The estimate of infected individuals of the 2019-Novel Coronavirus in South Korea by incoming international students from the countries of risk of 2019-Novel Coronavirus: a simulation study

Sukhyun Ryu[1, 2], Sheikh Taslim Ali[3], Jun-sik Lim[4], Byung Chul Chun[2,5]

1. Department of Preventive Medicine, College of Medicine, Konyang University, Daejeon; gentryu@onehealth.or.kr

2. Korean Society of Epidemiology 2019-nCoV Task Force Team

3. WHO Collaborating Centre for Infectious Disease Epidemiology and Control, School of Public Health, Li Ka Shing Faculty of Medicine, The University of Hong Kong, Hong Kong Special Administrative Region, China; alist15@hku.hk

4. Department of Public Health Science, Graduate School of Public Health, Seoul National University, Seoul; borizook@onehealth.or.kr

5. Department of Preventive Medicine, Korea University College of Medicine, Seoul, Korea; chun@korea.ac.kr

Abstract

Objectives: Overall, 37000 international students from the country of risk of 2019 Novel Coronavirus (COVID-19) will arrive in South Korea. The individuals from the country of risk of COVID-19 are included a home-quarantine program, but the efficacy of the program is uncertain.

Methods: To estimate the possible number of infected individuals due to the large influx of international students, the deterministic compartment was modeled by different compliance of home-quarantine.

Results: Our findings, under the strict compliance of quarantine for the incoming international students, indicate it is less likely to occur epidemics in South Korea.

1

Conclusion: To mitigate possible epidemics, considerable public health resources with high compliance of quarantine are needed.

Introduction

The respiratory virus has been threatened three times in South Korea since the 21st century; SARS (Severe Acute Respiratory Virus- Coronavirus), MERS (Middle East Respiratory Virus- Corona virus) and 2019 Novel Coronavirus (COVID-19). Since the first identified individual of COVID-19 infection on 20 January 2020 in South Korea, the number of laboratory-confirmed individuals is increasing as of February 12, 2020 (1). To reduce the incoming possible exposed individuals of COVID-19 from Wuhan, China, international travel ban departed from Hubei province, China to South Korea has been implemented on February 3, 2020 (2) (Figure 1). Furthermore, to identify the potentially exposed individuals of COVID-19, the Korean public health authority has been operated a quarantine program. The target individual of quarantine defined as the person who traveled from the country of risk of COVID-19 infection within 14 days or who contacted laboratory-confirmed COVID-19 infected persons within 14 days (3). The quarantined individuals are asked to comply with home quarantine and are monitored by the local public health workers twice a day for 14 days after contact with the infected individuals (3).

On 14 February 2020, Korean public health authority identified an individual of COVID-19 infection and the patient was contacted with a suspected individual who avoided the quarantine program during his period of self-quarantine. Previous literature demonstrated the effectiveness of quarantine is highly likely varied due to the individuals' daily motility patterns (4); however, the compliance of self-quarantine is still in question.

Overall, 37000 international students from China, where major Chinese cities are likely sustaining localized outbreaks (5), will join the spring semester in Seoul, Korea on March 1, 2020. Therefore, this large number of incoming young individuals departing from the Country of risk of COVID-19 is a potential threat to occur local transmission in South Korea.

2

Here, we aimed to estimate the number of infected individuals in Seoul, Korea by different compliance of self-quarantine of those incoming international students. Our study provides evidence of the public health resources taken for the epidemic preparedness to be the best for public health authorities.

Materials and Methods

To simulate the possible epidemics, we used the deterministic compartment model of susceptible-exposed-infectious-removed (SEIR) type (see the Supplementary Appendix). We assumed that the population mixed homogenously, and there had been no COVID-19 transmission occurred in the community in South Korea.

