Telehealth and Cost-effectiveness Analysis at a Centralized COVID-19 Quarantine Center in Taiwan: A Cohort Study

Yung-Feng Yen, Yi-Fan Tsai, Vincent Yi-Fong Su, Shang-Yih Chan, Wen-Ruey Yu, Hsuan Ho, Chu-Chieh Chen, Lin-Chung Woung, Sheng-Jean Huang

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Abstract

Background: Telehealth has been recommended for monitoring the progression of non-severe infections in patients with the coronavirus disease of 2019 (COVID-19). However, telehealth has not been widely implemented in monitoring severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection in quarantined individuals. Moreover, studies on the cost-effectiveness of the COVID-19 quarantine are scarce.

Objective: This cohort study aimed to use telehealth to monitor COVID-19 infections in 217 quarantined Taiwanese travelers and analyze the cost-effectiveness of the quarantine.

Methods: Travelers were quarantined for 14 days at the Taiwan Yangmingshan quarantine center and monitored until they were discharged. Travelers' clinical symptoms were evaluated twice daily. A multi-disciplinary medical team used the telehealth system to provide timely assistance for ill travelers. The cost of the mandatory quarantine was calculated according to data from the Ministry of Health and Welfare, Taiwan.

Results: In 217 quarantined travelers, the SARS-CoV-2 testing was negative upon admission to the quarantine center. During the quarantine, 28 (12.9%) travelers became ill and were evaluated via telehealth. Three travelers with fever were hospitalized after the telehealth assessment, and subsequent tests for COVID-19 were negative for all three patients. The total costs during the quarantine were 193,938 USD, which equated to 894 USD per individual.

Conclusions: Telehealth is an effective instrument in monitoring COVID-19 infection in quarantined travelers and could help provide timely disease management in those who are ill. It is imperative and cost-effective to screen and quarantine international travelers for SARS-COV-2 infection to reduce the nationwide spread of COVID-19.

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Conclusions: Telehealth is an effective instrument in monitoring COVID-19 infection in quarantined travelers and could help provide timely disease management in those who are ill. It is imperative to screen and quarantine international travelers for SARS-COV-2 infection to reduce the nationwide spread of COVID-19.

KEYWORDS: COVID-19; international travelers; quarantine; telehealth; cost-effectiveness

Introduction

The coronavirus disease 2019 (COVID-19) is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and was first detected in Wuhan, China in December 2019. It caused a rapidly accelerating global pandemic in 2020 [1]; and as of November 13, 2020, more than 51.8 million individuals have been infected with COVID-19 globally, with the official death toll reaching 1.3 million [2].

As the COVID-19 outbreak emerged, the Taiwanese government implemented several strategies to prevent the nationwide spread of COVID-19, including border controls, proactive screening measures, and quarantine procedures [3, 4]. According to the Taiwan Communicable Disease Control Act [5], as of January 2020, all international travelers who visited regions with a declared COVID-19 outbreak were to complete a 14-day mandatory quarantine. By November 13, 2020, 597 laboratory-confirmed COVID-19 cases were reported to Taiwan Centers for Disease Control (CDC), including 505 (84.6%) imported cases [6]. The national mortality rate in laboratory-confirmed COVID-19 cases was 1.2% [6].

Currently, there are no effective pharmacological interventions or vaccines available to treat or prevent COVID-19 [7, 8]. Therefore, nonpharmacological public health measures such as quarantine, isolation, social distancing, and community containment are the only effective ways to prevent and control the COVID-19 outbreak [9]. Quarantine is the most effective tool for controlling the COVID-19 outbreak [9], which refers to the restriction of asymptomatic healthy people who have had contact with confirmed or suspected COVID-19 cases. Quarantine can be voluntary or mandatory; and may be applied at an individual or group level. A recent Cochrane review showed that the quarantine strategy could significantly reduce the number of people infected with the novel coronavirus and decrease the number of COVID-19 related deaths [10].

During quarantine, all individuals should be monitored for the onset of any symptoms, or there is a risk of a delay in the detection and prompt management of the virus. Telehealth through a line of communication is an efficient way of monitoring quarantined individuals and could assist in providing timely care for those who require it [11]. Although telehealth has been recommended to screen COVID-19 patients at emergent department [12] and provide care for non-severe COVID-19 cases [13], it has not been widely implemented in the monitoring of COVID-19 infection in quarantined individuals.

