National pertussis surveillance in South Korea 1955–2011: epidemiological and clinical trends

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SUMMARY

Background: Although there has been substantial progress in controlling pertussis in South Korea, the reported number of pertussis case-patients has gradually been increasing during the last decade. To address this, we summarized the surveillance data on pertussis collected during the period 1955–2011. Detailed epidemiologic and clinical data were determined, primarily using data from recent years.

Methods: We analyzed data from the national surveillance system to describe the occurrence of pertussis. The annual numbers of reported pertussis case-patients were identified for the period 1955–2000. For 2001–2009, information including limited demographic characteristics and the date of onset of symptoms were identified. For 2010–2011, detailed epidemiologic and clinical information of reported pertussis case-patients were collected.

Results: During 1955–2011, the secular trend was characterized by a gradual decrease in the reported number of cases from 1955 to the late 1990s, then a recent increase starting in the early 2000s. In 2009, a large number of reported cases occurred in infants <1 year of age. In 2011, an increase in reported cases among adolescents and adults aged ≥15 years was observed. During 2010–2011, 29.8% of reported cases were not immunized and 11.3% had not been immunized in a timely manner. Of adolescents and adults aged ≥15 years, 91.7% did not have a record of immunization.

Conclusions: During 2010–2011, a shift in age group was observed in pertussis case-patients: 33.8% were young infants <3 months of age and 29.0% were adolescents and adults ≥15 years of age. Considering that infants without timely vaccination may be vulnerable to an increased risk of pertussis infection, steps to provide timely vaccination to infants, to provide Tdap vaccination to adolescents and adults, and to enhance surveillance to capture adult pertussis cases should be taken in South Korea.

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1. Introduction

Pertussis is a highly communicable disease caused by the bacterium Bordetella pertussis, characterized by paroxysmal cough including inspiratory whoop and post-tussive vomiting.1 Prior to the introduction of a vaccine, pertussis was common in infants and young children and sometimes caused severe complications such as pneumonia, seizures, encephalopathy, and death.2 During the past decades, the availability of pertussis vaccine in combination with diphtheria and tetanus toxoids has markedly decreased the incidence of pertussis to a low level.3 Yet, pertussis continues to produce a substantial childhood disease burden in countries with incompletely implemented vaccination programs.4

Despite achieving high vaccination coverage, some countries have reported an increase in pertussis incidence in recent years.5–7 The lack of natural booster events and waning immunity in adolescents and adults have been implicated in this resurgence of pertussis.8,9 Furthermore, the resurgence could possibly be attributed to an increase in pertussis among young infants resulting from the reduced transfer of transplacental antibody from mother to fetus.10

In South Korea, the government started to recommend routine DTwP (diphtheria, tetanus, and whole cell pertussis) vaccination in 1954 and introduced the DTaP (diphtheria, tetanus, and acellular pertussis) vaccine into the National Immunization Program (NIP) in 1989, and there has since been substantial progress in controlling pertussis, with low numbers of reported cases until the 2000s.11,12 However, the reported number of pertussis case-patients has gradually been increasing during the last decade.13 To date, the factors affecting this increase in pertussis in South Korea remain unclear.

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The limitation of the current universal vaccination program targeting infants and children less than 7 years of age may be implicated in the recent increase in pertussis in South Korea. In 2009, the Tdap vaccine (reduced dose tetanus, diphtheria, and pertussis) was licensed in South Korea for use in adolescents and adults aged older than 11 years. However, additional data from multiple years are needed to guide decisions on the adoption of the Tdap vaccination into the NIP. To address this, we summarized the surveillance data on pertussis collected in South Korea during 1955 to 2011 with a view to identifying the susceptible population and to provide baseline data for the pertussis prevention and control policy in South Korea. Detailed epidemiologic and clinical data were determined primarily using data from recent years.

2. Methods

2.1. National surveillance

The national pertussis surveillance system was first established in 1954 in South Korea. It involves the passive reporting of clinically diagnosed case-patients by medical practitioners. In 2001, a major revision was made to the system, resulting in the collection of data using the standardized clinical and laboratory case definition of pertussis based on the World Health Organization (WHO) case definition, and active investigation of passively reported case-patients. In 2010, the Korea Centers for Disease Control and Prevention (KCDC) updated the pertussis case surveillance system to collect complete and detailed information, including route of transmission and disease severity for all reported case-patients.

2.2. Pertussis immunization program

Although pertussis vaccination has been recommended for universal vaccination for the past 50 years, data on national vaccination coverage are very limited in South Korea. The recent estimated vaccination coverage for the full series (at least four doses) of DTaP vaccine in children ranged between 65.7% and 94.0%.

