



Published in final edited form as:

Health Secur. 2019 ; 17(2): 100–108. doi:10.1089/hs.2018.0115.

Economic impact of the 2015 MERS outbreak on the Republic of Korea's tourism-related industries

Heesoo Joo, PhD¹, Brian A. Maskery, PhD¹, Andre D. Berro, MPH¹, Lisa D. Rotz, MD¹, Yeon-Kyeng Lee, PhD², and Clive M. Brown, MD¹

¹Division of Global Migration and Quarantine, Centers for Disease Control and Prevention, Atlanta, GA, USA

²Korea Centers for Disease Control and Prevention, Cheongju-si, Chungcheongbuk-do, Republic of Korea

Abstract

Background—The 2015 Middle East respiratory syndrome (MERS) outbreak in the Republic of Korea (ROK) is an example of an infectious disease outbreak initiated by international travelers to a high-income country.

Objective—To determine the economic impact of the MERS outbreak on the tourism and travel-related service sectors, including accommodation, food and beverage, and transportation, in the ROK.

Methods—We projected monthly numbers of non-citizen arrivals and indices of services for three travel-related service sectors during and after the MERS outbreak (June 2015–June 2016) using seasonal autoregressive integrated moving average models. Tourism losses were estimated by multiplying the monthly differences between projected and actual numbers of non-citizen arrivals by average tourism expenditure per capita. Estimated tourism losses were allocated to travel-related service sectors to understand the distribution of losses across service sectors.

Results—The MERS outbreak was correlated with a reduction of 2.1 million non-citizen visitors corresponding with US \$2.6 billion in tourism loss for the ROK. Estimated losses in the accommodation, food and beverage service, and transportation sectors associated with the decrease of non-citizen visitors were US \$542 million, US \$359 million, and US \$106 million, respectively. The losses were demonstrated by lower than expected indices of services for the accommodation, and food and beverage service sectors in June and July 2015 and for the transportation sector in June 2015.

Conclusions—The results support previous findings that public health emergencies due to traveler-associated outbreaks of infectious diseases can cause significant losses to the broader economies of affected countries.

Keywords

Middle East respiratory syndrome; MERS; outbreak; tourism; travel industry; economic impact; economic burden of disease

1. Introduction

The introduction of novel infectious diseases by international travelers can lead to costly outbreaks even in high-income countries with well-developed healthcare systems. The 2003 severe acute respiratory syndrome (SARS) outbreak in Canada, which resulted in 251 cases and 43 deaths [1], caused \$4.3 billion in losses to the accommodation and food service sector in Canada [2].

Another recent example is the 2015 Middle East respiratory syndrome (MERS) in the Republic of Korea (ROK), initiated by an infected traveler returning from the Middle East. MERS is a respiratory disease caused by a novel coronavirus [3]. The MERS outbreak in the ROK started on May 20, 2015, when the first case of MERS was confirmed [4]. The outbreak resulted in 186 hospitalizations and 38 deaths, with more than 16,000 people quarantined because of potential exposures by December 23, 2015, when the World Health Organization (WHO) declared the end of the MERS outbreak in the ROK [4, 5].

The Ministry of Health and Welfare of the ROK reported that the central government's revised budget for the MERS response was 973 billion won (US \$860 million using the 2015 average exchange rate of 1,131.49 won per US dollar) [4, 6]. The main budget items were national quarantine system reform and MERS response activities such as emergency support for MERS patients and hospitals, facilities for infectious disease treatment, and loans for affected medical institutions [4]. In addition, direct medical costs of MERS diagnosis and treatment between May and September 2015 were about 14 billion won (US \$12 million) based on national health insurance claims data [4]. Although local governments also compiled supplementary budgets for the MERS response, the scale of the local governments' budgets for the response is unknown.

In addition to governments and healthcare, other industries reported significant losses during the outbreak. Although the WHO did not issue any travel restrictions for the ROK during the outbreak, some nations and localities, such as Taiwan and China (Sichuan, Shandong, Guangzhou, and Hong Kong Special Administrative Region), issued travel advisories [7]. Declines in arriving international travelers were observed in 2015 compared to 2014 [5, 8]. The Korea Centers for Disease Control and Prevention recommended avoiding visits to crowded places and Ministry of Education and Ministry of Health and Welfare of the ROK recommended refraining school activities such as field trips and sports events [9, 10]. Because of the recommendations and exposure fears, some individuals might have avoided going out.

Although ever-increasing international travel volumes may contribute to the risk of travel-related infectious disease outbreaks, the potential economic impacts of travel-related outbreaks in high-income countries are not well understood. In this analysis, we estimated

some of the costs of the 2015 MERS outbreak in the ROK, specifically the costs to the tourism industry and selected travel-associated service sectors.

2. Materials and Methods

We examined changes in arriving international tourists and three travel-related service sectors—accommodation, food and beverage, and transportation—to estimate the impact of the 2015 MERS outbreak in the ROK. They were selected from a previous study, which reviewed the impact of SARS and identified which service sectors had incurred significant losses [2].

Data

We obtained numbers of monthly non-citizen visitors' arrivals from TOURGO, the Korea tourism knowledge and information system of the Korea Culture and Tourism Institute [11]. The data were generated using international guidelines from the United Nations World Tourism Organization [11]. We excluded arrivals of Korean citizens who were living abroad because their reasons for travel during the outbreak may have differed from those of non-citizen visitors. The international tourism receipts per foreign traveler, which are defined by the World Trade Organization as expenditures per person of international inbound visitors in a destination country, were also from TOURGO [12]. The average expenditure per non-citizen traveler varied by month ranged \$997-\$1,296 per traveler between June and September 2015 and was \$1,126 per traveler in weighted average.