Quarantine strategy has been used in many countries in an attempt to curb the ongoing COVID-19 pandemic. However, the cost-effectiveness of such strategies has not been extensively studied [10]. A current report indicates that the quarantine strategy is efficient in curbing the spread of COVID-19, and the cost of a quarantine strategy is cheaper than a lockdown of workplaces [14].

This cohort study reports on a model used for screening and quarantining Taiwanese travelers following an evacuation flight from Hubei, China. In this model, telehealth was used to monitor COVID-19 infection among the travelers at a centralized quarantine center, and the cost-effectiveness of the 14-day mandatory quarantine was analyzed..

Methods

Background Information and Study Subjects

In late January 2020, the Taiwanese government established a centralized quarantine center to screen and monitor COVID-19 infections in international travelers who had visited countries with a declared COVID-19 outbreak [5]. On March 30, 2020, the government of Taiwan arranged a special charter flight to evacuate Taiwanese travelers who had become stranded in Hubei, China; and return them to Taiwan. Upon arrival in Taiwan, the travelers proceeded to one of the largest national centralized quarantine centers, Taipei Yangmingshan, for the mandatory 14-day quarantine period. The Yangmingshan quarantine center included six quarantined wards on three floors.

This cohort study included all the passengers of the charter flight; who were subsequently followed up until their discharge from the quarantine center, or until April 15. This study was approved by the Institutional Review Board of Taipei City Hospital (no. TCHIRB- 10904014-E).

Infection Control Strategies

The body temperature of Taiwanese travelers was checked at the international airport in China and individuals with fever were not allowed to board the charter flight. All travelers were required to disinfect their hands with alcohol-based hand sanitizer at the boarding port; and to wear personal protective equipment (PPE) which included a face mask and medical gown provided by the Taiwanese government. Meals were not provided during the flight to avoid cross-infection between passengers.

Upon arrival at the international airport in Taiwan, the national chemical defense troops used a 1:10 diluted sodium hypochlorite solution (5000 ppm) to disinfect the travelers' luggage. The travelers then proceeded to the Yangmingshan quarantine center for the 14-day quarantine period. They were

required to record their body temperature twice daily with a thermometer which was provided to them. Additionally, daily meals were delivered to the individuals' rooms and janitors used a 1:10 diluted sodium hypochlorite solution to clean the quarantine center once daily.

COVID-19 Screening and Monitoring

During admission to the Yangmingshan centralized quarantine center, the travelers were screened for COVID-19 using a real-time reverse transcriptase–polymerase chain reaction (RT-PCR) test. If an individual tested positive for COVID-19, they were transferred to a hospital for medical isolation and treatment.

Travelers' clinical symptoms were recorded twice daily by their primary care nurses via telephonic communication. If an individual developed fever or became ill, a Multidisciplinary Team (MDT) consisting of 15 medical workers used telehealth to assess the travelers' condition.

Telehealth System

The telehealth system at the Yangmingshan quarantine center was developed on a popular social media app called LINE, which is a freeware app operated by the Naver Corporation in South Korea. The LINE-based telehealth system established two-way communication between the MDT and 217 quarantined travelers. Through a unique ID, the quarantined individuals were invited to join an official LINE group, in which the quarantined travelers could report their symptoms to the MDT members. When the MDT members received a message regarding the quarantined travelers' symptoms, the MDT members initiated a one-to-one video call through LINE to clinically evaluate the patient. MDT members collaboratively discussed the traveler's condition during the telehealth service and provided appropriate management and treatment interventions for the patient. If a quarantined traveler presented with fever or shortness of breath, the individual would be transferred

to the hospital for further treatment.

Manpower and Cost at Yangmingshan Quarantine Center

The manpower who were responsible for overseeing the travelers' quarantine at Yangmingshan quarantine center included a Multidisciplinary Team, police officers, janitors, a logistics group, and administration staff. The MDT consisted of three doctors, ten nurses, a pharmacist, and a psychologist. Three physicians, including a general practitioner, a pediatrician, and a cardiologist, gave treatment advice according to the travelers' condition during the telehealth services. Ten nurses were responsible for taking care of travelers during the 12-hour day and night shifts in the six quarantined wards. The nurses communicated daily with quarantined travelers to evaluate their clinical condition and record their body temperature. Pharmacists delivered medications to ill quarantined travelers. Physicians and nurses wore PPE when examining the travelers in person.

