Short Communication

A Comparative Study of the Epidemiology of Human Leptospirosis in Korea and Japan between 2006 and 2012

Myeong-Jin Lee*, Shinichiro Miki, Masahiro Kitagawa, and Won-Chang Lee

Department of Public Health, Otemae College of Nutrition, Osaka 540-0008, Japan; and College of Veterinary Medicine, Konkuk University, Seoul 143-701, Korea

SUMMARY: We undertook a comparative analysis of the epidemiology of reported human leptospirosis (HL) cases in Korea and Japan. Between 2006 and 2012, the cumulative incidence of HL in Korea was higher than that in Japan (1.26 vs. 0.14 per 100,000 population, respectively), and the total reported cases were 632 and 196, respectively. Significantly more men were infected than women in both Korea (63.0% men, $P < 0.01$) and Japan (87.8% men, $P < 0.01$). In both countries, the incidence was highest among those aged 40 years and older (60%), and peaked in autumn (78.5% cases in Korea, and 46.9% cases in Japan). However, Japan exhibited a significantly higher proportion of male cases, a younger age distribution, and less prominent seasonality. A significant difference was observed in the incidence of HL between the capital city and rural areas in Korea, but not in Japan. The differences in agricultural and forestry practices, and the efficacy or wastewater treatment infrastructure might influence the incidence level in rural areas in both countries. The differences between the 2 countries might be because of their unique geographical characteristics and variations in their levels of industrialization.

Leptospirosis is one of the most important zoonoses worldwide, and is caused by spirochetes of the genus *Leptospira* that are transmitted from animals to humans (1–5). There are over 200 known serovars, divided into 25 serogroups based on antigenic similarities. Human leptospirosis (HL) has been recognized as an emerging global public health issue because of its increasing incidence rates in both developing and developed countries (6). Most of the increased incidences in developed countries have been attributed to travel and associated activities in developing countries (6,7), rather than an increase of incidence in developed countries. HL is transmitted from rodents via direct contact with infected urine or from infected surfaces. The pathogenic agent is known to persist in highly humid environments for longer periods (1–5,8). Although the global burden of this disease is unknown because of the paucity of data, the incidence is estimated to range from 0.1/100,000 to 1/100,000 of the population per year in temperate regions, to over 100/100,000 of the population per year during epidemics in the tropics. An estimated 300,000–500,000 severe cases occur each year globally, with a case fatality rate of up to 30% (1,6,9).

HL cases were first identified in Korea in late 1984 (4). Since then, almost 100 cases of HL have been reported annually in rural areas of Korea (3,4). Recently, there has been a marked decrease in new cases; however, reported cases still occur (4,6,10). In Japan, yearly HL deaths had exceeded 200 in the period before 1960; reported incidences subsequently declined rapidly with annual reported cases falling to below 20 (11).

Korea and Japan are geographically close to each other and share similar cultural characteristics. The spatial distribution of reported cases of leptospirosis is influenced by local geography and topology, and at least in Korea, the incidences are associated with rice paddy farming (4,12). The pattern of occurrence also shows strong seasonality with higher incidence from summer to autumn, typically following heavy rainfall, typhoons, or flooding, commonly observed in the period before the harvest season (3,4,10,13).

In this comparative descriptive study, we investigated the epidemiology of the reported leptospirosis cases in Korea and Japan between 2006 and 2012, and compared the demographic and geographic characteristics of the cases between the 2 countries. In order to accomplish this, we analyzed the data on national incidence, and the regional distribution (capital city and other areas), gender, age, and time of the year for reported cases. The raw data on confirmed HL cases in Korea ($n = 632$) were obtained from the National Notified Disease Surveillance System of the Korea Center for Disease Control and Prevention; an agency of the Ministry of Health and Welfare (9). Data on reported HL cases in Japan ($n = 196$) were obtained from the National Epidemiological Surveillance of Infectious Diseases surveillance system, administered by the National Institute of Infectious Diseases in Japan (13). In order to assess differences among groups in each country and between the 2 countries, we used Pearson's chi-squared test. The analyses were performed using Excel 2007 (Microsoft Corp., Redmond, WA, USA), and $P < 0.05$ was considered statistically significant.

Table 1 shows the incidence of HL in Korea and Japan between 2006 and 2012. In Korea, the cumulative incidence per 100,000 population during the study period was 1.26 per 100,000 population, and annual
incidences were in the range 0.05–0.43. The cumulative incidence in Japan was 0.14 over the same period and annual incidences were in the range 0.01–0.03. This difference could be attributed to the divergence in agricultural modernization between the 2 countries since 1960, uptake of vaccines by residents in endemic areas, and disparities in the efficacy of water supply infrastructure and wastewater treatment systems (4,5,11).