The proportions of each spending area from international tourism receipts came from a report by Korea Institute for Industrial Economics and Trade [13]. The proportions of non-citizens' tourism expenditures were used to estimate economic impacts on three travel-related service sectors and were 20.9% for accommodation, 13.9% for food and beverage, and 4.1% for transportation [13].

Monthly indices of services were also used to analyze the impact of the MERS outbreak on these three service sectors [14]. The index is developed to understand each service industry's production activities by using weights of value-added criteria, which reflect each service industry's relative importance to the economy [14]. Indices of services are used to project gross domestic product (GDP). The indices use a base of 100 for the year 2010. Increasing month-to-month values would indicate expansion in an industry's composite performance, while decreasing month-to-month values would indicate contractions. Overall, values over 100 would demonstrate a relative increase in performance relative to 2010.

Estimation of projected values if the 2015 MERS outbreak had not occurred

We estimated the projected values of non-citizen visitors' arrivals or indices of services in the absence of the MERS outbreak for the 13-month period June 2015 through June 2016. This included the 7-month outbreak period (June–December 2015) and a 6-month period after the outbreak (January–June 2016). We excluded May 2015 from our projection because only one-third of the month was affected by the MERS outbreak. Since the first case was confirmed near the end of May 2015, non-citizen travelers might not have had enough time to modify May 2015 travel plans. The numbers of non-citizen visitors' arrivals in May 2015

increased by 7.3% compared to May 2014. Projected values for 6 months after the outbreak ended were analyzed to consider whether later increases in non-citizen visitors' arrivals or above-average levels for indices of services could have offset losses observed during the outbreak period.

We used seasonal autoregressive integrated moving average (SARIMA) models [15] programmed in R software to project values for each month. The SARIMA model used monthly non-citizen visitor arrivals data during January 2011–May 2015 to estimate projected values (i.e., in the absence of the outbreak) during the outbreak and for 6 months afterward (June 2015 through June 2016). We also used monthly indices of services from the three travel-related service sectors in developing the SARIMA models. We used the monthly indices of services data from January 2011 to May 2015 for accommodation and transportation sectors. For food and beverage, the monthly indices of services during January 2005–May 2015 were used because neither monthly nor seasonal pattern was recognized using data from January 2011 to May 2015.

Estimation of the impacts of the outbreak

We estimated the monthly changes in tourism revenue during the examined period by multiplying the estimated monthly changes in numbers of non-citizen visitors' arrivals by the average international tourism receipts per capita of each month. Monthly differences in non-citizen visitors' arrivals during the outbreak were calculated by subtracting monthly projected numbers of non-citizen visitors' arrivals from the actual arrivals of each month.

We estimated the total changes in tourism revenue associated with the MERS outbreak based on the sum of monthly changes in tourism between June 2015 and June 2016 using the following equation.

$$\sum_i^I (Actual_i - projected_i) \times \text{tourism expenditure per person}_i$$

For this equation, “*I*” indicates each month between June 2015 and June 2016. *Actual_i* is the actual number of non-citizen visitors' arrivals in month *i*, while *Projected_i* is the projected number of non-citizen visitors' arrivals in month *i* if the MERS outbreak had not happened. We included only months in which the difference between the actual and projected values was significantly different from zero ($p < 0.05$). Thus, total estimated changes excluded months with no significant differences.

The economic consequences for the travel-related service industries were estimated by multiplying monthly changes in tourism revenue by each sector's percentage contribution to total tourism expenditure in 2015. We were unable to translate changes in index values into monetary values. Instead, we analyzed these indices of services to determine if declines in non-citizen arrivals were associated with lower than expected index values.

We conducted one-way sensitivity analyses to confirm the robustness of estimates of economic losses. The 95% confidence intervals of the projected values from the SARIMA

model were used for the upper-bound (97.5%) and lower-bound (2.5%) estimates of the numbers of the non-citizen visitors' arrivals. To create a plausible range of average tourism expenditure per capita estimates, we used the highest and lowest monthly average tourism expenditure per capita in 2015 as the upper- and the lower-bounds inputs.

3. Results

Tourism

Numbers of arrivals of non-citizen visitors in 2015 dramatically decreased between June and September 2015 (Figure 1). Between October and December 2015, the numbers of non-citizen visitors' arrivals recovered to levels that would have been expected without the MERS outbreak. After the outbreak period (January–June 2016), the projected values and the actual values were not significantly different. The actual values never significantly exceeded projected values during and after the MERS outbreak, suggesting that travelers who decided to cancel travel plans during the outbreak did not simply postpone travel until after the outbreak ended.

The MERS outbreak was associated with 2.1 million fewer non-citizen visitors, corresponding to about US \$2.6 billion in lost tourism revenue for the ROK (Table 1). The loss of 2.1 million arrivals is about 16% of the total number of actual non-citizen visitors' arrivals (13 million in 2015). From June through September, there was 37.4% decrease (2.1 million out of 5.7 million projected non-citizen arrivals). The biggest loss in non-citizen arrivals was observed in July 2015 [58%, 95% confidence interval (CI): 53%–62%].