Police officers were responsible for the security of travelers at five sentries and ensured that all travelers obeyed the COVID-19 quarantine rules and completed the 14-day mandatory quarantine order. In total, 18 police officers were divided into three groups, which included one leader in each group. Three groups of police officers worked in 12-hour day and night shifts. Three janitors were responsible for environmental disinfection in the six quarantined wards, and one janitor was responsible for two quarantined wards on one floor. The logistics group, made up of ten people, was responsible for meal preparation and ensuring that sufficient supplies were provided for the 217 travelers during the 14-day quarantine.

The cost of the quarantine for the travelers at the Yangmingshan quarantine center was covered by the disaster reserve in the national Ministry of Health and Welfare, which included the payment of the multi-disciplinary medical team, non-medical personnel, and telehealth services, as well as the

provision of PPE.

Statistical Analysis

First, participants' demographic data were analyzed. Continuous data are presented as means (standard deviations [SD]), and two-sample t-tests were used for comparisons between groups. Categorical data were analyzed with Pearson's χ^2-tests where appropriate.

A timeline infographic was used to display the progression of clinical symptoms in hospitalized travelers. The labor and overall costs of the quarantine were calculated according to the disaster reserve data from the Taiwan Ministry of Health and Welfare. All data management and analyses were performed using SPSS 19.0 (SPSS, Chicago IL, USA) software packages.

Results

Participants Selection and Epidemiologic Features

This sample comprised 217 Taiwanese travelers who were stranded in Hubei, China due to the COVID-19 pandemic and returned to Taiwan on March 30, 2020 (Figure 1). The mean age of the sample was 30.0 (*SD* = 19.4) years, and 130 of the 217 subjects (59.9%) were female. All travelers tested negative for COVID-19 by an RT-PCR throat swab upon admission to the Taipei Yangmingshan quarantine center. During the 14-day quarantine, 28 of 217 travelers (13%) received telehealth consultations due to illness.

Characteristics of Quarantined Travelers with and without Telehealth

Table 1 shows the characteristics of quarantined travelers with and without telehealth. There was no significant difference in age and sex in quarantined travelers with and without telehealth. Three travelers had fever and received clinical assessment using telehealth during the 14-day quarantine period.

Symptoms and Management in Quarantined Travelers Receiving Telehealth

The symptoms and management of quarantined travelers receiving telehealth were recorded during the 14-day mandatory quarantine (Multimedia Appendix 1). The most common symptoms requiring telehealth consultations in quarantined travelers were fever (n=3), diarrhea (n=3), toothache (n=3), and skin rashes (n=3). Three travelers developed fever during the 14-day quarantine period and were hospitalized after the telehealth assessment.

Of 28 quarantined travelers with telehealth, one traveler with diabetes presented with dizziness and weakness on the fifth day and was suspected to be hypoglycemic during the telehealth clinical evaluation. The patient’s blood glucose test indicated a level of 75 mg/dl when healthcare workers

wearing PPE visited this individual.

Clinical Features in Hospitalized Patients

Figure 2 shows the progression of clinical symptoms in three hospitalized travelers. One traveler developed fever and illness two days after quarantine and another two travelers had fever three days after being admitted to the centralized quarantine center. Chest x-rays of all three patients were negative for pneumonia. Moreover, a second round of SARS-CoV-2 testing by RT-PCR throat swab was negative for COVID-19 in all three individuals. They were subsequently discharged from the hospital on April 5, and returned to the Yangmingshan quarantine center to complete the mandatory quarantine.

Cost Analysis during the 14-day Mandatory Quarantine in Taiwanese Travelers

Table 2 shows the labor and overall cost incurred during the 14-day mandatory quarantine. The major manpower consisted of police officers (n=18), followed by the MDT (n=15). Moreover, the major expense was the labor cost of the MDT (72,334 USD; 37.30%), followed by police officers (66,427 USD; 34.25%) and the cost of PPE (16,016 USD; 8.26%). The total cost incurred during the 14-day quarantine was 193,938 USD, which equated to 894 USD per traveler.

