

STATUS OF *PLASMODIUM VIVAX* MALARIA IN THE REPUBLIC OF KOREA DURING 2001–2003

JOON-SUP YEOM, SEUNG-HO RYU, SEJOONG OH, WON-JA LEE, TAE-SEON KIM, KI-HWAN KIM, YOUNG-A KIM, SUN-YOUNG AHN, JE-EUN CHA, AND JAE-WON PARK*

Department of Internal Medicine and Department of Occupational Medicine, Kangbuk Samsung Hospital, Sungkyunkwan University School of Medicine, Seoul, Republic of Korea; Korean Armed Forces Medical Command, Gyeonggi-do, Republic of Korea; Department of Medical Zoology, Korea Center for Disease Control and Prevention, Seoul, Republic of Korea; Department of Microbiology, Gachon Medical School, Incheon, Republic of Korea

Abstract. The Republic of Korea experienced a re-emergence of *Plasmodium vivax* malaria in 1993. The incidence of this disease increased rapidly through 2000 with its geographic distribution expanding from the vicinity near the Demilitarized Zone to the adjacent outlying areas. However, the number of cases of *P. vivax* malaria since that time period has decreased. A total of 2,538 cases occurred in 2001, and this decreased to 1,761 cases and 1,164 cases in the two subsequent years. A total of 5,463 cases of *P. vivax* malaria were reported from 2001 through 2003; 25.26% (1,380) were reported among Republic of Korea military personnel, 27.48% (1,501) were among veterans who had been discharged from the military within two years, and 47.26% (2,582) were among the civilian population. Mosquito control activities by the North Korean and South Korean governments, chemoprophylaxis of Republic of Korea Army personnel, and the low level of *Anopheles* mosquitoes in 2001 may have been factors responsible for the decreasing number of malaria cases. However, local transmission might have taken place in urban regions of the malaria-risk areas that are within 30 km south of the Demilitarized Zone. Extensive intervention and continued surveillance are warranted to prevent the epidemic from re-expanding and to eliminate this disease in the Republic of Korea.

INTRODUCTION

Plasmodium vivax is the causative agent of malaria (benign tertian malaria) in the Republic of Korea and was endemic on the Korean Peninsula for many centuries until the late 1970s, at which time the Republic of Korea was declared free of malaria.¹ During the Korean War (1950–1953), the Republic of Korea and United States military had many casualties as a result of *P. vivax* malaria. For example, approximately 15% of all the febrile illnesses reported among Republic of Korea army personnel were the result of malaria.^{2–4} As the socio-economic conditions in the Republic of Korea improved and associated malaria control efforts were strengthened, this country was finally declared free of malaria in 1979.¹ However, a number of focal indigenous cases, which originated either from imported cases or from the result of the disease's long latency period, continued to be reported until 1984.⁵

Plasmodium vivax malaria has recently become a major public health threat affecting both the civilian and military communities in the areas near the Demilitarized Zone (DMZ). Since its re-emergence in 1993, the annual incidence of *P. vivax* malaria has increased rapidly, mostly among the military personnel and veterans in border areas and reached 4,142 cases in 2000.⁶ During this period, the geographic distribution of malaria expanded southward from the DMZ to the counties bordering Seoul.⁶ In addition to a rapid increase in the military, similar increase in malaria cases were observed among civilians, and the time of occurrence of the first case of malaria with a short incubation period was becoming earlier during this period.⁶

The current re-emergence of *P. vivax* malaria might be the result of infected mosquitoes originating from North Korea near the DMZ.^{7,8} North Korea, which denied the existence of *P. vivax* malaria prior to the government's official acknowl-

edgment of the disease in 1999, has been receiving money and supplies to control *P. vivax* malaria since 2000. In the Republic of Korea, the number of soldiers during their terms of service in the malaria-risk areas who have received chloroquine and terminal primaquine chemoprophylaxis has been increasing steadily, and the duration of chemoprophylaxis has been extended from 16 weeks in 1997 to 22 weeks since 2001.⁹ In this study, we evaluated the epidemiologic characteristics, i.e., the number of cases of each group, the geographic distribution of these cases and their monthly and annual incidence, and the number of *Anopheles* mosquitoes, to analyze the nature of malaria infection in the Republic of Korea from 2001 through 2003.

MATERIALS AND METHODS

Malaria is one of the group III communicable diseases that exist in the Republic of Korea. The Division of Communicable Diseases Information and Surveillance at the Korea Center for Disease Control and Prevention (Seoul, Republic of Korea) collects data on all cases among civilians and veterans, and all the cases occurring in military personnel must be reported to the Office of the Surgeon General at the Army Headquarters. All *P. vivax* malaria cases are also reported to the Ministry of Health and Welfare. The case definition of malaria includes any febrile illness in which *P. vivax* parasites have been demonstrated in peripheral blood smears.^{1,10} Cases among military veterans were defined as those personnel who 1) had a malaria attack within 24 months after discharge from military service, and 2) had been stationed in area at risk for malaria.

