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A Review on COVID-19 Quarantine

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Abstract

As COVID-19 spreads around the globe, the governments have imposed quarantines and travel bans on an unprecedented scale. They are often the first response against new infectious diseases. However, these old tools are usually of limited utility for highly transmissible diseases, and if imposed with too heavy a hand, or in too haphazard a manner, they can be counterproductive. In public health practice, "quarantine" refers to the separation of persons who have been exposed to an infectious disease. In order to clarify the extent to which an ideal quarantine measure suppresses epidemics, a review on several studies, considers a simple case in which an individual is detected and its neighbors are promptly quarantined. A well mixed "susceptible exposed infectious recovered" (SEIR) compartmental model was employed to described the dynamics of the COVID-19, and quarantine intervention measures of the authority. Considering infected individuals as contagious during the latency period, the well-mixed SEIR model fitting results based on the assumed contact rates of latent individuals are within 6-18, which represented the possible impact of quarantine and isolation interventions on disease infections. The reviews revealed that by reducing the contact rate of latent individuals, interventions such as quarantine and isolation can effectively reduce the potential peak number of COVID-19 infections and delay the time of peak infection.

Keywords: COVID-19; SEIR compartmental model; Latent individuals; Quarantine; Disease; Contact rate.

Introduction

Quarantine is one of the best method for preventing communicable diseases which has been practicing for so many years in times of public health importance. It is defined as to separate and restrict the movement of well persons who may have been exposed to a communicable disease to see if they become ill. Quarantine now is managed by the Division of Global migration and quarantine, a part of CDC's National Center for emerging and zoonotic infectious diseases. Its headquarters is in Atlanta. It's main purpose is to detain, .medically examine, or conditionally release individuals and wildlife suspected of carrying a communicable disease.[1]

Types:

1. Voluntary quarantine(self-quarantine)
2. Mandatory quarantine- private residence, hospital, public institution and others (cruise ships etc.)
3. Other measures- Avoiding crowding, hand hygiene, isolation, Personal protective equipments, school measures/ closures, social distancing, workplace measures/ closures.[2]

List of quarantinable diseases

1. Cholera
2. Diphtheria
3. TB
4. Plague
5. Smallpox
6. Yellow fever
7. Viral hemorrhagic fever

8. SARS
9. Flu[3]

The international sanitary regulations:

- WHA in 1948 replace the multiplicity of conventions by a single code based on epidemiological principles and to provide an international instrument.
- In article 21, the regulations concerning sanitary and quarantine requirements are given.
- In 1950 a draft of international sanitary regulationswas prepared by expert committee was sent to all member states. There are total 21 states have submitted their reservations.
- In 2017, the agency issued new quarantine regulations (codified in 42 Code of Federal Regulations (CFR), parts 70 and 71) suggesting that CDC may isolate, quarantine, examine or bar travel of anyone within the country who CDC officials reasonably believe may bring a communicable disease into the country or spread it across the stateliness.
- Though the CDC's quarantine powers permit it to deny entry into the United States for a quarantinable disease, President Trump relied on Sections 212(f) and 215 (a) of the Immigration and Naturalization Act to ban Chinese and Iranian nationals from entering the country.(1)

Areas covering

International transport- ships, aircraft, trains and road vehicles. It deals with maintaining sanitary conditions and taking measures against diseases at seaports and airports open to international traffic, arrival and departure, sanitary documents (It is defined as the certificates of vaccination, drafting or drafting exemption certificate and the health declarations for ships and aircraft) and charges.[4]

Provisions

1. Protection against qurantinablediseases. Eg. Plague, cholera, yellow fever, small pox, blood-borne typhus and blood-borne relapsing fever.
2. Vaccination
3. Mecca pilgrimage
4. The effective working of international quarantine requires complete, reliable and up to date information on the appearance, presence and termination of quarantinablediseases in each state and territory.
5. National health administrations should notify WHO of the appearance of quarantine diseases in their territory, send supplementary reports of the disease continues to be present.
6. Information collated by WHO quarantine and information services at Geneva, Singapore, Washington and Alexanndriaby spreading information to all countries through network of epidemiological radio-telegraphic communication.[5]

Emporiatrics

It is the science deals with promoting and protecting the health of international travelers, providing advice. The Quarantine stations are located at 20 pots in U.S. It's main responsibility is to enforce foreign quarantine regulations at all ports of entry. The Legislations include,

1. Federal law- the section 361 of Public health service Act. Is amended to take measures to prevent the entry and spread of communicable diseases from foreign countries into the U.S and between states.