Discussion

This cohort study reports a model for the screening and quarantining of international travelers who had visited countries with a declared COVID-19 outbreak. All travelers tested negative for COVID-19 during the 14-day mandatory quarantine period. Three travelers with fever were hospitalized after the telehealth assessment, and subsequent tests for COVID-19 were negative for all three patients. The total costs during the quarantine were 193,938 USD, which equated to 894 USD per individual. Our study demonstrates that strict infectious control measures, proactive screening, and a Multi-Disciplinary Team integrated with the use of telehealth contributed toward the successful quarantine of international travelers, while remaining a cost-effective method of containing the spread of COVID-19.

Quarantine is an effective strategy to control and prevent COVID-19 outbreak[9]. However, monitoring individuals in quarantine is essential to provide prompt management and early detection of COVID-19 cases. By establishing a line of communication between healthcare workers and quarantined individuals, telehealth can provide timely assessment of quarantined individuals and fast-track the hospitalization of those who develop symptoms of the novel coronavirus. Although telehealth has not been widely adopted in monitoring COVID-19 infections in quarantined individuals, a study in China used the telehealth system to monitor 188 home-quarantined individuals; and found that 74 (39.4%) individuals were infected with the novel coronavirus [15]. Moreover, six (8.1%) of the 74 confirmed COVID-19 cases were hospitalized after the telehealth assessment [15]. Our study used telehealth to monitor COVID-19 infections in 217 international travelers during the 14-day mandatory quarantine. Three travelers with fever were hospitalized after the telehealth assessment, and subsequent tests for COVID-19 were negative for all three patients. Since telehealth can assist in providing timely assessment and would not delay the hospitalization in quarantined individuals, our study suggests that it is imperative to adopt the telehealth to monitor

COVID-19 infections in this population.

Our report is among the first to analyze the cost-effectiveness of an enforced quarantine program. We found that the total cost of a 14-day quarantine for 217 international travelers was 193,938 USD; equating to 894 USD per traveler. Although none of the 217 Taiwanese travelers tested positive for the novel coronavirus during the 14-day mandatory quarantine period, this study highlights the importance of screening and immediately quarantining international returning travelers because of the high risk of COVID-19 in this population [16]. The quarantine strategy in our report is also corroborated by a recent study, which reported that the quarantine strategy is efficient in curbing the COVID-19 outbreak, and its relative efficacy increases when supplemented with other measures designed to reduce disease transmission [14].

The LINE-based telehealth could provide timely assessment and care for patients who require it. During the COVID-19 surge, LINE-based telehealth could provide care for non-severe COVID-19 cases in hospital [13], and healthcare workers through the telehealth system could provide timely assessment and management for COVID-19 patients and reduce the transmission of SARS-CoV-2 in the healthcare facilities [11].

Nevertheless, the present study has two limitations. First, our study did not compare the cost-effectiveness of a 14-day quarantine for high-risk COVID-19 individuals. This cohort study found that none of the 217 Taiwanese travelers tested positive for the novel coronavirus during the 14-day mandatory quarantine period. As SARS-CoV-2 is highly contagious [17], it is imperative to screen and quarantine travelers who have visited countries with a declared COVID-19 outbreak. Second, the external validity of our findings may be a concern because all our patients were Taiwanese. The generalizability of our results to other non-Asian ethnic groups requires further verification.

However, our findings suggest new avenues for future research.

Conclusion

This prospective cohort study reports an enforced quarantine program integration with telehealth system to monitor COVID-19 infections in quarantined individuals. Telehealth not only provided timely management for quarantined individuals with illness; but also reduced the risk of COVID-19 infection in healthcare workers. Our study suggests that it is imperative to screen and quarantine international returning travelers to reduce the nationwide spread of COVID-19.

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Authors' Contributions

YFY, YFT, VYS, SYC, WRY, HH, CMH, LCW, and SJH substantially contributed to the conception and design of the study, data analysis, data interpretation, and the drafting of the manuscript. YFY, YFT, VYS, SYC, HH, CMH, CCC, LCW, and SJH substantially contributed to data acquisition and interpretation of the results. All authors all approved the final version of the manuscript.

Conflicts of Interest

None declared.