2.3. Data collection and analysis

We analyzed data for the period 1955–2011 collected by the national surveillance system to describe the occurrence of pertussis in South Korea. From 1955 to 2000, only the annual numbers of reported pertussis case-patients were identified. From 2001 to 2009, information including limited demographic characteristics and date of the onset of symptoms were identified. From 2010 to 2011, detailed epidemiologic and clinical information of reported pertussis case-patients were collected. For case-patients reported in 2010–2011, we used the case definition as described by the WHO; a clinical case is defined as a case diagnosed as pertussis by a physician, or a person with a cough lasting at least 2 weeks with at least one of the following symptoms: paroxysm of coughing, inspiratory whooping, or post-tussive vomiting. Laboratory confirmation is defined as isolation of B. pertussis, or detection of genomic sequences by means of PCR from a clinical pertussis case-patient.

Note that the analysis of epidemiologic and clinical information was considered only for the 2010–2011 surveillance data because data for 1955–2009 were incomplete (most of the clinical and demographic information were missing). Because we used data from a legally mandated, government-sponsored routine surveillance system, institutional review board approval and informed consent were not required for the KCDC.

3. Results


From 1955 to 2011, a total of 178,265 pertussis case-patients were passively reported in South Korea (Figure 1). Four major peaks were observed before the 1990s: 33,218 cases in 1961–1962, 8373 cases in 1966, 8592 cases in 1969–1970, and 3176 cases in 1980–1981. The secular trend was characterized by a gradual decrease in reported numbers from 1955 to the late 1990s, then a gradual increase starting in the early 2000s (Figure 2).

During 2001–2011, the number of reported pertussis case-patients was highest among infants <1 year of age. In 2009, a large number of reported cases occurred in infants <1 year of age (n = 58). There was, however, an increase in reported cases among adolescents and adults aged ≥15 years in 2011 (n = 34; Figure 2).

During 2001–2003 and 2004–2006, pertussis case-patients were reported throughout the year, with increases observed during the summer season between July and August, peaking during October and November (Figure 3). During 2007–2009 and 2010–2011, the increase in reported cases occurred earlier than in the previous years: the increase was observed during the late spring season in May, peaking during August and September. During 2010–2011, there was another peak observed in November.

3.2. Epidemiologic and clinical findings 2010–2011

The frequencies and percentages of pertussis case-patients reported in 2010–2011 by selected epidemiologic characteristics are shown in Table 1. Among 124 case-patients, 95 (76.6%) were confirmed by laboratory methods. Among 42 infants aged <3 months, 42.9% had their symptom onset during October–December, whereas 44.1% of adolescents and adults aged ≥15 years had symptom onset earlier, during July–September. Of 124 pertussis case-patients, 24.2% were found to have identified the source of transmission as another family member. A total of 14 (11.3%) pertussis case-patients were found not to have been immunized in a timely manner. Among 24 infants aged 3–11 months, six (25%) did not receive vaccination in a timely manner. Of adolescents and adults aged ≥15 years, 97.7% did not have a record of immunization.

The frequencies and percentages of selected clinical characteristics in pertussis case-patients reported in 2010–2011 are shown in Table 2. Overall, 69.4% (86/124) of pertussis case-patients had a paroxysmal cough, whereas 9.7% (12/124) had only mild symptoms such as mild cough and/or rhinorrhea. Of infants aged <3 months, 64.3% (27/42) had inspiratory whoop, whereas only 13.9% (5/36) of adolescents and adults aged ≥15 years had this symptom. Of infants aged <3 months, 45.2% (19/42) had apnea and/or dyspnea, whereas 16.7% (6/36) of adolescents and adults had this symptom. Nineteen of 42 infants aged <3 months (45.2%) were hospitalized, and 10 (23.8%) had respiratory complications such as pneumonia or bronchiolitis.

4. Discussion

This is the first published report of national pertussis surveillance data for South Korea covering a period of 56 years. As the data for 1955–2000 were not collected using a standardized case definition for suspected pertussis infection, we focused on the 2001–2009 and 2010–2011 periods, for which more complete and detailed data on case-patients were available.