We assumed the 0.2, 1, or 3% of the incoming international students is the pre-infectious period in which previous literature reported that asymptomatic fraction of SARS is 0.2-3% (6, 7). We also assumed that the international students would arrive in Seoul, Korea in 15 days before and following 1 March 2020 and there is no individual isolated during the entry screening at their arrival. Furthermore, all of them are quarantined at home or university dormitory according to the current Korean quarantine program of COVID-19 by the local public health authority. The baseline scenarios of a currently identified number of imported infected persons from China of 12 as of 6 February 2020 with the assumption of 90% compliance of home-quarantine during their pre-infectious period. The different scenarios with the different compliance of quarantine for 70, 80, or 90% among those international students were modeled as well (i.e., Upon the arrival of international student from country of risk of COVID-19 infection, Korean public health authorities implemented quarantine them at home or university dormitory with the compliance of 70, 80, or 90%). We consider the time horizon of 180 days for the number of individuals infected and quarantined since 20 January when the first COVID-19 identified in South Korea. The

parameter values of our model obtained from previous studies are shown in Supplement

Appendix.

Results

We estimated that the total number of infected individuals reached at 38-67 on 8 March-14

March, 184-280 on 12 March-23 March, and 546-813 on 13 March-22 March with the arrival of

0.2%, 1% or 3% of pre-infectious individuals arrived, respectively in Seoul, Korea (Figure 2).

We also estimated the number of individuals isolated from the Korean quarantine program was

peaked at 38-64 on 9-22 March, 182-268 on 12 March – 25 March, and 539-780 on 12 March -23

March, with the arrival of 0.2%, 1% or 3% of pre-infectious individuals arrived, respectively in

Seoul, Korea (Figure 3). The number of infected and isolated individuals is identified larger by

the higher fraction of the subclinical stage of COVID-19; however, the number of infected and

isolated individuals is smaller by higher efficacy of the quarantine program

Discussion

In the absence of effective vaccine and treatment of infectious disease, quarantine of suspected

individuals of infection including exposed persons of infection from epidemic countries has been

used as one of the mitigation strategies implemented by public health authorities (8, 9).

The laboratory-confirmed individuals of COVID-19 infection are increasing in China and other

countries in Asia. In South Korea, the likelihood of local transmission is increasing by travelers

from COVID-19 affected countries.

The quarantine of possibly exposed individuals of COVID-19 is an efficient public health

strategy to reduce the transmission using limited public health resources because unidentified

infected individuals are highly likely to be identified among the exposed individuals of infectious

diseases (9). Therefore, it is crucial to estimate the number of infected individuals by the different

compliance of self-quarantine to provide relevant evidence to public health authorities in order to improve the compliance of the quarantine program for the international students in advance.

In South Korea, the individuals contacted with the infected person were asked to comply with home quarantine and were monitored by the local public health workers twice a day for 14 days after contact with the infected individuals (3). The individuals who were not included in the quarantine program but experienced with any possible contact were encouraged to notify the public health authorities and able them to be quarantined. All the daily necessities have been provided to all quarantined individuals by the public health authorities to avoid possible contact with any susceptible population as the law is indicated. Therefore, the current Korean quarantine program is a very broad and large number of persons included. However, due to the lack of public health resources, the quarantine program for the incoming international students will be monitored by the education authority which has a lack of experience of the disease control. This may affect the efficacy of quarantine and the number of infected and isolated individuals as well. Our findings indicate that it is less likely to occur epidemics in South Korea due to the incoming international students; however, the number of infected and isolated individuals increased by mid or late of March.

Our results indicate that it is less likely to occur epidemics in South Korea due to the incoming international students. However, this may consume a large number of public health resources including monitoring individuals quarantined and isolation of infected individuals.

There are several limitations to this study. First, some of the parameter including the latent period and rate of infection among contacted we used, was not identified from the COVID-19. This may affect the results. Second, we used the deterministic model which does not present a confidence interval. However, the deterministic model is a sufficient simulation method to model the dynamics of the number of infected individuals which is much smaller than the total population

5

(10). Third, we did not consider the transmission occurred before the symptom onset and the subclinical infection.

Conclusion

As public health resources are limited, quarantine of the possibly exposed individuals of COVID-19 is crucial for public health authorities to prevent local transmission. Strict quarantine for individuals from countries of risk for COVID-19 infection is important to reduce the number of infected individuals and prevent possible epidemics in the community.

