals at a later date [19–40]. Even though a delay in testing reduces the chance of getting false-negative results, it increases the duration and the cost of implementing isolation/quarantine measures at home and in public settings. This may come with mental and financial concerns [41–43]. Wells et al. (2021) also found that quarantine measures implemented for a week followed by testing on exiting the quarantine helped to reduce the post-quarantine transmission effectively [44]. However, testing the individuals at the start of the quarantine provides only marginal benefits and should be combined with testing on exit. Kretzschmar et al. also confirmed that a delay in testing by 0 days, three days, and seven days, reduced the rate of disease control by 79.9%, 41.8%, and 4.9% respectively. If the period of contracting the infection is known, the optimal day to test is on the sixth day of the quarantine [37–39]. It is also noted that the RT-PCR test to diagnose COVID was less sensitive for many individuals, especially if the individual is tested during the incubation period (e.g., after the onset of symptoms). Isolating an individual for a week and then testing at the time of exit or keeping the individual for six-day isolation and testing at the time of entry are two forms of isolation strategies, both providing the same or lower transmission rate compared to 14-day isolation without testing [28]. Testing the individual at the time of exit reduces 14-day quarantine by half while when we test at the time of entry, it shortens the quarantine by only one day. The best time to test was immediately following leaving a quarantine lasting a week or less. For an individual who is quarantined for more than seven days post-infection, the test should be performed at the time of entry. It is recommended to test at the time of entrance for individuals who were placed in quarantine seven days or more after infection.

Mandatory negative COVID-19 RT-PCR test within 48 hours for all travelers to enter the country should also be debatable. One should be careful as a single RT-PCR test upon arrival prevents local transmission of imported cases by only 40% to 50%. Testing for COVID-19 by a RT-PCR before

departure will help to reduce the chances of transmission of viral particles to the co-passengers during travel. This is crucial, especially if a person is traveling from areas with a high rate of infection [33–52]. However, pre-departure testing does not ensure that the traveler may not get infected during the travel or upon arrival. The risk of contracting the virus during travel still exists and therefore the chances of the person not being detected upon entering another country is high if screening is not done again upon arrival. Hence, testing upon arrival along with a mandatory 3-7 days quarantine should be considered. Additionally, pre-departure test results done within 48 hours of travel should be considered. If the RT-PCR is done three days before the date of departure and entry into a country, repeat the test before departure and arrival. Studies using mathematical modeling have shown that more than 50% of travelers who are infected can infiltrate the public despite thermal screening at airports. This transmission of infection could have been avoided if compulsory quarantine of travelers, but one should also note that this can be costly and creates a psychological burden on the individual [45–48].

How Important Was Contact Tracing for Isolation and Quarantine Strategies?

The isolation of infected individuals combined with contact tracing is more effective than isolation and quarantine alone (50–60% compared to 2–30%) [31–41]. A setting where half of the infected individuals can be identified and isolated can control the onward transmission by 100%. This can reduce the onward transmission similar to a situation where all the infected individuals are identified, but only 50% are isolated [35–49]. A cross-sectional study on 5802 subjects in the UK showed that for each new case of COVID-19, around thirty-six people should be outlined and to control the outbreak by 90%, around 80% of contacts need to be monitored and isolated. However, this number may vary depending upon on number of infected individuals, setting, and demographic characteristics of a country (e.g., population density) [27]. Contact tracing and monitoring should occur for both symptomatic and asymptomatic individuals and their contacts. When the percentage of asymptomatic infections is greater than 30% and the R_0 of infection is 2.5, contact tracing, quarantine, and isolation alone are not sufficient to contain the infection [50–57]. In such situations, disease transmission by social distancing can be prevented only by reducing contact with people outside the house by 90%. Since social distancing reduces household contacts by only 50%, contact tracing and isolating contacts with people outside the house is important. Additionally, a reduction in transmission reduction by 29% and 35% can be obtained with self-isolation alone, if symptomatic cases inside and outside the household are isolated and outlined. Lai et al. (2021) suggested aggressive contact tracing of both symptomatic and asymptomatic individuals to identify the infected cases once every three days would help to detect the cases and isolate them at an early stage [4,5]. Early detection of cases and regular testing for the entire population were better to detect the infected individuals [54–56]. A reduction of 2% in transmission was noted if mass testing of approximately 5% of the population was done every week. Another study showed that around 64% of transmission reduction can be achieved by household quarantine and self-isolation, along with manually tracing all contacts. Kucharski et al. conducted a mathematical modeling study to assess the reduction in transmission when different methods are used to control the spread of infection. The authors constructed a model of individual-level transmission stratified by context (home, job, school, or other) using data from 40,162 UK participants in the BBC Pandemic. The authors also calculated how many contacts ought to be quarantined daily under various scenarios, as well as how much the effective reproduction number would decrease. According to the findings, isolation and tracing strategies together would be more effective at reducing transmission than mass testing or self-isolation alone. A weekly 5% population test, for example, would yield a 2% mean reduction in transmission. Of all the cases, 29% are self-isolated by symptomatic cases within the household, 35% are self-isolated by symptomatic cases outside the household, 37% are self-isolation plus household quarantine, 64% are self-isolation and household quarantine plus manual contact tracing of all contacts, 57% are manual contact tracing of acquaintances only, and 47% are app-based tracing processes. If limits were put on encounters outside of the home, place of employment, or educational institution, manual contact tracing of acquaintances alone might have a comparable impact on transmission reduction as