The one-way sensitivity analyses examined the uncertainty associated with the numbers of projected non-citizen arrivals in the absence of a MERS outbreak and the average tourism expenditure per non-citizen tourist. The estimated losses in tourism revenue ranged from US \$1.9 billion to US \$3.2 billion when the predicted numbers of non-citizen arrivals varied from 5.2 million to 6.3 million, corresponding to outbreak-associated net decreases of 1.6 million to 2.7 million during June–September 2015 (Appendix Figure 1). When the tourism expenditure per person varied from US \$934 to US \$1,388, the estimated losses varied between US \$2.0 billion and US \$3.0 billion.

Accommodation, food and beverage, and transportation

The impacts of the MERS outbreak on indices of services were significant during peak outbreak months (Figures 2, 3, and 4). Statistically significant decreases in the accommodation and food and beverage indices of services were observed between June and July 2015, while the transportation index was significantly lower only in June 2015. In June 2015, indices of services were 22.6% [95% CI: 16.7%–27.8%] lower than expected for accommodation, 9.9% [95% CI: 6.5%–13.0%] lower for food and beverage, and 5.3% [95% CI: 1.9%–8.5%] lower for transportation.

The estimated accommodation losses associated with non-citizen visitors were US \$542 million [95% CI: \$408 million–\$676 million] (Table 2). The estimated losses in the food and beverage service activities and the transportation sector were \$359 million [95% CI: \$270 million–\$451 million] and US \$106 million [95% CI: \$80 million–\$133 million],

respectively. More details about the results of one-way sensitivity analyses are shown in Appendix Figure 1.

4. Discussion

The losses estimated for the 2015 MERS outbreak in the ROK reinforce that public health emergencies could cause significant economic losses in multiple business sectors. The estimated annual loss in tourism revenue was about 18% of international tourism receipts (US \$15.1 billion)[12], and 4% of total (international and domestic) tourism receipts (US \$64.6 billion)[6, 13] of the ROK in 2015. The estimated US \$2.6 billion loss in tourism revenue was much higher than healthcare claims for MERS diagnosis and treatment (US \$12 million) [4] during the outbreak. Tourism losses also greatly exceeded the central government's budget associated with MERS response activities (US \$860 million) [4].

The MERS outbreak, however, did not make a visible impact on Korea's annual GDP growth in 2015. In 2015, annual nominal GDP in the ROK (1,564 trillion won, US \$1,382 billion [6, 16]) grew 5% relative to 2014. The lost tourism revenue from non-citizen travelers (US \$2.6 billion) was about 0.2% of 2015 GDP. Because the travel and tourism industry contributed only 5.1% of total GDP in the ROK in 2015 [17], the temporary decrease in non-citizen arrivals had a relatively small effect on total GDP. If similar outbreaks occurred in countries more dependent on tourism, the impact on total GDP could be substantial.

Governments may want to identify the sectors with the largest potential economic losses to encourage the development of sector preparedness plans and to prioritize emergency funding during an outbreak. The impact on specific tourism-associated sectors varied. The estimated losses to accommodation and food and beverage services associated with non-citizen travelers (US \$901 million) were about 2.7% of the annual nominal GDP of the restaurants and hotels sector in 2015 (38,192 billion won, US \$33.8 billion) [6, 16]. However, the estimated loss to the transportation sector (US \$106 million) was only 0.2% of the annual nominal GDP of the transportation and storage sector (56,155 billion won, \$49.6 billion)[6, 16]. During 2014–2017, the United States experienced two imported cases of Ebola and two imported cases of MERS from international travelers [18, 19]. Importation of emerging infectious diseases by travelers requires appropriate management to prevent disease outbreaks. Although the imported MERS and Ebola cases in the United States did not result in severe outbreaks, the threat of emerging infectious disease outbreaks in the United States or other high-income countries remains and may be increasing along with global travel volume [20]. Thus, it is important to understand the possible economic impact of outbreaks on various sectors when considering spending on preventive programs to mitigate future outbreaks.

This study has some limitations. For some indicators in the ROK, such as GDP by industry, only quarterly and annual values were available. Because monthly or daily information was not available, we could not directly use GDP to estimate economic impact. Quarterly industry-specific GDPs did not show any significant losses when the actual values were compared to projected values in the absence of a 2015 MERS outbreak.

In addition, for tourism expenditure per capita and the proportion of each spending area for tourism expenditure in the ROK, only statistics per non-resident were available. Since we examined non-citizen tourism arrivals and estimated loss in tourism revenue from non-citizen visitors, we assumed that statistics per non-citizen visitor were equivalent to the statistics per non-resident visitor. Because about 98% of non-resident visitors to the ROK in 2015 were non-citizens, the assumption is realistic.

Also, we assumed that tourism expenditure per capita and the breakdown of expenditure by spending area in the ROK would not be affected by the MERS outbreak. Although we examined a range of estimates for monthly tourism expenditure per capita, it is possible that we overestimated or underestimated the impact of the MERS outbreak because travelers choosing to cancel travel because of the outbreak may differ from travelers who chose to travel to ROK despite the outbreak.

We limited our analysis of the economic impact on service industries to losses associated with non-citizen visitors. The national tourism receipts include citizens' domestic travel expenditures, citizens' travel-related expenditures before and after international travel, and tourism expenditures of non-citizen visitors. However, the impact of the MERS outbreak on Korean citizens' travel expenditure appeared to be negligible based on the reported growth rates of Korean outbound travel and domestic travel in 2015 (Appendix Figure 2).

Korean citizens' outbound departures increased 20.1% in 2015 over 2014 [8] [21]. This increase was higher than the average annual departure growth rate of 8.2% observed during 2012–2014 and the growth rate of 15.9% in 2016 [8]. The additional expenditures from outbound Korean travelers may offset some of the lost tourism receipts associated with the reduction in arriving non-citizens during the outbreak.