Acknowledgments

Conflict of interests

We declare no competing interests

Funding source

Not applicable

Ethical approval

Not applicable

References

1.   Ryu S, Chun BC. Epidemiological characteristics of 2019 novel coronavirus: an interim review. Epidemiol Health. 2020;0(0):e2020006-0.

2.   Times TK. Korea to ban entry from visitors from Hubei Province. 2020.

3.   Welfare KMoHa. Response guideline for 2019 nCoV: Korean Ministry of Health and Welfare February 8, 2020.

4.   Sattenspiel L, Herring DA. Simulating the effect of quarantine on the spread of the 1918-19 flu in central Canada. Bull Math Biol. 2003 Jan;65(1):1-26.

5.   Wu JT, Leung K, Leung GM. Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study. The Lancet.

6.   Ip M, Chan PK, Lee N, Wu A, Ng TK, Chan L, et al. Seroprevalence of antibody to severe acute respiratory syndrome (SARS)-associated coronavirus among health care workers in SARS and non-SARS medical wards. Clin Infect Dis. 2004 Jun 15;38(12):e116-8.

7.   Leung GM, Chung PH, Tsang T, Lim W, Chan SK, Chau P, et al. SARS-CoV antibody prevalence in all Hong Kong patient contacts. Emerg Infect Dis. 2004 Sep;10(9):1653-6.

8.   Fraser C, Riley S, Anderson RM, Ferguson NM. Factors that make an infectious disease outbreak controllable. Proc Natl Acad Sci U S A. 2004 Apr 20;101(16):6146-51.