comprehensive contact tracing. We estimated that under most contact tracing approaches, 15,000–41,000 contacts would be placed in quarantine each day based on the premise that 1000 new symptomatic patients would satisfy the contact tracing requirements each day [25].

If contact tracing is done using contact tracing apps, the detection of the infected individual significantly improves with an 80% reduction in disease transmission. Although there are technological limitations to using app-based technology for contact tracing due to the non-availability of smartphones and the internet in some areas, app-based tracing was found to be more effective compared to conventional tracing. According to Endo et al., contact tracing can lower the true reproduction rate by as much as 60%. On the other hand, the fundamental reproduction number (R0) for COVID-19 was predicted to be between 2 and 4 in the absence of any interventions. The most important factor that determines the effectiveness of any contact tracing system is the quarantine or isolation of the first or primary case, followed by the isolation or quarantine of all subsequent cases [47]. Additionally, to establish an effective system during any pandemic, the index and secondary cases must be determined quickly and accurately. Contact tracing for both symptomatic and pre-symptomatic cases is required. Studies have shown that there always be a specified segment of infected individuals in different age groups that would not have any symptoms [36–41]. And around 35% of all onward transmission occurs from these asymptomatic individuals during their pre-symptomatic phase. Thus, the effectiveness of any contact tracing and infection control strategy depends upon the ability to detect and locate both pre-symptomatic and asymptomatic cases and restrict their onward transmission by effective and strict quarantine. If the transmission rate for asymptomatic and pre-symptomatic cases is declining, it is easier to trace a large number of contacts before the onset of symptoms. However, if the pre-symptomatic rate is higher, monitoring contacts should be paired with stricter social distancing efforts to manage the outbreak.

When to Exit Quarantine and Isolation

The COVID-19 infection could have been reduced with strict and effective quarantine procedures initiated early and optimally followed by the public. Exist of quarantine is a key factor determining the rate of transmission. The CDC has listed various criteria for discontinuing quarantine/isolation based on the symptom-based strategy [50–58] (Table 4 lists criteria to decide when to exit the quarantine). Initially, 14 days of quarantine was mandatory, which was later reduced to seven days. There was a major reduction in the quarantine period. A major problem with a short quarantine period was the cause for failure of quarantine measures, as the SARS-CoV-2 virus had a long incubation period. It is estimated that around 7.3% of patients may have a longer incubation period than the recommended 14-day quarantine period and may be symptomatic even after completion of the quarantine [40,41].

Table 4. Modelling studies on the role of isolation and quarantine in controlling COVID-19 infection.

