PLASMODIUM VIVAX MALARIA IN THE REPUBLIC OF KOREA DURING 2004–2005: CHANGING PATTERNS OF INFECTION

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Abstract. Vivax malaria re-emerged in the Republic of Korea (ROK) in 1993. The annual incidence of this disease, which had increased rapidly through 2000 with geographic expansion, started to decrease in 2001, reaching 864 cases in 2004; however, the trends changed in 2005 when 1,304 cases were reported. Among 2,168 cases of vivax malaria reported from 2004 through 2005, 389 cases (17.9%) were ROK military personnel, 565 cases (26.1%) were veterans who had been discharged from the military within 2 years of report of infection, and 1,214 cases (56.0%) were civilians. Local transmission might have taken place during this period in the southern side of the Demilitarized Zone. Regional increase of vivax malaria in North Korea, increased local transmissions in ROK, and active transmission by vector mosquitoes during the transmission season might be important factors responsible for the re-increase of vivax malaria in ROK during 2005.

INTRODUCTION

Plasmodium vivax malaria had been endemic on the Korean Peninsula for many centuries.1 During the Korean War (1950–1953), ~15% of all febrile illnesses among the Republic of Korea (South Korea; ROK) military personnel were caused by malaria.2,3 As socioeconomic conditions in ROK improved and associated malaria control efforts were strengthened, P. vivax malaria cases decreased rapidly, and finally ROK was declared malaria free in 1979.4,5 However P. vivax malaria has recently become an important health threat in ROK since its re-emergence in 1993.

The current re-emergence of P. vivax malaria in ROK might be the result of infected mosquitoes originating from the Democratic People’s Republic of Korea (North Korea; DPRK) near the Demilitarized Zone (DMZ); this has been supported by epidemiologic data.6,7 During the early period of re-emergence, most P. vivax malaria cases were reported among ROK military personnel, and the geographic distribution was confined to the DMZ and areas adjacent to the DMZ where no civilians live. However, the number of P. vivax malaria cases among the civilian population, whose residence was located farther from the DMZ, has increased every year with the geographic distribution expanding into cities and counties bordering Seoul.6 The annual incidence of P. vivax malaria increased rapidly to reach 4,141 cases in 2000. However, the number of annual P. vivax malaria cases among the civilian population, whose residence was located farther from the DMZ, has increased every year with the geographic distribution expanding into cities and counties bordering Seoul.6 The number of Anopheles mosquitoes was monitored using a light trap in Ganghwa County, which is one of the malaria-risk areas in ROK, during the malaria transmission season from 2003 through 2005. Trapping was conducted once a week between 7:00 PM Tuesday and 6:00 AM Wednesday from May through October.

RESULTS

In 2004, the incidence of malaria was 25.9% less than that in 2003.5 However, in 2005, the incidence was 50.9% more than the previous year (Table 1). Of a total of 2,168 cases of P. vivax malaria that occurred during 2004 and 2005, 389 cases (17.9%) were reported among military personnel, 565 cases (26.1%) were reported among veterans who served in malaria-risk areas, and 1,214 cases (56.0%) were reported among civilians (Table 1). The proportion of civilians among the total annual cases increased consistently during the study period, reaching nearly 60% in 2005.
In 2004, the number of P. vivax malaria cases among military personnel decreased in almost all malaria-risk areas compared with 2003 (Figure 1). The number of civilian cases also decreased in almost every risk area except in Goyang, Dongducheon Cities, and Yanggu County. No civilian case occurred in Pocheon, Gapyeong, Hwacheon, and Inje Counties. However, in 2005, the number of P. vivax malaria cases among military personnel and civilians increased in many malaria-risk areas as the total annual incidence increased (Figure 1). In particular, increase of civilian cases was remarkable in the western part of the malaria-risk areas including Ganghwa County, Gimpo, Goyang, Incheon, and Paju Cities. In Ganghwa County, the incidence among civilians was 118% more than in 2004, and in Gimpo, Goyang, and Incheon Cities, it was 79%, 69%, and 74%, respectively, more than in 2004. In Paju City, the incidence among civilians was 55% more in 2005 than in 2004. In 2005, 6 soldiers and 10 civilian cases occurred in Namyangju City, at the northeastern fringe of Seoul (Figure 1). Namyangju City had never previously been included among the malaria-risk areas.