Abbreviations

COVID-19: coronavirus disease of 2019

SARS-CoV-2: severe acute respiratory syndrome coronavirus 2

CDC: Centers for Disease Control

PPE: personal protective equipment

SD: standard deviations

RT-PCR: real-time reverse transcriptase–polymerase chain reaction

MDT: Multidisciplinary Team

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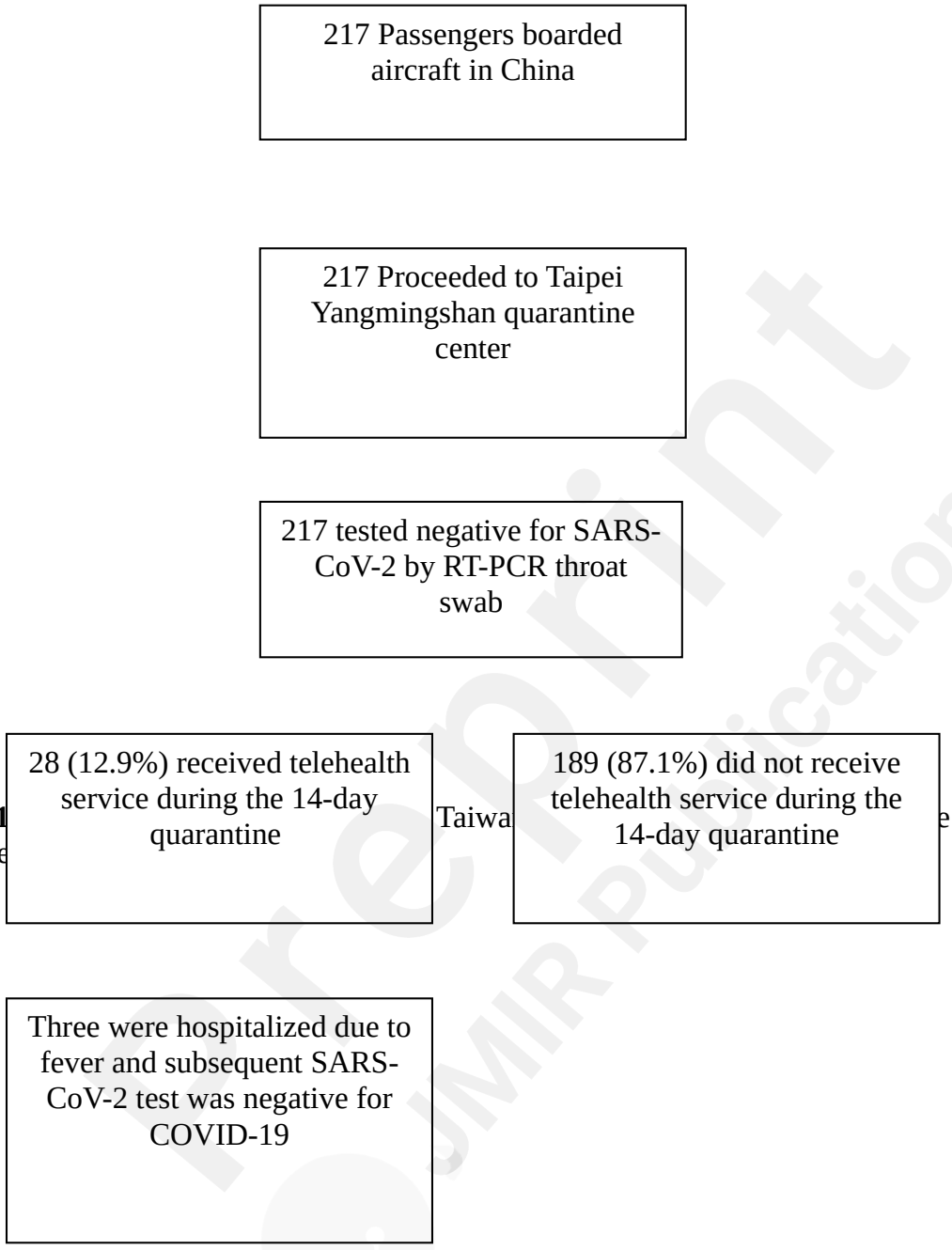