Although pertussis has traditionally been a disease affecting young children, observations on the age group distribution depict a shift in the age group of pertussis case-patients in South Korea. During 2010–2011, 33.8% (42/124) of pertussis case-patients were
young infants <3 months of age. This finding concurs with reports from elsewhere for other countries that have reported a resurgence of pertussis even though they have achieved high vaccination coverage.7,18 Moreover, our observation of the high proportion of pertussis case-patients in adolescents and adults aged ≥15 years (29.0%, 36/124) is in consonance with other reports that have pointed towards an age shift in pertussis incidence to an older susceptible population.19,20 This shift in pertussis infection in adolescents and adults may lead to serious consequences for susceptible infants, because adolescents (usually older siblings) and adults (parents or grandparents) are the potential sources of infection for young infants less than 3 months of age.21

Recent surveillance data for pertussis from other countries have shown an upward and/or downward shift in age distribution. In countries with a high quality pertussis vaccination program such as Taiwan, Switzerland, and Germany, many cases have been seen in infants <1 year of age; however, adolescents and the adult age group have also accounted for an increased proportion of cases.22–24 The reasons for this change may include the increased level of surveillance over more recent years, the decrease in vaccine-induced or natural booster-induced population immunity, and a demographic transition or shift.25,26

In this study, we also found that timely vaccination was not received in 11.3% (14/124) of the case-patients, and vaccination history was not documented in 91.7% (33/36) of the adolescents and adults aged over 15 years. Strengthening of routine DTaP vaccination should be the cornerstone of pertussis control and it could be achieved by providing timely vaccination to infants and children coupled with providing sustainable outreach services. In 2012, 253 public health centers and >6000 private clinics
nationwide now participate in a national electronic vaccination registry system, which keeps electronic records of all vaccines given at that institution. In order to improve timeliness and completion of vaccination, the systems provide a free reminder/recall notification cellular-phone message to the parents.

Moreover, utilizing Tdap vaccination for adolescents and adults to prevent transmission from the primary source of infection to unprotected infants should be a public health priority. In 2012, the Korean Advisory Committee on Immunization Practices decided to introduce the Tdap vaccine into the NIP, with the aim of providing protection against pertussis to adolescents and adults who could be the potential source of infection for infants who have not yet completed DTaP vaccination. Tdap is now recommended for adolescents aged 11–12 years who have completed their DTaP vaccination series; adolescents and adults aged 11–64 years who have frequent contact with infants <1 year of age; and for any wounded patients who require Td (tetanus–diphtheria vaccine) vaccination – Tdap may be given instead of Td. Since January 2012, full financial support for Tdap vaccination from the government has been provided for adolescents aged 11–12 years.

Our findings demonstrate that although the majority (72.2%) of adolescents and adults aged ≥15 years experienced paroxysmal cough, 11.1% had only minimal symptoms such as mild cough and/or rhinorrhea. Similar to other studies that have demonstrated an atypical presence of the typical clinical presentation for pertussis in adults, our study revealed only 13.9%, 8.3%, and 16.7% of adolescents and adults experienced inspiratory whoop, post-tussive vomiting, and dyspnea, respectively. Since recent studies have shown that adolescents and adults are a reservoir for pertussis infection and serve as a source of transmission within the family, strengthening surveillance on adolescents and adults with atypical symptoms of pertussis should be highlighted. We discovered that the source of infection for 40.5% (17/42) of infants less than 3 months of age was identified as being another family member. Considering that infants younger than 3 months of age usually stay at home and have no interaction other than with their family members, conducting a sensitive and timely investigation on the asymptomatic or atypical symptomatic family members should be a public health priority.

Our study using surveillance data to describe the epidemiology and to evaluate the disease burden of pertussis has several limitations. First, there are weaknesses in the design of the surveillance system resulting from the need to balance limited resources and data quality. For example, surveillance only covered passive reporting from physicians who suspected a pertussis

Table 1
Epidemiologic characteristics of reported pertussis case-patients by age group, Republic of Korea, 2010–2011