Xiuli et al. 2020 [41]	Assessed the evolution process of COVID-19 in China. and how the result depends on different containment strategies (quarantine measures with or without with vaccination or the use of effective containment strategy).	QSEIR modelling/ China	Quarantine/ isolation are the most effective strategy to control the spread of infection.
Qiu and Xiao (2020) [9]	The SARS-CoV-2 epidemics in Wuhan, China, was studied to assess the impact of national public health responses on control of COVID-19	Susceptible-Exposed-Infectious-Out of the Healthcare System (with health care	Delaying the lockdown by one to six days would have increased the infection rate from 1.23 to 4.94 times, whereas imposing the lockdown seven days early would have resulted in 21,508 total cases of

		/maximum beds in Hospital) SEIO (MH) model / China	infection. After seven days, the epidemic would eventually spiral out of control. Public gatherings raised the transmission parameter by 5% in a single day and ultimately leads to an increase of 4,243 infected individuals.
Tian et al. 2020 [14]	Assessed the effect of COVID-19 and containment strategies using information from case studies, migration patterns, and public health initiatives.	China	The COVID-19 pandemic was 2.91 days behind schedule in other cities due to the Wuhan shutdown. When compared to cities that started control later (20.6), early implementation of control measures resulted in (33.3%) fewer cases on average (13.0) in the first week of their outbreaks.
Tang et al. 2020 [1]	To estimate the basic reproduction number and control the pandemic by utilizing strong measures	Mathematical Modelling, $R_0 = 6.47$ / China	Quarantine and isolation, in addition to intensive contact tracing, may effectively decrease the level of control. With severe travel limitations being implemented, the number of affected people in Beijing over 7 days fell by 91.14% compared to the situation with no travel restrictions. The results showed that increasing the quarantine rate by 10 or 20 times will bring forward the peak by 6.5 or 9 days, and lead to a reduction of the peak value in terms of the number of infected individuals by 87% or 93%. This indicates that enhancing quarantine and isolation following contact tracing and reducing the contact rate can significantly lower the peak and reduce the cumulative number of predicted reported cases
Ferguson et al. 2020 [24]	To assess the role of non-pharmaceutical interventions in controlling COVID-19 infections.	Mathematical modeling study	To achieve a R_0 value ≤ 1 , social isolation, strict isolation, and quarantine are required. It is required that colleges, universities, public gathering places, and schools close. A 50% reduction in death rates and a roughly 66.66% decrease in healthcare demand are achievable with adequate mitigating measures.
Yang et al. 2020 [19]	The model predicted the course of the epidemic using epidemiological data from COVID-19 patient counts every day supplied by the National Health Commission of China.	Mathematical Modelling, A modified susceptible-exposed-infected-removed SEIR and artificial intelligence (AI) approach/ China	The extent of the pandemic would have tripled if isolation and quarantine had been imposed five days later. If the interventions had been implemented five days sooner than they had been, there would have been 40,991 cases nationwide.