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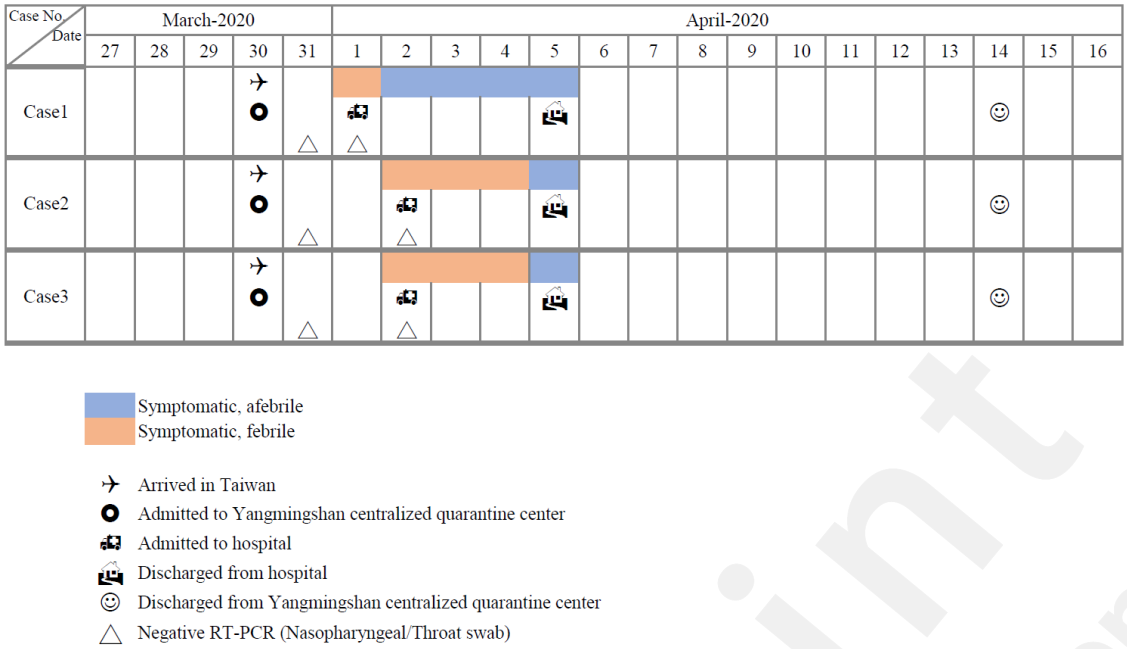


Figure 2. Time course of clinical symptoms in the hospitalized travelers.

Table 1. Characteristics of Taiwanese travelers at a centralized quarantine center, by telehealth service.

Characteristics	No. (%) of subjects[a]			
	Total, n=217	With telehealth service, n=28	Without telehealth service, n=189	*P* value
Demographics				
Age, yr				
Mean ± SD	30.03±19.40	33.0±18.1	29.6±17.3	0.33
<20	78 (35.9)	8 (28.6)	70 (37.0)	0.68
20-39	54 (24.9)	8 (28.6)	46 (24.3)	
≥40	85 (39.2)	12 (42.8)	73 (38.7)	
Sex				
Female	130 (59.9)	10 (35.7)	77 (40.7)	0.61
Male	87 (40.1)	18 (64.3)	112 (59.3)	
Number of family members				
1	79 (36.4)	19 (67.9)	60 (31.7)	<.001
≥2	138 (63.6)	9 (32.1)	129 (68.3)	
Fever during the 14-day quarantine				
No	214 (98.6)	25 (89.3)	189 (100.0)	<.001
Yes	3 (1.4)	3 (10.7)	0	
Hospitalization				
No	214 (98.6)	25 (89.3)	189 (100.0)	<.001
Yes	3 (1.4)	3 (10.7)	0	

SD, standard deviation. [a]Unless stated otherwise.