<table>
<thead>
<tr>
<th>Age group</th>
<th>&lt;3 months (n = 42)</th>
<th>3–5 months (n = 18)</th>
<th>6–11 months (n = 6)</th>
<th>1–4 years (n = 12)</th>
<th>5–9 years (n = 7)</th>
<th>10–14 years (n = 3)</th>
<th>≥15 years (n = 36)</th>
<th>Total (n = 124)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory confirmed cases</td>
<td>31 (73.8)</td>
<td>15 (83.3)</td>
<td>5 (83.3)</td>
<td>10 (83.3)</td>
<td>5 (71.4)</td>
<td>2 (66.7)</td>
<td>27 (75)</td>
<td>95 (76.6)</td>
</tr>
<tr>
<td>Male sex</td>
<td>24 (57.1)</td>
<td>11 (61.1)</td>
<td>2 (33.3)</td>
<td>3 (25)</td>
<td>5 (71.4)</td>
<td>0 (0)</td>
<td>13 (36.1)</td>
<td>58 (46.8)</td>
</tr>
<tr>
<td>Month of symptom onset</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan-Mar</td>
<td>11 (26.2)</td>
<td>3 (17.6)</td>
<td>2 (40)</td>
<td>1 (9.1)</td>
<td>1 (16.7)</td>
<td>0 (0)</td>
<td>1 (2.9)</td>
<td>19 (15.3)</td>
</tr>
<tr>
<td>Apr-Jun</td>
<td>8 (19.0)</td>
<td>5 (29.4)</td>
<td>1 (20)</td>
<td>3 (27.3)</td>
<td>1 (16.7)</td>
<td>3 (100)</td>
<td>7 (20.6)</td>
<td>28 (22.6)</td>
</tr>
<tr>
<td>Jul-Sep</td>
<td>5 (11.9)</td>
<td>7 (41.2)</td>
<td>1 (20)</td>
<td>5 (45.5)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>15 (44.1)</td>
<td>33 (26.6)</td>
</tr>
<tr>
<td>Oct-Dec</td>
<td>18 (42.9)</td>
<td>2 (11.8)</td>
<td>1 (20)</td>
<td>2 (18.2)</td>
<td>4 (66.7)</td>
<td>0 (0)</td>
<td>11 (32.4)</td>
<td>38 (30.6)</td>
</tr>
<tr>
<td>Unknown</td>
<td>0 (0)</td>
<td>1 (5.6)</td>
<td>1 (20)</td>
<td>1 (10)</td>
<td>1 (16.7)</td>
<td>0 (0)</td>
<td>2 (6.0)</td>
<td>6 (4.8)</td>
</tr>
<tr>
<td>Intrafamilial transmissiona</td>
<td>17 (40.5)</td>
<td>4 (22.2)</td>
<td>1 (16.7)</td>
<td>3 (25)</td>
<td>0 (0)</td>
<td>1 (33.3)</td>
<td>4 (11.1)</td>
<td>30 (24.2)</td>
</tr>
<tr>
<td>Living with infant &lt;12 months</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5 (41.7)</td>
<td>2 (28.6)</td>
<td>1 (33.3)</td>
<td>8 (22.2)</td>
<td>16 (12.9)</td>
</tr>
<tr>
<td>Vaccination status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 dose</td>
<td>34 (81.0)</td>
<td>3 (16.7)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>37 (29.8)</td>
</tr>
<tr>
<td>1 dose</td>
<td>8 (19.0)</td>
<td>14 (77.8)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>1 (14.3)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>23 (18.5)</td>
</tr>
<tr>
<td>2 doses</td>
<td>-</td>
<td>1 (5.6)</td>
<td>2 (33.3)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>3 (2.4)</td>
</tr>
<tr>
<td>3 doses</td>
<td>-</td>
<td>4 (66.7)</td>
<td>-</td>
<td>3 (25)</td>
<td>1 (14.3)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>8 (6.5)</td>
</tr>
<tr>
<td>4 doses</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7 (58.3)</td>
<td>2 (28.6)</td>
<td>0 (0)</td>
<td>9 (7.3)</td>
<td></td>
</tr>
<tr>
<td>5 doses</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1 (8.3)</td>
<td>2 (28.6)</td>
<td>2 (66.7)</td>
<td>2 (5.6)</td>
<td>7 (5.6)</td>
</tr>
<tr>
<td>Non-timely vaccinationb</td>
<td>-</td>
<td>4 (22.2)</td>
<td>2 (33.3)</td>
<td>4 (33.3)</td>
<td>4 (57.1)</td>
<td>0 (0)</td>
<td>-</td>
<td>14 (11.3)</td>
</tr>
<tr>
<td>Unknown vaccination history</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1 (8.3)</td>
<td>1 (14.3)</td>
<td>1 (33.3)</td>
<td>33 (91.7)</td>
<td>36 (29.0)</td>
</tr>
</tbody>
</table>

a Refers to two or more family members who live at the same postal address and are reported as pertussis case-patients.
b Refers to pertussis case-patients who had not completed DTaP vaccination ≥1 dose by 2 months; ≥2 doses by 4 months; ≥3 doses by 6 months; ≥4 doses by 18 months; and 5 doses by 6 years of age.

