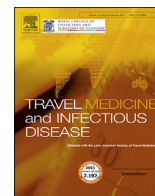




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Importation of travel-related infectious diseases is increasing in South Korea: An analysis of salmonellosis, shigellosis, malaria, and dengue surveillance data

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ABSTRACT

Background: International travel has an important role in transmission of emerging infectious diseases. We described the imported infectious diseases in Korea from 2003 to 2012, and to analyze association of travels with the change in the incidences.

Methods: We used National Notifiable Disease Surveillance System to investigate the incidence of salmonellosis, shigellosis, malaria, and dengue. Data from Korea Tourism Organization was used to describe the inbound and outbound travelers by their age group, gender, and purpose of travel. We assessed association between international travel and the incidence of the infectious diseases, and seasonal variability.

Results: Among 1849 imported cases, dengue comprised the largest number with 631 cases. The proportion of imported cases among total cases gradually increased from 4.1% in 2003 to 30.3% in 2012 ($P < 0.001$). There was a positive correlation between the number of travelers and the number of imported cases of shigellosis, dengue ($P < 0.001$), but not for malaria. Seasonal variability was observed for importation of salmonellosis, shigellosis and dengue fever ($P = 0.005$).

Conclusion: International travel was associated with the incidence of imported infectious diseases in Korea. Pre-travel consultation for international travelers planned to visit endemic area should be recommended strongly.

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1. Introduction

International travel has an important role in transmission of emerging and re-emerging infectious diseases across the geographical areas [1]. The travel-associated transmission of diseases was anticipated during the past decades. Since 1980s, meningococcal epidemic was transmitted globally after the Hajj pilgrimage [2]. In the early 2000s, severe acute respiratory syndrome rapidly spread around the world because travelers infected with the virus traveled on airplane to distant countries [3]. Moreover, importation of measles cases along air travel had caused an outbreak of the disease, which was once eliminated from the United States [4].

In spite of the major health issue to both sending and receiving countries, importation of infectious diseases had been a problem that is ignored in countries with growing economies including South Korea. International travel in Korea is a growing industry with over 10 million outbound travelers travel every year in the 2000s [5]. Destinations are in every continent including country with poorly developed, as well as those with an advanced hygiene and public health infrastructure.

Recently in Korea, there has been a concern in increased number of imported infectious diseases, including emerging infectious diseases such dengue [6]. The increase in international travel may have an association with an increase in the number of imported infectious diseases. However, the incidence of imported infectious diseases has not been reflected in surveillance programs as they largely fail to capture comprehensive epidemiological data. In this study, we aimed to describe the imported infectious diseases in Korea from 2003 to 2012, and to analyze association of international travels with change in incidence.

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2. Methods

2.1. Data source and definition

We used National Notifiable Disease Surveillance System (NNDSS), which collects passively reported data on clinically-diagnosed and laboratory-confirmed cases of the 75 designated infectious diseases. The monthly number of inbound and outbound travelers by their age group, gender, purpose of travel (for inbound travelers), and destination (for outbound travelers) was obtained from the Korea Tourism Organization [7]. An imported case was defined as infection acquired outside Korea, based on the travel history of individual case-patient and incubation period of infectious diseases. An endemic case was defined as infection acquired inside Korea within incubation periods for respective infectious diseases.

2.2. Data analysis

We selected four infectious diseases that are potentially importable to South Korea: salmonellosis, shigellosis, malaria, and dengue. We assessed the association of imported infectious diseases cases and international travelers using Spearman rank correlation test. The relation between seasonal variability and the monthly incidence of imported infectious diseases was examined. We then assessed the monthly proportion of imported cases among total cases including endemic transmissions.

To explore the linear trend and seasonality from 2003 to 2012, we used linear regression time-series analysis. The total numbers of inbound and outbound travelers, age group, gender, purpose of visit (for inbound travelers), and destination (for outbound travelers) were assessed. Multivariable regression analysis was used to adjust for the time-trend effect and seasonality. All analyses were performed using SPSS (SPSS Inc., USA) and using the R 3.0.2 statistical software. Because all the data used in this study is anonymous and publically available, this study was exempted from ethical consideration.