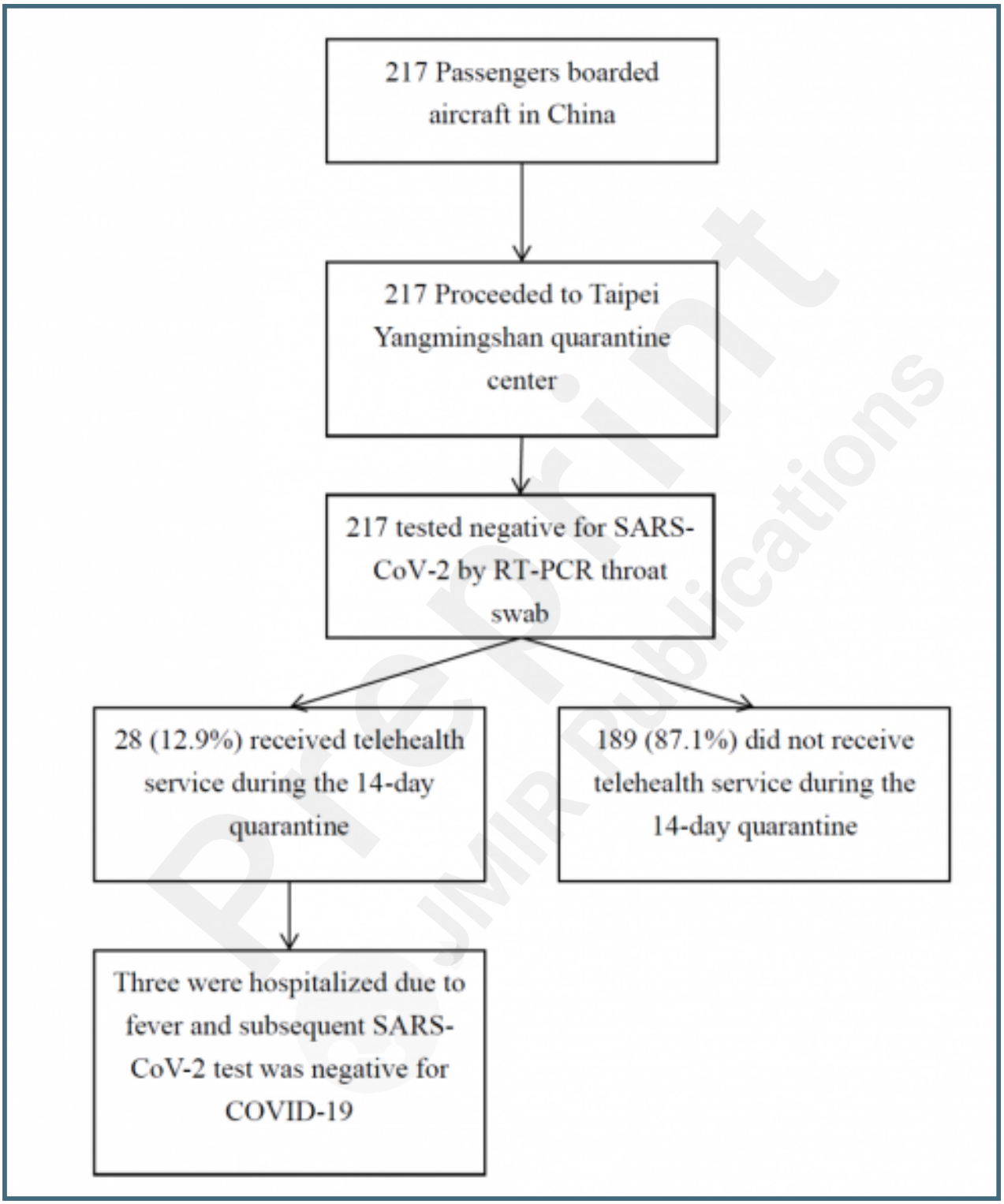
Table 2. Cost analysis during the 14-days mandatory quarantine in 217 Taiwanese travelers.

Variables	Number	Cost (US dollar)	%
Personnel costs			
Multi-Disciplinary medical team	15	72,334	37.3
Police officers	18	66,427	34.25
Janitors	3	10,880	5.61
Logistic group	10	8,033	4.14
Administration staff	1	894	0.46
Non-Personnel costs			
Telehealth equipment	-	2,838	1.46
Personal protective equipment	-	16,016	8.26
Disinfecting equipment	-	115	0.06
Infectious waste disposal	-	1,400	0.72
Staff uniform disinfection	-	6,667	3.44
Meals and daily supplies for quarantined travelers	-	8,334	4.30
Total costs	-	193,938	100.0