Korean citizens' outbound departure-related expenditures in the ROK would include purchasing flight tickets or tour packages and shopping at duty-free shops. The expenditures were about 28% (US \$18.4 billion) of Korean tourism receipts in 2015 [13]; however, we had insufficient data to quantify monthly tourism-related domestic expenditures from citizens before or after their international travel[13]. Thus, we could not include these figures in the analyses.

The estimated numbers of domestic trips of Koreans in the Korea National Tourism Survey increased 4.9% in 2015 from 2014 (Appendix Figure 2) [22]. The tourism expenditures on domestic trips by Korean citizens increased 2.2% in 2015 compared to their tourism expenditures in 2014 [22]. We expect that domestic travel could be postponed relatively easily until after the end of the outbreak. However, it is possible that the growth of citizens' domestic travel would have been even more robust without the MERS outbreak.

We only reported losses to non-citizen tourism and tourism-related service sectors, but the outbreak may have affected other business sectors. We examined the impacts on indices of services for other sectors, including leisure and sports, and healthcare services, but did not observe significant impacts in these sectors.

In addition, the estimation of the economic impact of one outbreak may not apply to the costs of other infectious disease outbreaks (e.g., pandemic influenza, viral hemorrhagic fever) in different countries. Outbreak costs may depend on the specific infectious disease, country-specific behavioral responses to infectious disease threats, and country-specific industry composition, population density, and healthcare infrastructure.

Despite these limitations, our study derived reasonable estimates of the economic impact of a sizable outbreak initiated by an international traveler. The findings expand the knowledge base of economic impacts of travel-associated infectious disease outbreaks in high-income countries.

5. Conclusions

The 2015 MERS outbreak in the ROK was associated with an estimated \$2.6 billion in lost revenue for the tourism and tourism-related service sectors, which was equivalent to 0.2% of GDP in 2015. We found that the losses were permanent because visitors cancelled rather than postponed travel. The results of this analysis are consistent with similar studies conducted to examine the costs of SARS outbreaks and may be applied to other high-income countries to help estimate the costs of a potential similar outbreak. These results can help inform resource allocation decisions for preparedness and response activities to mitigate the risk of introduction and spread of novel infectious diseases associated with international travelers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The findings and conclusions of this article are those of the authors and do not necessarily represent the official position of the US Centers for Disease Control and Prevention (CDC) and the Korea Centers for Disease Control & Prevention.

References

1. World Health Organization. Summary of probable SARS cases with onset of illness from 1 November 2002 to 31 July 2003. http://www.who.int/csr/sars/country/table2004_04_21/en/. Accessed March 12, 2019.
2. Keogh-Brown MR, Smith RD. The economic impact of SARS: how does the reality match the predictions? *Health Policy* 2008;88(1):110–120. [PubMed: 18436332]
3. Centers For Disease Control and Prevention. Middle East Respiratory Syndrome (MERS). Last reviewed September 14, 2019. <http://www.cdc.gov/coronavirus/mers/about/index.html>. Accessed March 12, 2019.
4. Ministry of Health and Welfare, the Republic of Korea. The 2015 MERS outbreak in the Republic of Korea: Learning from MERS. 2016 http://www.cdc.go.kr/CDC/notice/CdcKrIntro0101.jsp?menuIds=HOME006-MNU2804-MNU2939&fid=10890&q_type=title&q_value=%EB%A9%94%EB%A5%B4%EC%8A%A4&cid=128379&pageNum=. Accessed March 13, 2019.
5. Korea Centers for Disease Control and Prevention. Middle East respiratory syndrome coronavirus outbreak in the Republic of Korea, 2015. *Osong Public Health Res Perspect* 2015;6(4):269–278. [PubMed: 26473095]