Most of the P. vivax malaria cases occurred from June through September, with the peak from late June to late August in 2004 and from early July to early September in 2005, respectively (Figure 2). The 10-day incidence peak of civilian cases never reached 50 cases during 2004; however, it increased to reach 80 cases in 2005.

Anopheles sinensis mosquitoes, which are the major transmission vector in ROK, were collected and counted on a weekly basis in Ganghwa County from 2003 through 2005. Despite a higher density during mid-August in 2005, the weekly number of mosquitoes during this time revealed a similar pattern (Figure 3). However, in 2004 and 2005, the numbers of mosquitoes in September were higher than 2003, respectively.

**DISCUSSION**

Malaria re-increased in 2005. It was the first time in 4 years after the number of cases started to decrease every year since 2001. Increase in the number of cases mostly appeared in the western part of the malaria-risk areas including Ganghwa County, Gimpo, Goyang, Incheon, and Paju Cities. However, the number of P. vivax malaria cases decreased to a negligible level during this period in the eastern part of the malaria-risk areas.

**TABLE 1**

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2005</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soldiers</td>
<td>159 (18.4%/−43.6%)†</td>
<td>230 (17.6%/+44.7%)‡</td>
<td>389 (17.9%)§</td>
</tr>
<tr>
<td>Veterans*</td>
<td>248 (28.7%/−10.8%)†</td>
<td>317 (24.3%/+27.8%)‡</td>
<td>565 (26.1%)‡</td>
</tr>
<tr>
<td>Civilians†</td>
<td>457 (52.9%/−24.6%)‡</td>
<td>1,214 (58.1%/+55.5%)‡</td>
<td>1,671 (56.0%)§</td>
</tr>
<tr>
<td>Total</td>
<td>864 (100%/−25.9%)‡</td>
<td>1,304 (100%/+50.9%)‡</td>
<td>2,168 (100%)§</td>
</tr>
</tbody>
</table>

* Veterans include soldiers who were retired or discharged from the military for ≥ 2 years and previously assigned to a malaria-risk area.
† Civilians include veterans who were discharged from the military for > 2 years.
‡ The first numerical values in parentheses represent the proportion of each group out of total annual incidence, and the second numerical values in parentheses represent the rate of increase compared with the annual incidence of the previous year. In 2003, a total of 1,166 cases occurred. Among them 282 cases were soldiers, 278 cases were veterans and 606 cases were civilians. A civilian case and a veteran case, which occurred in December of 2003 were reported belatedly in the following year; therefore, cases of occurrence of P. vivax malaria in ROK in 2003 should be corrected from 1,164 cases to 1,166 cases.
§ Numerical values in parentheses represent the proportion of each group out of total incidence during 2004 and 2005.

**Figure 1.** Distribution of reported malaria cases among the Republic of Korea (ROK) military personnel and civilians in malaria-risk areas. A. Political boundaries of the malaria-risk areas in the ROK. DMZ, Demilitarized Zone. B. Annual malaria cases among military personnel (left) and civilians (right). Large dots represent 100 cases, medium dots represent 10 cases, and small dots represent 1 case.

**Figure 2.** Number of malaria cases of each group, reported at 10-day intervals, from 2004 through 2005 in the ROK.
malaria in ROK might be mainly attributed to the infected mosquitoes originating from DPRK near the DMZ; the malaria situation in DPRK might be an important influence on malaria in ROK. However, increase of *P. vivax* malaria cases in ROK in 2005 was inconsistent with the malaria situation in DPRK of the same year. In 2005, *P. vivax* malaria cases decreased to 11,507, which were ~34% of the total number of cases, 33,803, in 2004, in DPRK. Despite the decrease of *P. vivax* malaria cases in DPRK, the malaria incidence might increase regionally in the malaria-high-risk areas. In DPRK, most of the malaria high-risk areas include Gaeseong City, the North and the South Hwanghae Provinces, and Gangwon Province, which are adjacent to the DMZ. Geographic distribution of *P. vivax* malaria cases in ROK in 2005 suggests that malaria incidence might increase in the western part of the malaria high-risk areas in DPRK. Since the re-emergence of *P. vivax* malaria in the early 1990s, these areas have shown the highest incidence of infection. To control the high burden of *P. vivax* malaria in these areas, DPRK has performed presumptive anti-relapse therapy using 15 mg of primaquine base for 2 weeks before the transmission season (usually April) on civilians who have lived in high-risk areas since 2002. However, presumptive anti-relapse therapy was not performed in Gaeseong City in 2005 because of its side effects such as anorexia, nausea, vomiting, and anemia. In 2006, the DPRK government requested 50% more anti-malarial agents than the preceding year (personal communication). Based on these facts, we suspect that the number of *P. vivax* malaria cases largely increased in these areas, and this might have caused an increase of *P. vivax* malaria cases in the western part of the malaria-risk areas in ROK during 2005.