3. Results

3.1. General surveillance

Over the 10-year period from 2003 through 2012, we identified 1849 imported cases of salmonellosis, shigellosis, malaria, and dengue (Table 1). Among those, dengue comprised the largest number of cases with 631, followed by shigellosis ($n = 482$) and malaria ($n = 407$). The proportion of imported cases was highest in

dengue (100%), followed by shigellosis (15.7%) and salmonellosis (15.3%). Overall during the 10-year period, the proportion of imported cases among total cases gradually increased from 4.1% in 2003 to 30.3% in 2012 (Table 1, $P < 0.001$ for trend). The proportion generally increased for salmonellosis (from 8.0% in 2003 to 27.8% in 2012, $P < 0.001$ for trend) and shigellosis (from 0.6% to 46.7%, $P < 0.001$ for trend), while the proportion was relatively constant for malaria (from 5.2% to 9.7%, $P = 0.019$ for trend).

3.2. Secular trend and seasonality

From 2003 to 2012, the number of inbound travelers showed linear increase, while the number of outbound travelers increased from 2003 to 2007, with a decline during 2008–2009, and a rebound increase after 2010 (Fig. 1). The secular or long-term trend was characterized by a gradual increase in number of cases of imported infectious diseases from 2003 through 2012, with occasional decreases and rebounds in 2005 and 2010–2013. A cyclical pattern of occurrences of imported infectious diseases at interval of about 3–6 months was noted, with malaria being the major pathogen in the early 2000s, while dengue and shigellosis being the major pathogens in the late 2000s.

Estimation with linear regression model showed the best fit data of salmonellosis ($P = 0.007$), shigellosis ($P < 0.001$), and dengue ($P < 0.001$), while there was no significant linear trend was observed in the data of malaria (Fig. 2). Pearson correlation showed a positive correlation between the number of outbound and inbound travelers and the number of imported cases of shigellosis, dengue, and the total number of imported infectious diseases (Table 2, $P < 0.001$).

When classified by months, the proportion of imported cases of salmonellosis and shigellosis increases during summer season (July–September); while nearly half of malaria cases reported during winter season (January–February) are imported cases (Fig. 3). Throughout the year, all reported cases of dengue were imported cases, with the peak incidence during summer season. Variable seasonality was observed in the occurrence of imported salmonellosis, shigellosis and dengue fever ($P = 0.005$).

The upper curve in Fig. 4 shows the monthly number outbound travelers. There was a remarkable seasonal pattern, clustering during summer (July–August) and winter (January). Apparently, there was also an increase in the number of imported cases of dengue, malaria and shigellosis, during the summer and winter season. The shape of lower curve, which indicates the number of inbound international travelers, however, was dissimilar to the shape of the imported infectious diseases curve. Spearman rank correlation showed a correlation between monthly occurrence of

Table 1
Surveillance of imported infectious diseases in South Korea, 2003–2012.

Years	Salmonellosis**		Shigellosis**		Malaria		Dengue**		Total**	
	No.*	(%)	No.*	(%)	No.*	(%)	No.*	(%)	No.*	(%)
2003	21/262	(8.0)	6/996	(0.6)	61/1164	(5.2)	13/13	(100.0)	101/2435	(4.1)
2004	24/217	(11.1)	23/489	(4.7)	38/858	(4.4)	19/19	(100.0)	104/1583	(6.6)
2005	29/197	(14.7)	44/293	(15.0)	46/1360	(3.4)	29/29	(100.0)	148/1879	(7.9)
2006	42/235	(17.9)	20/299	(6.7)	28/1974	(1.4)	37/37	(100.0)	127/2545	(5.0)
2007	28/262	(10.7)	42/136	(30.9)	33/2205	(1.5)	94/94	(100.0)	197/2697	(7.3)
2008	20/228	(8.8)	60/196	(30.6)	29/1025	(2.8)	51/51	(100.0)	160/1500	(10.7)
2009	20/197	(10.2)	35/183	(19.1)	21/1298	(1.6)	58/58	(100.0)	134/1736	(7.7)
2010	34/173	(19.7)	102/220	(46.4)	49/1682	(2.9)	115/115	(100.0)	300/2190	(13.7)
2011	59/188	(31.4)	108/172	(62.8)	48/795	(6.0)	66/66	(100.0)	281/1221	(23.0)
2012	52/187	(27.8)	42/90	(46.7)	54/555	(9.7)	149/149	(100.0)	297/981	(30.3)
Total	329/2146	(15.3)	482/3074	(15.7)	407/12,916	(3.2)	631/631	(100.0)	1849/18,767	(9.9)

*No. in imported cases/total cases (imported + endemic cases).

** $P < 0.001$ for trend.

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