9.   Kenrad E. Nelson CMW. Infectious disease epidemiology. Third ed. Burlington, MA: Jones & Bartlett Learning.

10.   Ahmad MD, Usman M, Khan A, Imran M. Optimal control analysis of Ebola disease with control strategies of quarantine and vaccination. Infect Dis Poverty. 2016 Jul 13;5(1):72.
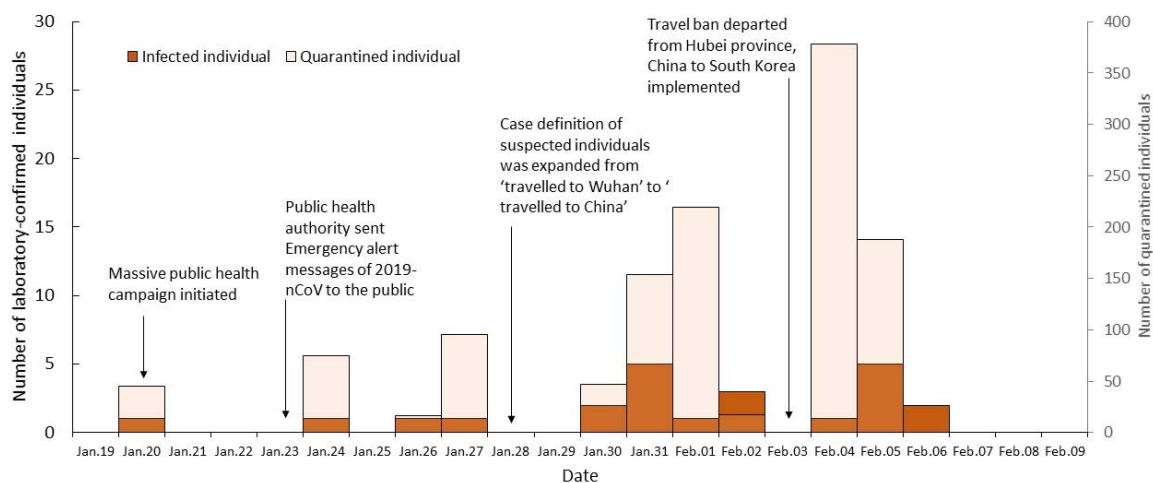
Figure 1. Timeline of the number of laboratory-confirmed individuals and number of individuals quarantined of 2019 Novel Coronavirus in South Korea
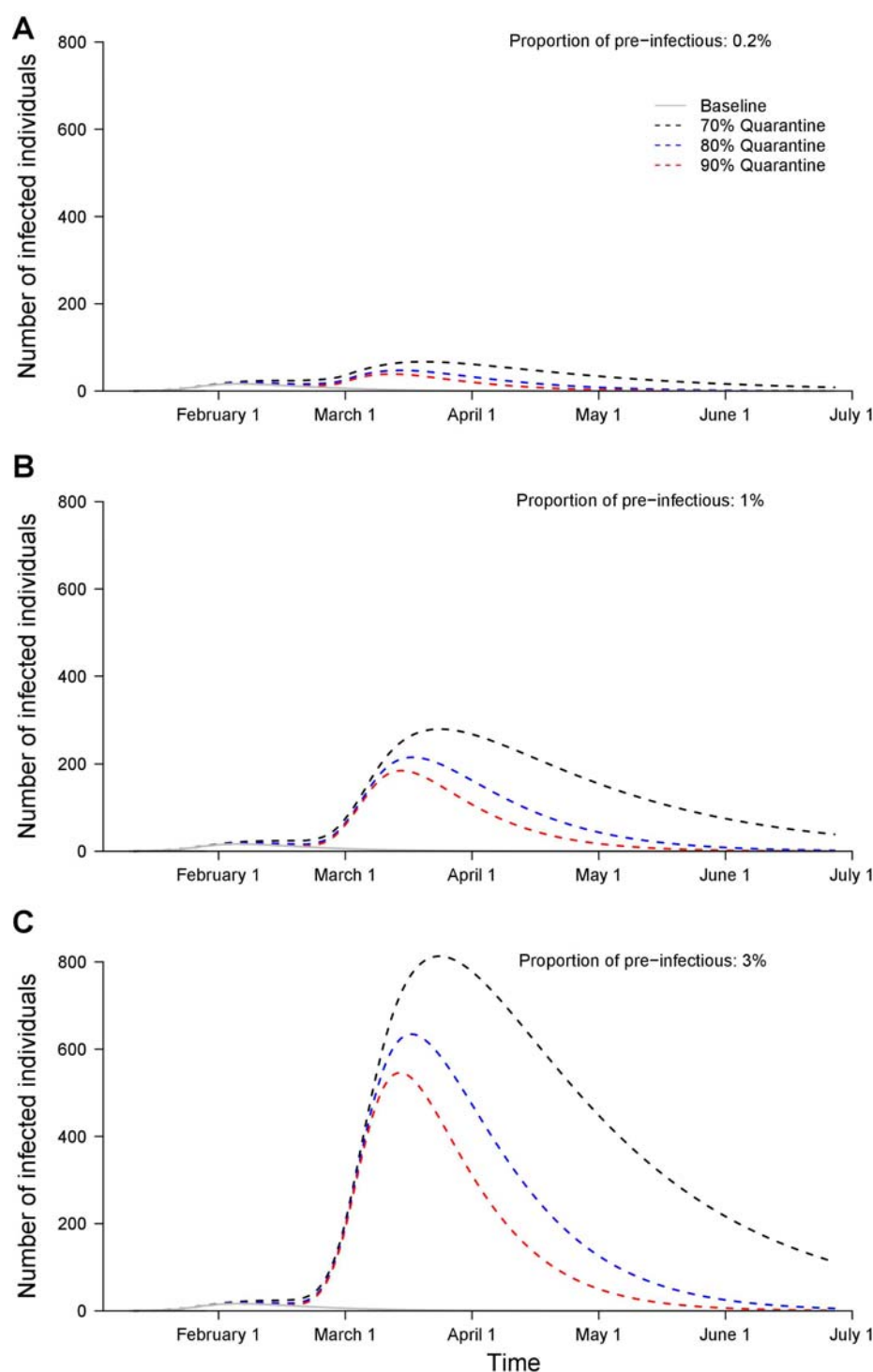