Peak et al. 2020 [6]	Using a stochastic branching model, determine the relative effectiveness of two sets of published parameters for the dynamics of the disease with mean serial intervals of 4.8 days and 7.5 days for interventions to control COVID-19.	Stochastic branching model/USA	Social distance can lower the reproductive number to 1.25; to limit the epidemic and obtain a R_0 of less than 1, continuous surveillance of 50% of contacts is required. With social distancing, tracing ten percent, fifty percent, or ninety percent of contacts leads to a median fall in R_0 of 3.2 percent, 15 percent, and 33 percent, respectively.
Tang et al. 2020 [2]	To evaluate the effectiveness of techniques (isolation and quarantine strategies) and forecast the COVID-19 epidemic trend based on various data sources.	Dynamic model/China	The control of the transmission of Coronavirus mainly depends on quarantine of suspected cases and isolating the confirmed cases. It is important to continue enhancing the quarantine and isolation strategy and improving the detection rate in mainland China.
Hou et al. 2020 [52]	To evaluate the role of the quarantine strategies in Wuhan.	Mixed SEIR modeling / China	We inferred the rate of underreporting in Wuhan to estimate the possible size of the outbreak in Wuhan, as well as key epidemiological parameters including the basic reproductive ratio and infectious period. It is possible to successfully lower the number of COVID-19-infected people and postpone the peak period by lowering latent patients' contact rate following isolation and quarantine.
Read et al. 2021 [23]	Predicted the number of confirmed cases in Wuhan and other Chinese cities, as well as in other nations or areas. Estimated the potential extent of the epidemic, as well as critical epidemiological factors such as the basic reproductive ratio and infectious time.	Transmission modelling study	The study found a basic reproductive number of 3.11 indicating that 58–76% of transmissions can be prevented to stop disease. The study also noted that the case ascertainment rate in Wuhan was 5.0%. The size of the epidemic in Wuhan would have been greater than what was published if the pandemic was not controlled by isolation and quarantine strategies.
Hellewell et al. 2020 [3]	To determine if isolation and contact tracking can effectively restrict the spread of viruses acquired from individuals moving into the nation.	Stochastic transmission modeling/ UK	What matters most in determining whether an outbreak ($R_0=1.5$) is manageable is how long symptoms gradually manifest before being placed under isolation. When less than 1% of transmission occurred before the onset of symptoms, contact tracing and isolation were only possible with R_0 values of 2.5 or 3.5.
Kretzschmar et al. 2021 [31]	Study of the effects of contact tracking and isolation utilizing different levels of timeliness and efficacy of contact tracing in	Stochastic transmission model/Netherlands	Isolation and contact tracing are ineffective in controlling the disease when the rate of asymptomatic infection exceeds 30% ($R_0 = 2.5$). 90% fewer non-household contacts are

	an environment with different degrees of social distancing.		needed for social distancing strategies to manage the disease effectively.
Lai et al. 2021 [5]	Explored the role of non-pharmaceutical interventions in controlling the COVID-19 pandemic in China	Modelling study	As of February 29, 2020, there had been 114,325 cases of COVID-19 in mainland China. Without non-pharmaceutical therapies, the number of cases would have increased 67-fold by February 29, 2020. The early detection and isolation of cases prevented more infections than did travel restrictions and contact reductions, but a combination of non-pharmaceutical interventions achieved the strongest and most rapid effect across the world.
Kucharski et al. 2020 [25]	Estimate the reduction in transmission under different strategies and the number of contacts isolated per day under various procedures for a particular level of symptomatic case incidence.	Mathematical modeling study USA, UK	Combining testing and isolation would be more effective than mass testing or isolation alone (50–60% compared to 2–30%). With 1000 new symptomatic cases each day triggering contact tracing, between 15000-41000 individuals were quarantined for most contact tracing strategies.
Kretzschmar et al. 2020 [30]	Identification of key factors to ensure successful contact tracing	Stochastic mathematical modeling study UK, Netherland	Improved access to screening, contact tracing, and digital apps could minimize the spread of illness by up to 80%.
Aleta et al. 2020 [28]	A quantitative investigation of the epidemic's progress and the efficacy of social isolation procedures.	Mathematical modeling study	The initial stage of extreme social distance, followed by rigorous testing, contact tracing, and quarantine, would ensure that the pandemic is contained while allowing for economic activity to continue.
Aronna et al. 2021 [8]	To assess the dynamics of COVID-19.	Modeling study/Brazil and Canada	Isolation and testing of asymptomatic cases at the earliest in a strict manner are critical for controlling the pandemic.
Chinazzi et al. 2020 [20]	To assess the effect of travel restrictions on the national and international spread of the disease.	Transmission model study	Travel quarantine in Wuhan barely delayed the outbreak's growth by 3 to 5 days in mainland China, but it had a huge international impact, resulting in an 80% reduction. 90% of travel restrictions to and from mainland China have just a minor impact on the epidemic trajectory unless accompanied by a 50% or greater reduction in community transmission.
Samui et al. 2020 [37]	Predict the dynamics of transmission of the COVID-19 pandemic in India.	Compartmental mathematical modelling study	Travel quarantine in Wuhan barely delayed the outbreak's growth by 3 to 5 days in mainland China, but it had a huge international impact, resulting in an 80% reduction. 90% of travel restrictions to and from