Our results also show that in both countries, significantly more men were infected compared to women ($P < 0.01$), accounting for 63.0% and 87.8% of total cases in Korea and Japan, respectively. The proportion of men was significantly higher in Japan compared to Korea (Table 1). These statistically significant gender differences in the risk of infection between the 2 countries might be the result of a variety of cultural, environmental, and ecological factors (1,4–6). In general, HL is predominantly affecting males working in arable farming and livestock industries (1,3,6). However, it is still possible that biological variations including hormonal and immunological or healthcare behavior may influence the differences between men and women (14).

When we classified HL cases in Korea by age group, 2.2% of the cases were aged 19 years or younger, 11.9% were aged 20–39, 29.4% were aged 40–59 and 56.5% were aged 60 years or older. In Japan, the proportions for the same age groups were 9.7%, 31.1%, 30.1%, and 29.1%, respectively. The proportions of cases differed significantly by age group within both countries ($P < 0.01$). These age distributions also differed between the 2 countries, with 85.9% and 59.2% of the cases occurring in individuals aged 40 years or older in Korea and Japan, respectively (Table 1). However, in both countries, these age distributions might reflect the increasing trend towards migration of young people from rural endemic areas to urban areas for employment, leaving elderly relatives to work in agriculture (3,11,15).

When we analyzed the seasonal pattern of reported HL cases in Korea, we found that 3.8% of the cases occurred in spring, 6.8% in summer, 78.5% in autumn, and 10.9% in winter, demonstrating significant seasonal variation in the distribution of cases ($P < 0.01$). In Japan, the proportions for the seasons were 28.6%, 46.9%, and 18.4%, respectively, again representing significant seasonal variation ($P < 0.01$). This seasonal distribution revealed that reported cases were more frequent in autumn, and this seasonal effect was more distinct in Korea compared to Japan (78.5% vs. 46.9% of the cases, respectively; $P < 0.01$; Table 1). During the study period, reported cases in Korea increased markedly in September, peaked in November, and began decreasing in the middle of December with the onset of the cold season. Meanwhile in Japan, reported cases increased from early summer until late autumn, which might be the result of flooding events in that period (Fig. 1) (3–5,10,13,15). Reported HL cases were precipitated by climatic events such as floods and heavy rainfalls, which might increase the risk of transmission to humans because of the displacement of rodent populations (1–5,9–11,13,15).

In developing countries, leptospirosis has been an emerging health threat in urban areas, particularly among impoverished slum communities with limited access to sanitation during periods of heavy seasonal rainfall (1,5,11,16).

We also compared the incidence of HL between the capital cities of each country, both intensely urbanized, as well as other regions including rural communities. In Korea, 29 cases (0.04 per 100,000 population) were reported in the capital city of Seoul, home to 21% of the Korean population, between 2006 and 2012. In comparison, 603 cases (0.22 per 100,000 population), were reported in other regions of the country, demonstrating a significantly higher incidence than the capital. Conversely, in Japan, 25 cases (0.03 per 100,000 population) were reported in the capital city of Tokyo, accounting for 11% of the national population, while 171 cases (0.02 per 100,000 population) were reported in other regions, suggesting the lack of a significant regional variation. A significantly higher proportion of cases were observed in rural areas of Korea compared to Japan (Table 1). In Japan, vaccination against *Leptospira* is considered to be among the factors that contributed towards the dramatic decrease in reported cases after 1960’s (11); the low level of incidence has been maintained despite the discontinuation of the vaccination program. In contrast, Kim reported a dramatic decrease in reported cases during the vaccination period (1988–1997; average annual incidence, 0.02 per 100,000 population), and an increase in reported cases after discontinuance of the vaccination program (1998–2011; 0.22 per 100,000 population) (4). This fact might explain the differing incidence levels in rural areas between the 2 countries. The differences in agricultural and forestry practices, and the efficacy of wastewater treatment infrastructure might contribute towards different incidence rates in rural areas of both countries. In addition, it is reported that the high proportion of cases observed in Japan is associated with overseas travel to developing countries (11,12); the frequency of overseas travel in Korea and Japan must be considered. Future studies investigating and comparing the level of modernization and lifestyles in rural areas of both countries are necessary. In addition, the possible contribution of