6. Bank of Korea Economic Statistics System. 8.8 Foreign exchange rate. <http://ecos.bok.or.kr/>. 7 28, 2017
7. Korea Ministry of Foreign Affairs. Travel warnings to the Republic of Korea due to the MERS outbreak from all foreign countries are lifted: response activities, achievements, and future plans for the MERS outbreak from Ministry of Foreign Affairs 2015 http://www.mofa.go.kr/www/brd/m_4080/view.do?seq=355787&srchFr=&srchTo=&srchWord=메르스&srchTp=0&multi_itm_seq=0&itm_seq_1=0&itm_seq_2=0&company_cd=&company_nm=&page=1. Accessed March 12, 2019.
8. Korea Tourism Organization. Korea Tourism Statistics. <http://kto.visitkorea.or.kr/kor/notice/data/status/tstat/profit/notice/inout/popup.kto>. Accessed March 12, 2019.
9. Korea Centers for Disease Control and Prevention, Ministry of Health and Welfare. Middle East respiratory syndrome information: recommendation for general public. 2015 http://www.cdc.go.kr/CDC/notice/CdcKrIntro0201.jsp?menuIds=HOME006-MNU2804-MNU2937&fid=21&q_type=&q_value=&cid=62943&pageNum=1. Accessed March 12
10. Ministry of Education and Ministry of Health and Welfare. The MERS response manual for schools (Elementary school and middle school). 2015 http://m.schoolsafe.kr/search_view/a/1/?seq=238. Accessed March 12, 2019.
11. TOURGO (Tourism Knowledge and Information System). Tourism arrival statistics. <http://know.tour.go.kr/stat/tourStatSearchDis.do?sessionId=8B29C231492BA57E875081E0A6D4C762>.
12. TOURGO (Tourism Knowledge and Information System). Korean tourism receipts and expenditures. <https://know.tour.go.kr/stat/tourStatSearchDis.do>. Accessed March 12, 2019.
13. Choi BH, et al. Research on improving tourism industry using statistics. 2017, Ministry of Culture, Sports and Tourism. https://www.mcst.go.kr/kor/s_notice/pressView.jsp?pSeq=15996&pMenuCD=0302000000&pCurrentPage=1&pTypeDept=&pSearchType=01&pSearchWord=#. Accessed March 12, 2019.
14. Korean Statistical Information Service (KOSIS), Statistics Korea. Statistical Database-Index of services by industry section (Year 2015=100.0). http://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1KS2015&vw_cd=MT_ETITLE&list_id=JH&scrId=&seqNo=&language=en&obj_var_id=&itm_id=&conn_path=A6&path=%252Feng%252Fsearch%252FsearchList.do. Accessed July 28, 2017.
15. Yu-Wei Chang, Meng-Yuan Liao. A seasonal ARIMA model of tourism forecasting: The case of Taiwan. *Asia Pacific Journal of Tourism Research* 2010;15(2):215–221.
16. Korean Statistical Information Service (KOSIS), Statistics Korea. Statistical Database-GDP and GNI by economic activities (not seasonally adjusted, current prices, quarterly & annual). http://kosis.kr/statHtml/statHtml.do?orgId=301&tblId=DT_102Y010&vw_cd=MT_ETITLE&list_id=301_A_1&scrId=&seqNo=&language=en&obj_var_id=&itm_id=&conn_path=A6&path=%252Feng%252Fsearch%252FsearchList.do. Accessed March 12, 2019.
17. World Travel & Tourism Council. The economic impact of travel & tourism March 2016, South Korea 2016.
18. Centers for Disease Control and Prevention. MERS in the U.S. Last reviewed September 14, 2017. <http://www.cdc.gov/coronavirus/mers/us.html>. Accessed March 12, 2019.
19. Centers for Disease Control and Prevention. 2014–2016 Ebola outbreak in West Africa. Last updated March 8, 2019. <http://www.cdc.gov/vhf/ebola/outbreaks/2014-west-africa/united-states-imported-case.html>. Accessed March 12, 2019.
20. Hamburg MA, et al. Germs go global: Why emerging infectious diseases are a threat to America. 2008 <https://www.tfah.org/report-details/germs-go-global/> Accessed March 12, 2019.
21. Korea Tourism Organization. Trends in non-resident arrivals, citizen departure, and tourism revenue and expenditure in November 2016. <http://kto.visitkorea.or.kr/kor/notice/data/status/profit/board/view.kto?id=427563&isNotice=false&instanceId=294&rnum=81>. Accessed March 12, 2019.
22. Korea Culture and Tourism Institute. Korea National Tourism Survey. 2016 <https://www.tour.go.kr/>. Accessed March 12, 2019.