The possibility of increased local transmissions in ROK should be considered as another cause for increase of *P. vivax* malaria cases in 2005. Because civilian cases exceeded one half of the total annual cases in 2003, the proportion of civilian cases steadily increased to reach nearly 60% of the total annual cases in 2005. It is believed that the chloroquine-primaquine chemoprophylaxis, which has been used by the ROK army since 1997, has helped reduce malaria in the military. The number of ROK soldiers given chemoprophylaxis increased constantly to reach > 90,000 soldiers during 2004 and 2005 (personal communication). In addition, 14-day presumptive anti-relapse therapy using primaquine has been used since 2001 on soldiers who complete a term of military service in malaria-risk areas before their discharge. Large-scaled chemoprophylaxis of soldiers serving in the malaria-risk areas resulted in a constant reduction of the proportion of military personnel and veteran cases among the total annual cases during this period. However, in Ganghwa County, Gimpo, Goyang, and Paju Cities, where increase of civilian cases were observed in 2005, the civilians lived generally south of the military establishment. The increased proportion of civilian cases in these areas suggests that local transmission might have taken place in the southern side of the areas where soldiers were stationed along the DMZ during this period. This pattern has been consistently observed since 2002 when civilian cases accounted for about one half of the total annual cases. In particular, the population densities of Gimpo, Goyang, and Paju Cities have become higher because of rapid urbanization. Within these locations, densely populated areas are adjacent to rural areas where the vector inhabits a favorable environment; this proximity may have increased the chances of local transmission. The sudden increase of military personnel and civilian cases in Namyangju City in 2005 was exceptional. This area had never been included among the malaria-risk areas since the first re-emergence in 1993. Even though it may be controversial whether the increase of malaria cases in Namyangju City was a focal epidemic or a direct expansion of the malaria-risk areas, special attention must be paid to this area because it is also one of the areas where rapid urbanization has been under way and where densely populated neighborhoods are adjacent to rural areas. The malaria cases identified on Yeongjong Island, where the Incheon International Airport is located, were included into the cases of Incheon City. Yeongjong Island has consistently had several malaria cases every year. Thus, precaution is necessary to prevent the direct expansion of *P. vivax* malaria to the International Airport.

For current *P. vivax* malaria in ROK, most short incubation transmission cases occurred after July. In 2004, the 10-day incidence in late August was higher than during late June to mid-August. This means that the short incubation transmission of malaria, caused by transmission by mosquitoes during the same season, actively occurred. Increased short incubation transmission in 2004 was consistent with the increased number of cases in 2005. The peak of the 10-day incidence, which appeared in early July, was extended longer to early September in 2005 compared with prior years; in addition, a small minor peak was observed in early October, which might have resulted from the higher number of mosquitoes in September in 2005. Therefore, malaria transmission was also active in 2005 and would influence the incidence in the following year.

In conclusion, the number of cases of *P. vivax* malaria in ROK increased in 2005; this was the first time since the trend for decreasing cases was observed in 2001, despite the steady
decrease in DPRK during this period. Increased civilian cases in the southern side of the areas where soldiers were stationed along the DMZ suggest active local transmissions in these areas. Regional increase of \textit{P. vivax} malaria cases in DPRK, increased local transmission, and active transmission by vector mosquitoes during the summer and early fall of this period might have contributed to the increase of \textit{P. vivax} malaria cases in ROK in 2005. Despite the decrease to negligible levels in the eastern part of the malaria-risk areas, 16 cases occurred in 2005 in Namyangju City, not previously included in the malaria-risk areas before 2005. Therefore, special attention should be focused on local transmission to prevent expansion of the infection.

Received October 17, 2006. Accepted for publication January 26, 2007.

Acknowledgments: The authors thank Min-Seon Kim and Hye-Jin Kim for drawing the maps.

Financial support: This study was supported by a grant of the Antimicrobial Resistance Program, National Research and Development Program of the National Institute of Health (NIH-4800-4845-300), Ministry of Health and Welfare, Republic of Korea.

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