| Table 1. Characteristics of reported leptospirosis cases in Korea and Japan, 2006–2012 | Korea ($n = 632$) | Japan ($n = 196$) | $P$-value |
| --- | --- | --- | --- |
| Cumulative incidence per 100,000 | 1.26 | 0.14 | $< 0.01$ |
| Gender |  |  |  |
| Male | 398 (63.0) | 172 (87.8) |  |
| Female | 234 (37.0) | 24 (12.2) |  |
| Age |  |  |  |
| $\leq 19$ | 14 (2.2) | 19 (9.7) |  |
| 20–39 | 75 (11.9) | 61 (31.1) |  |
| 40–59 | 186 (29.4) | 59 (30.1) |  |
| $\geq 60$ | 357 (56.5) | 57 (29.1) |  |
| Season |  |  |  |
| Spring | 24 (3.8) | 12 (6.1) |  |
| Summer | 43 (6.8) | 56 (28.6) |  |
| Autumn | 496 (78.5) | 92 (46.9) |  |
| Winter | 69 (10.9) | 36 (18.4) |  |
| Location |  |  |  |
| Capital city | 29 (4.6) | 25 (12.8) |  |
| Other | 603 (95.4) | 171 (87.2) |  |
differences in biological factors including immunosenescence or comorbidities should be considered. This study is an ecological assessment lacking an individual-unit level comparison; therefore, a potential ecological fallacy cannot be ruled out.

In summary, the present study provides a retrospective assessment of quantitative ecological data concerning the epidemiology, as well as the demographic and geographic characteristics associated with reported HL cases in Korea and Japan. The difference in HL incidence between the 2 countries might not only suggest the contribution of unique geographical characteristics, but also the variations in industrialization levels. The elucidation of the reasons accounting for the differences between the 2 countries is imperative for the effective prevention of HL among residents of at-risk areas.

Conflict of interest None to declare.

REFERENCES
1. World Health Organization. Human leptospirosis: guidance for diagnosis, surveillance and control. Available at <http://www.who.int/csr/don/en/WHO_CDS_CSR_EPH_2002.23.pdf>. Accessed December 21, 2014.
2. Vijayachari P, Sugunan AP, Shriram AN. Leptospirosis: an emerging global public health problem. J Biosci. 2008;33:557-69.
3. Jang Y, Kim H, Bang HA, et al. Epidemiological aspects of human brucellosis and leptospirosis outbreaks in Korea. J Clin Med Res. 2011;3:199-202.
4. Kim MJ. Leptospirosis in the Republic of Korea: historical perspectives, current status and future challenges. Infect Chemother. 2013;45:137-44.
5. Koizumi N, Muto M, Tanikawa T, et al. Human leptospirosis cases and the prevalence of harboring *Leptospira interrogans* in urban areas of Tokyo, Japan. J Med Microbiol. 2009;58:1227-30.
6. Lau C, Smythe L, Weinstein P. Leptospirosis: an emerging disease in travellers. Travel Med Infect Dis. 2010;8:33-9.
7. Bandara M, Ananda M, Wickramage K, et al. Globalization of leptospirosis through travel and migration. Global Health. 2014;10:61.
8. Cosson JF, Picardeau M, Mielcarek M, et al. Epidemiology of *Leptospira* transmitted by rodents in Southeast Asia. PLoS Negl Trop Dis. 2014;8:e2902.
9. Hartskeerl RA. Leptospirosis: current status and future trends. Indian J Med Microbiol. 2006;24:309.
10. Korea Center for Disease Control and Prevention (KCDC). Leptospirosis. Disease Web Statistical System, KCDC. Available at <http://www.cdc.go.kr/>. Accessed December 21, 2014.
11. Yanagihara Y, Villanueva SY, Yoshida S, et al. Current status of leptospirosis in Japan and Philippines. Comp Immunol Microbiol Infect Dis. 2007;30:399-413.
12. Victoriano AF, Smythe LD, Gloriani-Barzaga N, et al. Leptospirosis in the Asia Pacific region. BMC Infect Dis. 2009;9:147.
13. National Institute of Infectious Diseases, Japan (NIID). Leptospirosis. Infectious DiseasesWeekly Report (IDWR)/Infectious Agents Surveillance Report (IASR). Available at <http://www.nih.go.jp/niid/index-e.html>. Accessed at December 21, 2014.
14. Skufca J, Arima Y. Sex, gender and emerging infectious disease surveillance: a leptospirosis case study. Western Pac Surveill Response J. 2012;3:37-9.
15. National Institute of Infectious Diseases and Tuberculosis and Infectious Diseases Control Division, Ministry of Health, Labour and Welfare. Leptospirosis in Japan, November 2003–November 2007. Infect Agents Surveillance Rep. 2008;29:1’-2’. Available at <http://idsc.nih.go.jp/iasr/29/335/tpc335-j.html>. Accessed at December 21, 2014.
16. Johnson MAS, Smith H, Joseph P, et al. Environmental exposure and leptospirosis, Peru. Emerg Infect Dis. 2004;10:1016-22.