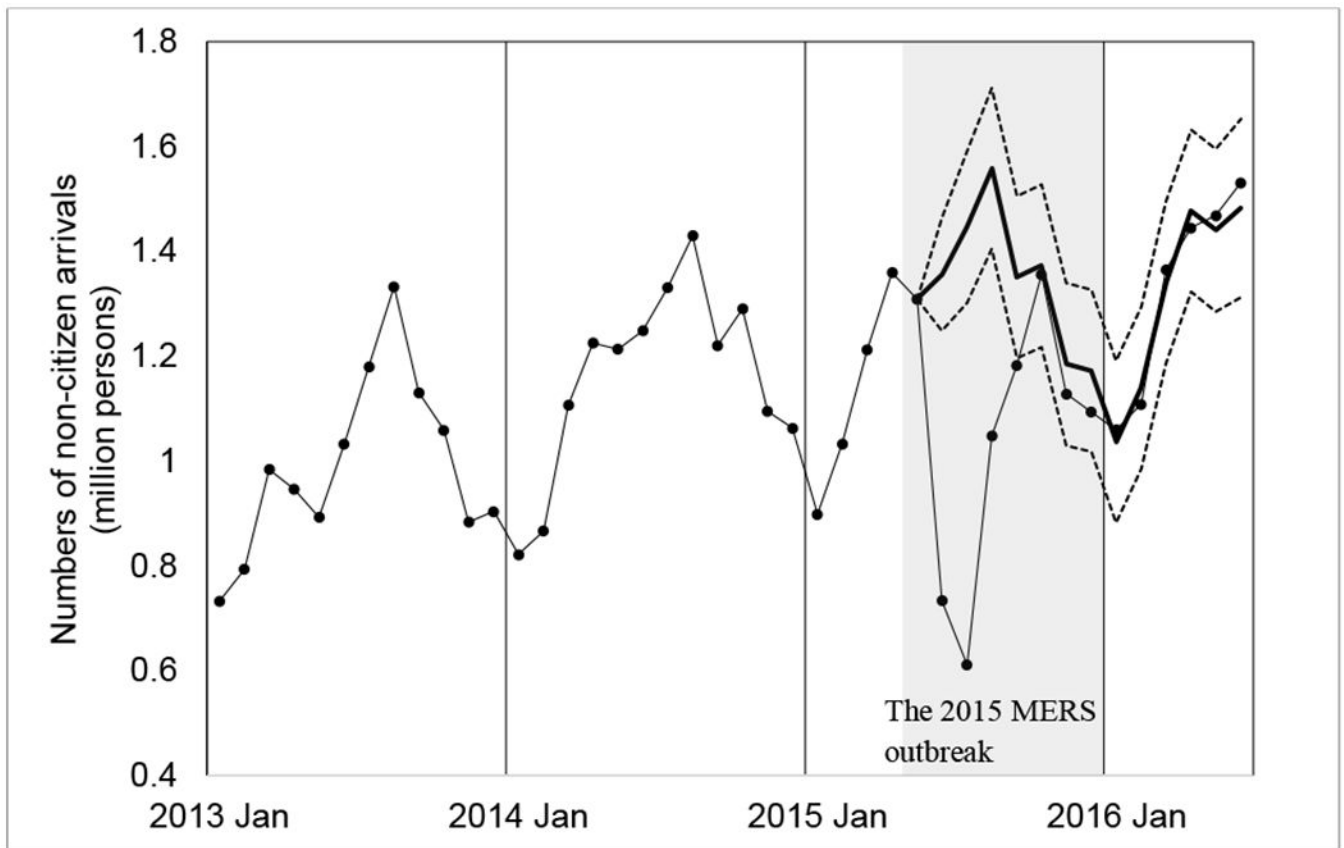


Figure 1: Actual monthly arrivals of non-citizen visitors in the Republic of Korea (January 2013–June 2016) and projected monthly arrivals during and after the 2015 Middle East respiratory syndrome (MERS) outbreak (June 2015–June 2016)
 Notes: The thin solid line with filled circle markers shows the actual numbers of non-citizen arrivals while the thick solid line is the projected numbers of non-citizen arrivals during and after the MERS outbreak period in the absence of the outbreak. The dotted line shows the 95% confidence interval of projected values. The shaded gray area indicates the period between the confirmation of the first MERS case in the Republic of Korea and the World Health Organization’s declaration of the end of the outbreak.

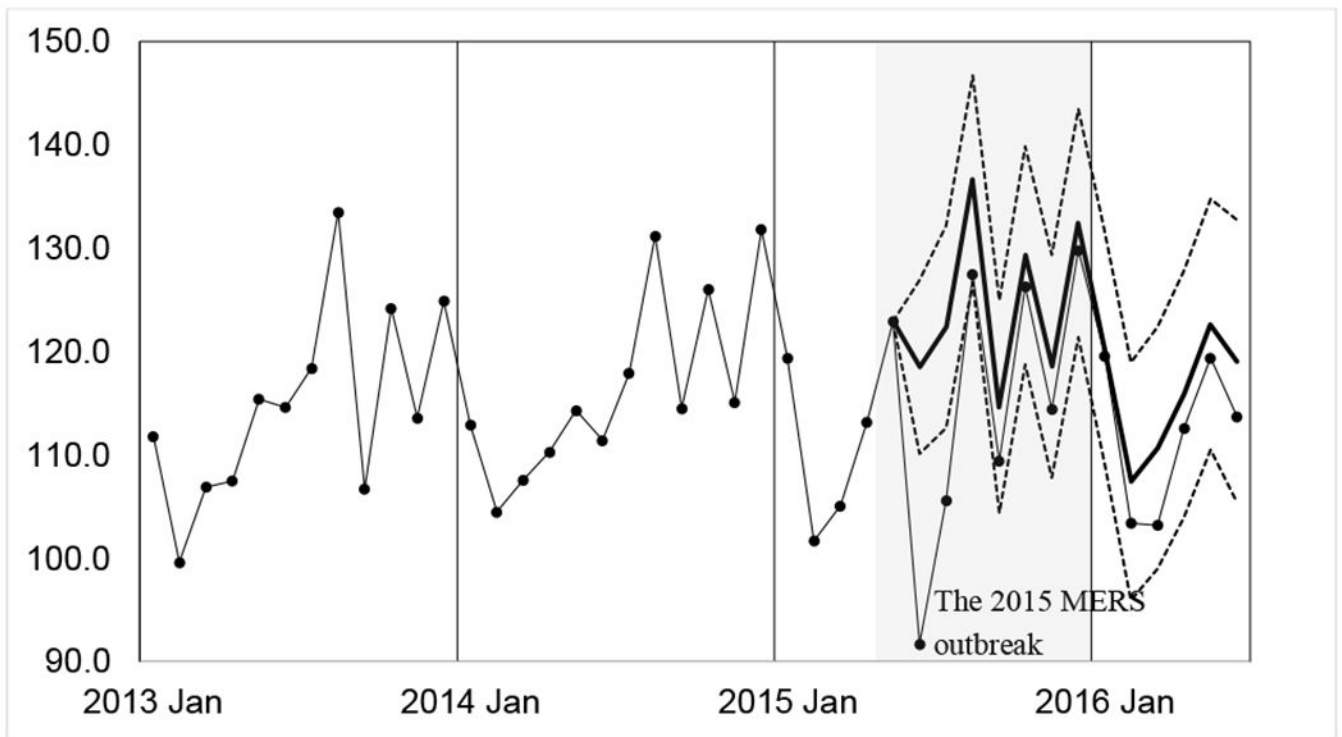


Figure 2: Actual monthly index of services of the accommodation sector in the Republic of Korea (Year 2010=100.0, January 2013–June 2016) and projected index of services during and after the 2015 Middle East respiratory syndrome (MERS) outbreak (June 2015–June 2016) Notes: The thin solid line with filled circle markers shows the actual index of services while the thick solid line is the projected index of services during and after the MERS outbreak period in the absence of the outbreak. The dotted line shows the 95% confidence interval of the projected index values. The shaded gray area indicates the period between the confirmation of the first MERS case in the Republic of Korea and the World Health Organization’s declaration of the end of the outbreak.