			mainland China have just a minor impact on the epidemic trajectory unless accompanied by a 50% or greater reduction in community transmission.
Wu et al. 2020 [21]	The scale of the Wuhan outbreak was estimated based on the number of cases entering places outside mainland China, along with the extent of the epidemic and preventive measures involved.	Transmission model study	As of January 25, 2020, 75,815 people in Wuhan were infected with 2019-nCoV, with a basic reproductive number of 2.68. The outbreak had a doubling time of 6.4 days. Chongqing, Beijing, Shanghai, Guangzhou, and Shenzhen imported 461, 113, 98, 11, and 80 infections from Wuhan, respectively. Independent self-sustaining epidemics in key cities around the world may become unavoidable due to the significant exportation of pre-symptomatic individuals and the lack of massive-scale health surveillance. Preparedness measures and mitigation strategies should have been ready.
Wells et al. 2021 [44]	Determined the possibility of post-quarantine transfer of infection by using tests for travel quarantine, quarantine of tracked contact, and quarantine of cases with an established duration of exposure.		Testing on leave or entry can cut the period of a 14-day quarantine in half while testing on entering reduces the quarantine to just one day. Shorter quarantines can be more successful when testing is done at the appropriate time.
Khajanchi et al. 2021 [34]	Assessed the effect of mathematical modelling on the COVID-19 pandemic with various intervention strategies.	Extended classical SEIR compartment.	The COVID-19 outbreak can be managed by reducing the disease transmission through contact tracking and hospitalization. Certain states develop exponentially, whereas others degrade with each new model example. There will be oscillatory dynamics in COVID-19 cases, and the sickness will become seasonal.
Tiwari et al. 2021 [68]	Assessed the dynamics of COVID-19 and the role of media awareness as a measure to control the coronavirus infection in varied subclasses (susceptible, asymptomatic infectives, aware susceptible and symptomatic infectives (also referred to as isolated infectives which are under treatment/hospitalized)	Compartmental model	Under specific conditions, the endemic equilibrium was discovered to be both locally and non-linearly asymptotically stable. Increasing people's awareness lessens their chances of contracting the coronavirus and alters their attitudes and behaviours. Furthermore, a person's behavioural response to global awareness efforts speeds up the rate at which symptomatic people are brought to hospitals and motivates asymptomatic people to take health precautions like social distancing and self-isolation. Raising awareness using digital platforms should become standard practice in

			India in order to reduce the number of ailments.
Sarkar et al. 2022 [17]	Investigated environmental contamination’s effect on the coronavirus pandemic’s spread through a mathematical model.		The study found that increasing immunisation of sensitive populations, hospitalising diseased persons, and reducing environmental pollution can all help to reduce disease prevalence. Furthermore, we notice that a seasonal pattern in illness transmission contributes to the pandemic’s endurance in the population throughout time. Numerical graphics show that as environmental contamination rates climbed, so did the number of affected people. However, if the setting is cleansed through sanitization, the number of diseased individuals cannot significantly grow.
Rai et al. 2022 [38]	Provide a statistical methodology for assessing the efficiency of social media marketing in containing coronavirus in India.		Raising awareness lessens the likelihood of being exposed to the coronavirus and alters attitudes and behaviours. Furthermore, a person’s behavioural response to global awareness initiatives accelerates the rate at which symptomatic people are brought to hospitals and motivates asymptomatic people to follow health precautions including social distancing and self-isolation. It is critical to adopt non-pharmaceutical intervention approaches like as isolation and quarantine to reduce the fundamental reproduction number below one. To reduce the number of infections in India, it should be standard practice to spread knowledge using social media platforms and use of the internet.

Table 4. CDC criteria based on the symptom-based strategy exiting isolation and its flaws and advantages [52–68].