2. CDC's role- The 42 code of Federal regulations parts 70 and 71, CDC is authorized to detain, medically examine and release persons arriving into the U.S and travelling between states.

3. State, local and Tribal law- All these have police power functions to protect the health, safety and welfare of persons within their borders.[6]

Psychological effects of quarantine

1. Acute stress disorder
2. Insomnia
3. Irritability
4. Feeling of anger[7]

Models of quarantine

Theoretically studies for epidemiological models demonstrated that infectious diseases could spread very easily in highly heterogeneous networks. Specifically two fundamental epidemic models, namely the susceptible infected removed model(SIR) and the susceptible infected susceptible model, exhibit outbreaks of finite relative sizes with an infinitesimal infection rate.[8]

A discrete-time SIR model

For a given network with N nodes, each node corresponds to one of the following three states: susceptible(S), infected (I), or removed (R). Any S node can be infected by contact with adjacent I nodes. An I node infects each of its S neighbors independently with probability T and then spontaneously becomes R. A node that changes to the state R loses its capability to infect other nodes and does not change its state any further. The dynamics of the whole system is as follows:

1. Randomly select a node as a seed. As an initial configuration, all nodes except the seed are set to S, and the seed is set to I.
2. Randomly select an I node i. compile a new list of the S neighbors of node i. randomly select a node from the list and change its state from S to I with probability T. repeat this procedure until the list is empty, and then change the state of node i to R.
3. Continue step (2) until I nodes cease to exist. That is, each node belongs to either S or R state in a final configuration.[9]

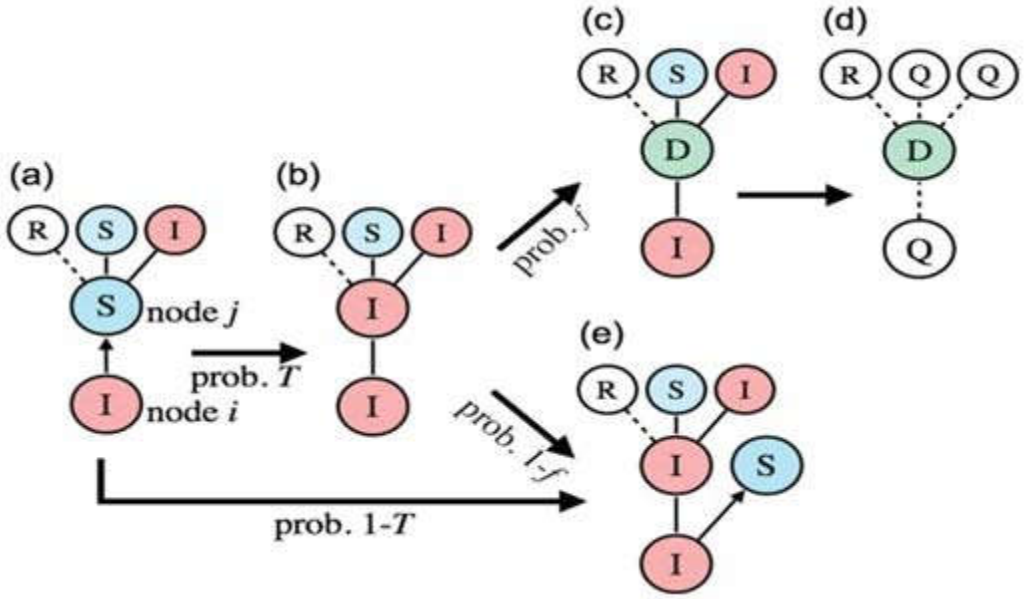


Fig. 1: Transition rules of the SIR Model with quarantine measures. (a) A node j is randomly selected among the susceptible eighbors of infected node I. (b) with probability T, disease is transmitted from I to j. Immediately after (b),(c) this newly infected node J is detected with probability f, and (d) node j and its susceptible and infected neighbors (including node I) are promptly isolated. (e) If node j is not detected, node I tries to infect the next susceptible neighbour.