Figure 2. Estimated daily number of infected individuals in Seoul, Korea under the different scenarios of the proportion of pre-infectious individuals of 0.2% (a), 1% (b) or 3% (c) by the different compliance of home-quarantine (gray; 70%, black; 80%, blue; 60% red).
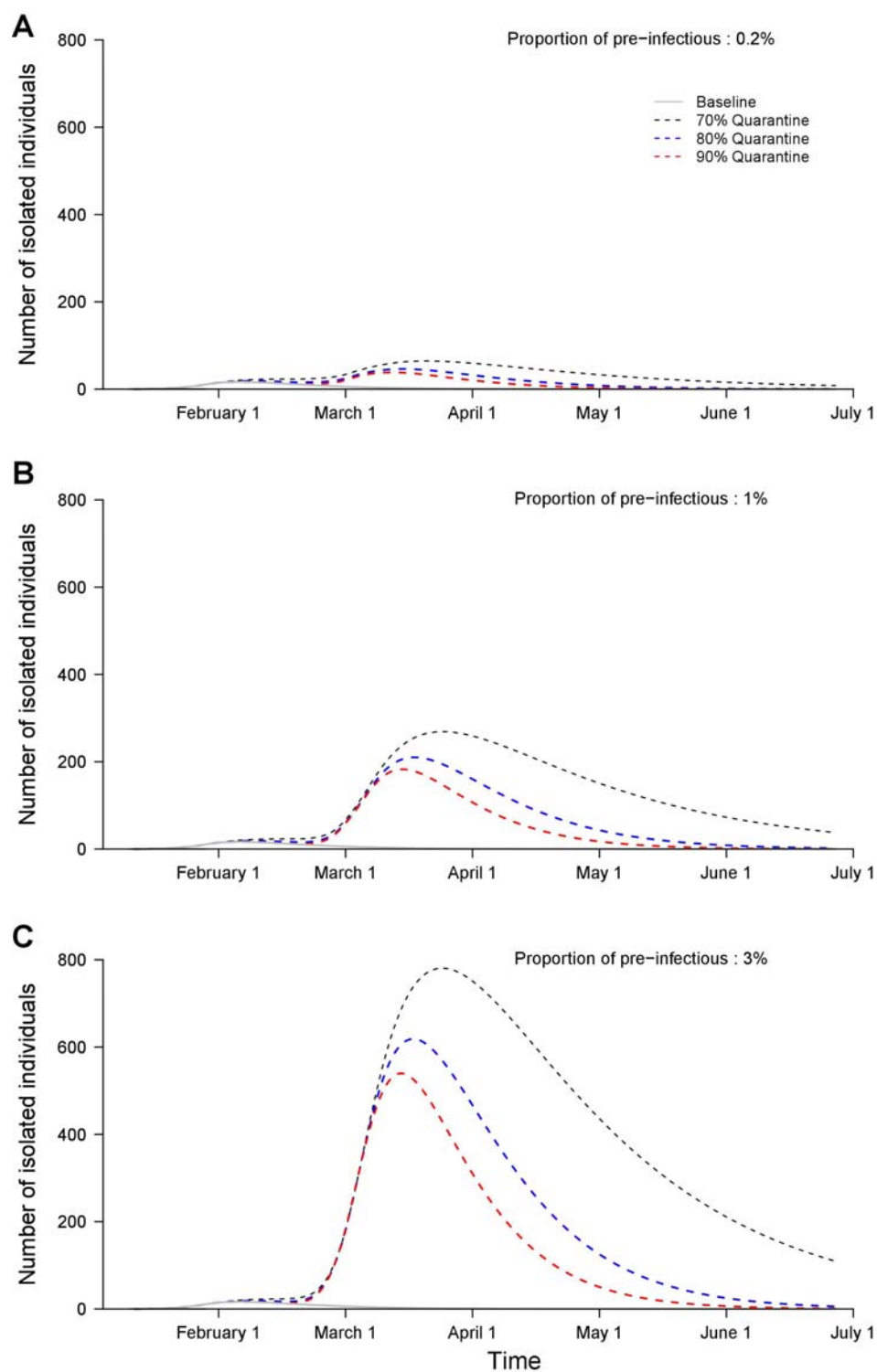
Figure 3. Estimated daily number of isolated individuals in Seoul, Korea under the different

scenarios of the proportion of pre-infectious individuals of 0.2% (a), 1% (b) or 3% (c) by the

different compliance of home-quarantine (gray; 70%, black; 80%, blue; 60% red).

10