CDC criteria based on the symptom-based strategy	Flaws/ advantages of the criteria
Patients with mild to moderate symptoms: Discontinue isolation if 10 days have elapsed since the commencement of symptoms, at least 24 hours have passed with no fever (without consumption of fever-reducing medications), and other symptoms have improved [56].	The major flaw in this could be that individuals may exit the quarantine center if they are asymptomatic or in the pre-symptomatic stage
Patients with severe symptoms: The duration of the isolation is extended up to 20 days from the commencement of symptoms [56–61].	Mental/ Financial. Problems associated with long quarantine/isolation
Asymptomatic patients: Discontinue isolation after 10 days since their first positive RT-PCR test. The key here is the time at which the RT-PCR is done.	If the RT-PCR is done when the virus is in the incubation stage or the viral load is sufficient to be

	detected, then the chances of allowing a possible contact to exit the isolation are high.
If an individual comes in contact with a patient with COVID-19 infection, one should isolate at home for a minimum of 14 days from the time of exposure.	The main problem here is the efficiency of residential isolation and quarantine, as well as the likelihood that the contact will become sick and report the disease later. There is a significant likelihood of people leaving the house while maintaining social distance within it. This raises the rate of home transmission and subsequent transfer of infection.
Additionally, the results obtained from using an FDA-authorized molecular viral assay to detect SARS-CoV-2 RNA should be negative from at least two consecutive respiratory specimens collected ≥ 24 hours apart (total of 2 negative specimens).	With the increased cost of testing, however, the chances of missing the infected individual are less [65]
For immunocompromised patients, the recovery of the replication-competent virus has been reported to last as long as 143 days after a positive SARS-CoV-2 test. Therefore, in such patients, a symptom-based strategy is not recommended. A test-based strategy should be considered in severely immunocompromised patients, such as patients who are on chemotherapy, undergoing organ transplantation, untreated HIV infection, and receiving prednisone $>20\text{mg/day}$ for more than 14 days.	Reduced mortality rate
Quarantine was not recommended for asymptomatic residents who were up to date with all COVID-19 vaccine doses or who had recovered from SARS-CoV-2 infection in the prior 90 days. For people who are unvaccinated or are more than six months out from their second mRNA dose (or more than 2 months after the J&J vaccine) and not yet boosted, CDC later recommended quarantine for 5 days followed by strict mask use for an additional 5 days.	Increased risk of becoming symptomatic and spreading infection to other
Alternatively, if a 5-day quarantine is not feasible, an exposed person must wear a well-fitting mask at all times when around others for 10 days after exposure. Individuals who have received their booster shot need to quarantine the following exposure but should wear a mask for 10 days after the exposure. For all those exposed to contagion, it is recommended to test for SARS-CoV-2 on day 5 of the exposure. If symptoms develop, individuals should quarantine immediately and exist only after a negative test	Chances of developing symptoms after 5 days and increased risk of spread of infection

Any decrease in the duration of a traced contact's quarantine period, according to Ashcroft et al. (2021), will raise the risk of transmission from that person if they are infected, albeit the exact amount of the reduction will determine how much. The anticipated transmission that the quarantine stops demonstrates the decreasing benefit of lengthening the quarantine. Extending the quarantine period beyond ten days yields essentially no extra advantages. The conventional quarantine technique can prevent a maximum of 90.8% of onward transmission from an infected traced contact; 90.1% can be prevented by release on day 10. Shorter-term quarantines may work better when implemented with the test-and-release method. Compared with a 10-day quarantine period, screening on the fifth day and discharging on the seventh day eliminates 98.5% of local transmission. Around 97.2 percent of local transmissions are still prevented by testing and releasing on day six, that is, without a wait between test and outcome. As a result, if the fast test has the same sensitivity and specificity as the

laboratory-based RT-PCR test, the length of quarantine for people with a negative test result can be reduced by one day without sacrificing efficacy. However, several criteria, including the economy, the length of the incubation period, the risk-benefit ratio, and the accessibility of COVID-19 vaccines and medications, were considered before reducing the quarantine from 2 to 1 week [53–59].

However, one should note that quarantine restrictions should be reduced gradually. The reduction in quarantine should happen only when the level of infection reaches a certain low point and should never reach a state of no quarantine policy. This implies that some protective measures, such as masking, social distancing, avoiding mass gatherings, and maintaining personal hygiene and infection control practices at home and office should be continued even towards the end of the pandemic. One of the most crucial points is when to allow the asymptomatic and mildly symptomatic patients to exit quarantine. Therefore, who can exist in quarantine is a crucial question and one should understand that mandatory completion of quarantine for symptomatic and asymptomatic individuals is necessary.