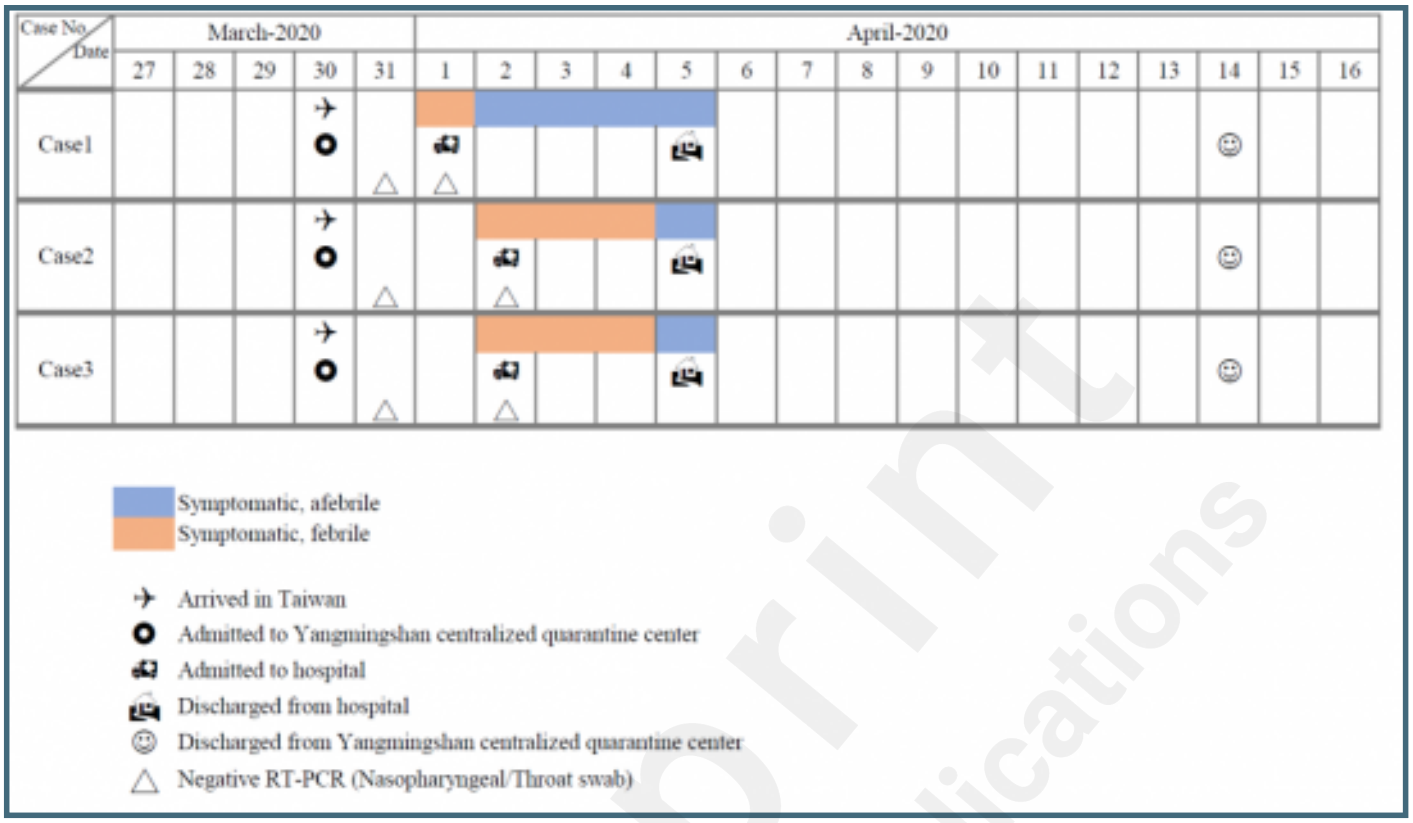
Supplementary Files

Figures

The process of follow-up in Taiwanese travelers quarantined at the Yangmingshan centralized quarantine center.



Time course of clinical symptoms in the hospitalized travelers.



Multimedia Appendixes

Symptoms and management in 28 quarantined travelers with telehealth.
URL: https://asset.jmir.pub/assets/99c87994e102ba791b2308819a47e487.docx