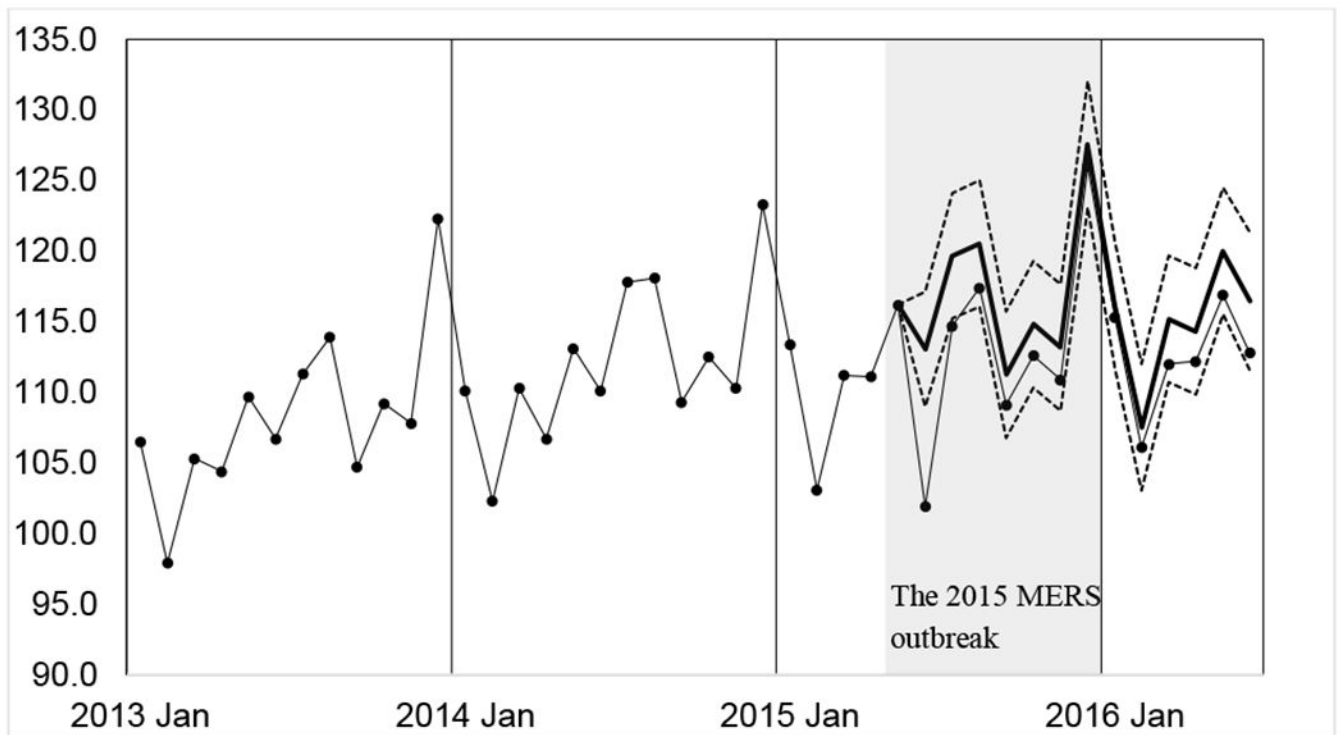


Figure 3: Actual monthly index of services of the food and beverage service in the Republic of Korea (Year 2010=100.0, January 2013–June 2016) and projected index of services during and after the 2015 Middle East respiratory syndrome (MERS) outbreak (June 2015–June 2016) Notes: The thin solid line with filled circle markers shows the actual index of services while the thick solid line is the projected index of services during and after the MERS outbreak period in the absence of the outbreak. The dotted line shows 95% confidence interval of the projected index values. The shaded gray area indicates the period between the confirmation of the first MERS case in the Republic of Korea and the World Health Organization’s declaration of the end of the outbreak.