Impact of Quarantine and Isolation on Public

Prolonged isolation/quarantine has many negative impacts such as considerable financial strain, psychological/ mental issues, social stigma, and loss of livelihood. Stress, anxiety, and long-term psychological issues in the form of traumatic stress, confusion, depression, anger, and greater incidences of panic disorder have been reported with the long quarantine period [34–39]. The conditions of isolation or quarantine centers also affect the mental health of an individual entering isolation. Lack of hygiene, psychological issues associated with longer duration of isolation, fear of contracting the infection from other inmates, overcrowding for families, small room size, cramped physical conditions, poor air quality with risk of aerosol and surface contamination, repetitious food choices, inadequate basic supplies, and lack of information and services from the authorities are some of the common problem linked with poor compliance to isolation and quarantine. Hotel quarantine was associated with poorer mental health issues than quarantine in private dwellings [38,39]. Shelter in place or working quarantine have also been reported to have less psychological impact [ref:40]. Working quarantine for also been linked to stress and anxiety in healthcare workers. A great number of health professionals spent months away from their families out of concern about spreading COVID-19. Loneliness was exacerbated by working remotely and experiencing rejection from the community. Ly et al. (2022) conducted a qualitative survey and noted that the primary problem is identifying positive cases, lack of facilities for quarantine and isolation, lack of physical space for building new facilities, and lack of financial resources to assist individuals during isolation and quarantine. Changes in societal behaviors and norms, fear of stigma, poor literacy rates, and language limitations have all been identified as problems associated with isolation and quarantine [58].

Poor community support, a lack of additional benefits, strict isolation/quarantine rules, non-adherence to self-isolating measures, an inclination or need to leave the house for chores and work, a lack of access to tests, and distrust in the government are all associated with failure to adhere to isolation and quarantine [46]. Studies have reported that only 69 (77%) patients completed follow-up, of these only 32 (46%) went outside to buy groceries (36%), to the workplace (9%), visit others (6%), or miscellaneous reasons (12%). More than half of the patients did not complete the quarantine period. The responsibilities for children, poor knowledge, and awareness about the COVID-19 infection were some of the common factors for not following the isolation/quarantine measures. It was also noted that lower socioeconomic status were less likely to follow the measures, but they were less compliant with the policies. The compliance is significantly higher among symptomatic patients than among those who were asymptomatic. Hence, constant education, increasing awareness, reminders to patients regarding the need for quarantine and how to adopt effective quarantine/isolation measures, and establishing a link between patients to various food programs, financial assistance, and other community resources could help to improve their compliance with quarantine and isolation. Some of the common examples of government initiatives that provided social security to the people were the “take care” initiative (New York) and “test-to-care” (San Francisco) [48–57]

Conclusions

Prompt and effective quarantine and isolation strategies complemented with active contact tracing are more effective than isolation and quarantine alone. However, for quarantine and isolation to work effectively, the public, policymakers, and government need to understand the key difference between quarantine and isolation, the right protocol, and the time to implement these measures. Balancing the negative repercussions of isolation and quarantine and striking a delicate balance between restriction and freedom of people is crucial. The lessons learned from our mistakes will prepare us to control future infectious diseases like COVID-19 more effectively.

Declarations

Author Contributions: Conceptualization: AC, SD. Data curation: AC, SD, KS, SG. Formal analysis: AC, SD, KS. Methodology: AC, SD, KS, SG. Writing – original draft: AC, SD, KS, SG. Writing – review & editing: AC, SD, KS, SG. Tables: AC, SD, KS. All authors have reviewed and approved the final manuscript

Funding: None

Institutional Review Board Statement: Not applicable

Informed Consent Statement: All authors agree to publish the manuscript in the present form

Data Availability Statement: data is available upon request upon email to Dr. Aditi Chopra (aditi.chopra@manipal.edu)

Acknowledgments: None

Conflicts of Interest: No potential conflict of Interest to be reported by any of the authors

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