SEIQR MODEL

Another study using this model found that social-distancing (actions which increase physical distance between individuals such as canceling public activities, and postponing festivals and school reopening) could significantly mitigate the epidemic size in mainland China and epicenter lockdown would partially neutralize this favourable effect. Therefore, social distancing strategy without epicenter lockdown would be more feasible and cost-effective.[10]

The well-mixed SEIR compartmental model

A well-mixed susceptible exposed infectious recovered SEIR compartmental model was applied to describe the dynamics of the COVID-19 epidemic process, based on the epidemiological characteristics of individuals, clinical progression of COVID-19, and quarantine intervention measures of the authority. The model was parameterixed by the data obtained from confirmed and suspected cares of COVID-19 reported by regions and provinces in China. The model was used to estimate the dynamics of COVID-19 in Wuhan city.

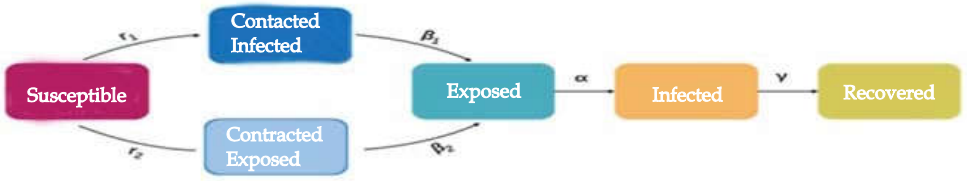
COVID-19 has an incubation period, and exposed people with no symptoms can carry SARS-COV-2, unlike SARSr-CoV. COVID-19 is contagious during the incubation period; therefore, the SEIR compartmental model was modified in the present study. For the well-mixed SEIRS model, the population under consideration is represented by 4 groups of individuals: susceptible (S) (vulnerable to SARS-CoV-2 infection), exposed (E) (latent individuals and those capable of spreading SARS-CoV-2, infectious (I) (symptomatic, capable of spreading SARS-CoV-2), and recovered (R) (immune to the SARS-CoV-2. The contact rates, r1 and r2, which represent the probabilityof susceptible persons coming into contact with infected individual and latent individuals being infected, respectively. The infected rates, β1 and β2, control the rate of spread. In this situation, β1 represents the probability of infection per exposure when a susceptible individual (S) has contacted with an infected patient (I) and becomes a latent exposed individual (E). While β2 represents the potential rate per exposure that a susceptible individual (S) has mutual contact with an exposed individual (E), and transmits to another exposed individual (E). since there are controversies about the transmissibility of latent infection, we can assume that the half of these asymptomatic latent infections were infectious.[11]

$$dS/d\,t=-r_1\beta_1 IS/N-r_2\beta_2 ES/N$$

$$dE/dt=r_1\beta IS/N-\alpha E+r_2\beta_2 ES/N$$

$$dI/dt=\alpha E-\gamma I$$

$$dR/dt=\gamma I$$



SEIO (MH) MODEL

Some studies used this model which shows that Wuhan lockdown decreased the R0 from 2.65 to 1.98. it was predicted that by implementing city lockdownseven days earlier, the total number of infected people would have dropped by 72%. Delaying 1-6 days would expand the epidemic size by even 5-times, while with 7 days of postponing lockdown implementation, the epidemic would be out of control.[12]

Metapopulation model

Several studies used metapopulationn models estimated that a 50% reduction in inter-city mobility would have a negligible effect. Also, with 25% transmissibility reduction and 50% reduction in tercity transmission, the peak of confirmed cases will dip by 50% in Wuhan city.[13]

Conclusion:

Based on the above models, many studies showed that the strict quarantine strategies in China such as home quarantine, traffic restrictions and travel bans, extension of thenewyear vacations and delay in returning to work significantly decreased the transmission of infection in the community and were highly successful in controlling the initial stages of epidemic spreading. Other studies also confirmed that positive effect of implementing mass quarantine and movement limitations in China during the COVID-19 epidemic. The findings of the present review showed good quality evidence for effectiveness of mass quarantine during the current stage of COVID-19 pandemic. However further investigations are required in the future.

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