Table 2
Clinical characteristics of reported pertussis case-patients by age group, Republic of Korea, 2010–2011

<table>
<thead>
<tr>
<th>Age group</th>
<th>&lt;3 months (n = 42)</th>
<th>3–5 months (n = 18)</th>
<th>6–11 months (n = 6)</th>
<th>1–4 years (n = 12)</th>
<th>5–9 years (n = 7)</th>
<th>10–14 years (n = 3)</th>
<th>≥15 years (n = 36)</th>
<th>Total (n = 124)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reported symptoms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paroxysmal cough</td>
<td>31 (73.8)</td>
<td>13 (72.2)</td>
<td>3 (50)</td>
<td>7 (58.3)</td>
<td>5 (71.4)</td>
<td>1 (33.3)</td>
<td>26 (72.2)</td>
<td>86 (69.4)</td>
</tr>
<tr>
<td>Inspiratory whoop</td>
<td>27 (64.3)</td>
<td>10 (55.6)</td>
<td>1 (16.7)</td>
<td>3 (25)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>5 (13.9)</td>
<td>46 (37.1)</td>
</tr>
<tr>
<td>Post-tussive vomiting</td>
<td>9 (21.4)</td>
<td>6 (33.3)</td>
<td>2 (33.3)</td>
<td>0 (0)</td>
<td>1 (14.3)</td>
<td>0 (0)</td>
<td>3 (8.3)</td>
<td>21 (16.9)</td>
</tr>
<tr>
<td>Apnea and/or dyspnea</td>
<td>19 (45.2)</td>
<td>7 (38.9)</td>
<td>2 (33.3)</td>
<td>1 (8.3)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>6 (16.7)</td>
<td>35 (28.2)</td>
</tr>
<tr>
<td>Cynosis</td>
<td>15 (35.7)</td>
<td>5 (27.8)</td>
<td>2 (33.3)</td>
<td>1 (8.3)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>2 (5.6)</td>
<td>25 (20.2)</td>
</tr>
<tr>
<td>Mild cough and/or rhinorrhea, only</td>
<td>1 (2.4)</td>
<td>1 (5.6)</td>
<td>1 (16.7)</td>
<td>3 (25)</td>
<td>2 (28.6)</td>
<td>0 (0)</td>
<td>4 (11.1)</td>
<td>12 (9.7)</td>
</tr>
<tr>
<td>Reported complications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pneumonia or bronchiolitis</td>
<td>10 (23.8)</td>
<td>5 (27.8)</td>
<td>1 (16.7)</td>
<td>1 (8.3)</td>
<td>1 (14.3)</td>
<td>1 (33.3)</td>
<td>2 (5.6)</td>
<td>21 (16.9)</td>
</tr>
<tr>
<td>Hospitalization</td>
<td>19 (45.2)</td>
<td>10 (55.6)</td>
<td>1 (16.7)</td>
<td>1 (8.3)</td>
<td>3 (42.9)</td>
<td>1 (33.3)</td>
<td>5 (13.9)</td>
<td>40 (32.3)</td>
</tr>
</tbody>
</table>
case-patient during 1955–2000. Moreover, 2001–2009 surveillance collected only limited information on reported case-patients. Second, improving the diagnosis by obtaining respiratory specimens is often too technically difficult for most health care facilities. Although the preferred methods for the laboratory diagnosis of pertussis are culture and PCR, not all institutions are capable of running these tests. In response, the KCDC has established a laboratory surveillance system that provides culture and PCR for suspected pertussis case-patients identified at most health care facilities; however, the system is still limited in terms of quantity. Third, the recent increase in reported cases in South Korea between 2001 and 2011 may be due to the intensification of recognition and surveillance systems. The recent increase in pertussis in other countries has probably attracted the attention of the health care professionals.

Despite these limitations, our data indicate the possibility of suboptimal protection against pertussis for infants <3 months of age, infants and children without timely vaccination, and adolescents and adults aged ≥15 years. Although we are facing an evolution in the pertussis vaccination program, the risk of endemic transmission and individual infection may remain, which underlines the need for comprehensive national baseline data. In addition, based on our data, the long-term strategy for implementing a pertussis vaccination program in South Korea needs to be re-examined and re-evaluated.

In conclusion, we report the pertussis surveillance data from South Korea for the period 1955–2011. Our data show that the most common age groups affected during 2010–2011 were those aged <3 months and ≥15 years. Considering that infants without timely vaccination are at increased risk of pertussis infection, steps to provide timely vaccination to infants and to provide Tdap vaccination to adolescents and adults is now being discussed in South Korea. Moreover, enhanced surveillance to capture adult pertussis case-patients with atypical symptoms should be in place in order to prevent transmission to vulnerable infants. Financial support for Tdap vaccination from the government may lead to a decrease in the susceptible population among adolescents and adults.

**Conflict of interest:** No conflict of interest exists.

**References**