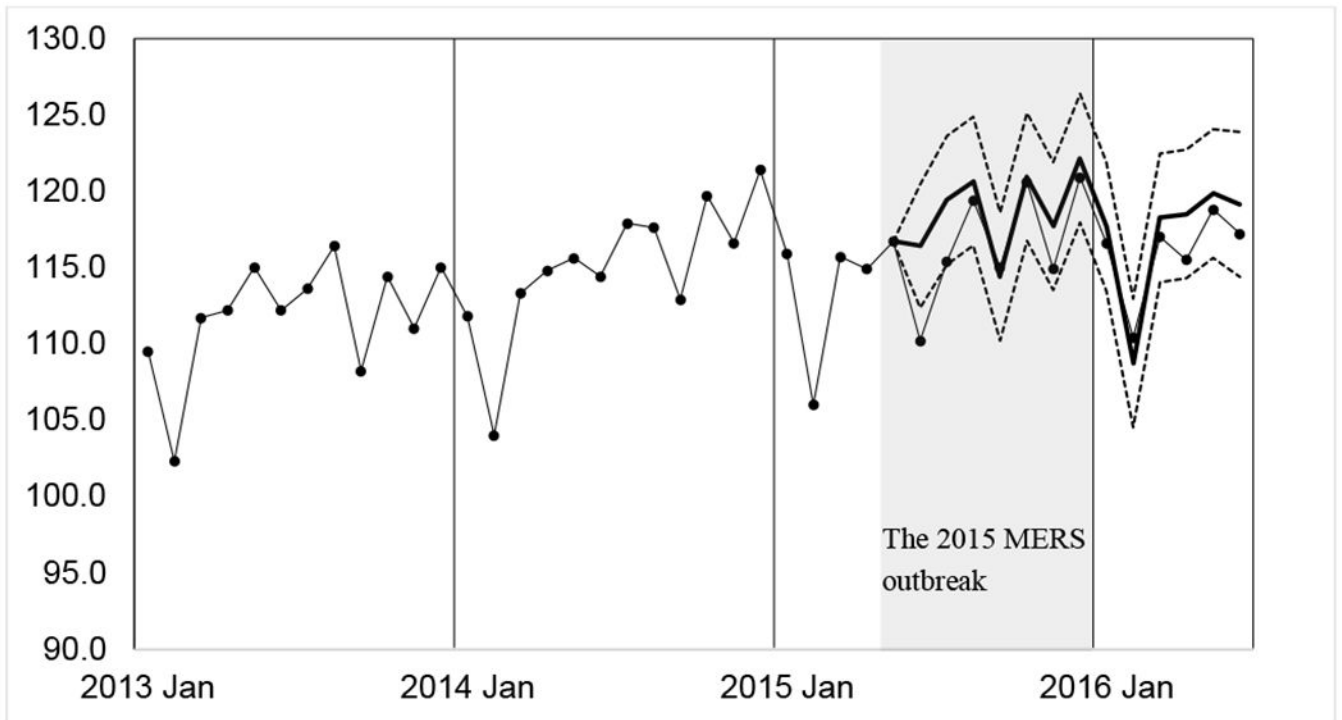


Figure 4:

Actual monthly index of services of the transportation sector in the Republic of Korea (Year 2010=100.0, January 2013–June 2016) and projected index of services during and after the 2015 Middle East respiratory syndrome (MERS) outbreak (June 2015–June 2016)

Notes: The thin solid line with filled circle markers shows the actual index of services while the thick solid line is the projected index of services during and after the MERS outbreak period in the absence of the outbreak. The dotted line shows 95% confidence interval of the projected index values. The shaded gray area indicates the period between the confirmation of the first MERS case in the Republic of Korea and the World Health Organization’s declaration of the end of the outbreak.

Table 1: Estimated losses in numbers of non-citizen arrivals and tourism expenditure in the Republic of Korea during the 2015 Middle East respiratory syndrome outbreak

Period	Numbers of non-citizen travelers' arrivals (million persons)			Percentage of decrease (%) (c)/(b) × 100%	Per person tourism expenditure (2015 US \$), (d)	Losses in tourism expenditure (2015 million US \$) (e)=(c)×(d)
	Actual (a)	Projected (b)	Losses (c)=(b)-(a)			
June	0.73	1.36 [1.25 – 1.46]	0.62 [0.51 – 0.73]	46 [41 – 50]	1,289	802 [663 – 941]
July	0.61	1.45 [1.30 – 1.59]	0.84 [0.69 – 0.98]	58 [53 – 62]	1,296	1,082 [895 – 1,269]
August	1.05	1.56 [1.40 – 1.71]	0.51 [0.36 – 0.66]	33 [25 – 39]	1,057	539 [377 – 701]
September	1.18	1.35 [1.20 – 1.51]	0.17 [0.01 – 0.32]	12 [1 – 21]	997	167 [13 – 322]
October	1.36	1.37 [1.22 – 1.53]	0.02 [–0.14 – 0.17]	1 [–11 – 11]	934	15 [–129 – 160]
November	1.13	1.18 [1.03 – 1.34]	0.06 [–0.10 – 0.21]	5 [–10 – 16]	1,066	61 [–105 – 226]
December	1.09	1.17 [1.02 – 1.33]	0.08 [–0.08 – 0.23]	7 [–8 – 18]	1,153	90 [–88 – 269]
Total: June–September 2015 ¹	3.57	5.71 [5.15 – 6.27]	2.14 [1.57 – 2.70]	37 [31 – 43]	1,126	2,590 [1,948 – 3,235]

Notes: 95% confidence intervals using the projected values are shown in the squared parentheses. Boldface indicates that the losses or percentage decreases are statistically significant, i.e., the numbers are significantly different from zero ($p < 0.05$).

¹We estimated the cumulative changes during June to September 2015 because the estimated losses were significant during June to September 2015.

Table 2:

Estimated revenue losses in service sectors (2015 million US dollars) in the Republic of Korea during the 2015 Middle East respiratory syndrome outbreak

Period	Accommodation (e)×20.9%	Food and beverage service (e)×13.9%	Transportation (e)×4.1%
June	168 [139 – 197]	111 [92 – 131]	33 [27 – 39]
July	226 [187 – 265]	150 [124 – 177]	44 [37 – 52]
August	113 [79 – 147]	75 [52 – 98]	22 [15 – 29]
September	35 [3 – 67]	23 [2 – 45]	7 [1 – 13]
October	3 [-27 – 33]	2 [-27 – 33]	1 [-5 – 7]
November	13 [-22 – 47]	8 [-22 – 47]	2 [-4 – 9]
December	19 [-18 – 56]	13 [-18 – 56]	4 [-4 – 11]
Total: June–September 2015 ¹	542 [408 – 676]	359 [270 – 451]	106 [80 – 133]

Notes: 95% confidence intervals are shown in the squared parentheses. Boldface indicates that the losses or percentage decreases are statistically significant, i.e., the results are significantly different from zero ($p < 0.05$). The estimated revenue losses in each sector were estimated by multiplying losses in tourism expenditure by proportion of each service sector on tourism expenditure.

¹We estimated the cumulative losses during June to September 2015 because the estimated losses were significant only during June to September 2015.