The annual geographic distribution of malaria in Republic of Korea military personnel, civilians and veterans was determined by the location where they lived or where they were stationed when the diagnosis was made. The seasonal incidence was analyzed by grouping cases according to 10-day intervals.

Light traps were used to collect mosquitoes in the high-risk

* Address correspondence to Jae-Won Park, Department of Microbiology, Gachon Medical School, 1198, Kuwol-dong, Namdong-gu, Incheon 405-760, Republic of Korea. E-mail: seorak@dreamwiz.com

areas during the malaria transmission season. Trapping was conducted once a week between 7:00 PM Monday and 6:00 AM Tuesday from June through September.

RESULTS

A total of 5,463 cases of *P. vivax* malaria occurred from January 1, 2001 through December 31, 2003 (Table 1). Of these cases, 25.26% (1,380) were reported among military personnel, 27.48% (1,501) were reported among veterans who served in malaria-risk areas, and 47.26% (2,582) were reported among civilians. During this period, the annual incidence of malaria constantly decreased every year, and the incidence of disease was 54% less in 2003 than that in 2001. There was a greater reduction in the percentage of cases among soldiers and veterans than among civilians. The proportion of civilians among the total cases increased persistently during this period, reaching more than half of the total cases in 2003. Conversely, the number of cases of soldiers and veterans was less than one fourth of the total cases in 2003.

From 2001 through 2003, the number of malaria cases has decreased steadily in almost every part of the malaria-risk areas (Figure 1). However, in 2001, the number of cases in Yanggu and Inje Counties was more than twice the number of cases that occurred in 2000. In 2002, in the western part of the malaria-risk areas including Gimpo and Ganghwa Counties, the number of malaria cases temporarily increased. From 2001 through 2003, the number of civilian cases in Goyang, Gimpo, and Paju Counties decreased less than in any other part of the malaria-risk areas.

Most of the malaria cases were diagnosed from June through September, with a unimodal peak in July and August (Figure 2). Unlike the civilians, in the military populations, the malaria incidence temporarily decreased in mid-June after chloroquine chemoprophylaxis was initiated. The 10-day incidence peak also decreased every year, and it finally decreased to less than 60 cases in 2003.

Anopheles sinensis mosquito, which is the major transmission vector in the Republic of Korea, was collected and counted on a weekly basis in Yeoncheon and Cheolwon Counties. Compared with the weekly number of mosquitoes during 2000 and 2002, the weekly number of mosquitoes was especially low in 2001 in both counties (Figure 3). Data for 2003 were not available.

DISCUSSION

The most distinctive feature of the *P. vivax* malaria demographics in the Republic of Korea from 2001 through 2003 was the constant reduction in the number of cases. Since the

re-emergence of malaria in 1993, the number of annual cases of *P. vivax* malaria has constantly increased, reaching 4,142 in 2000.^{6,11,12} However, the number of annual cases has decreased sharply since 2001. The reduced number of malaria cases during this period might be attributed to the improved control of *P. vivax* malaria in North Korea.¹³ As mentioned earlier, the re-emergence of *P. vivax* malaria in the Republic of Korea might be due to the malaria epidemic in North Korea, and the status of *P. vivax* malaria in North Korea near the DMZ could have a direct influence on the Republic of Korea.⁶ Since the start of economical assistance in 2000, the government of the Republic of Korea has donated materials worth more than \$500,000 annually to North Korea to help them control the disease. Although a shortage of data for malaria infection in North Korea prevents our full understanding of the status of this disease in North Korea, it is believed that the support of the government of the Republic of Korea has helped decrease malaria in North Korea.¹³ The constant reduction of cases in the Republic of Korea from 2001 through 2003 might be the result of the improved situation in North Korea and the chloroquine-primaquine chemoprophylaxis that has been used by the Republic of Korea army. In 1997, the Korean Ministry of National Defense addressed the increasing numbers and spread of malaria throughout the Republic of Korea, in part, by initiating a chemoprophylaxis policy using chloroquine and primaquine. Soldiers received weekly oral hydroxychloroquine sulfate (400 mg) from June through early October, followed by daily oral primaquine phosphate (15 mg) for two weeks. Candidates for chemoprophylaxis were determined by the epidemiologic data for the previous year, and the number of the Republic of Korea army soldiers given chemoprophylaxis increased constantly during this period; it reached more than 140,000 soldiers in 2002.⁹ This resulted in a greater reduction in the number of cases among soldiers and veterans than among civilians.

Plasmodium vivax malaria has decreased in many parts of the high-risk area during this same period. In 2001, the number of cases among soldiers decreased to less than half of those in 2000 in almost every part of the malaria-risk areas.⁶ However, the geographic distribution of malaria cases had expanded. In Yanggu and Inje Counties, where there are sections of the Taebaek mountain range, the number of cases increased 2–3-fold in 2001. Moreover, in the same year, soldiers in Yangpyeong, Hongcheon, Yeosu and Hoengseong counties were infected by malaria. These areas are adjacent to the southeastern parts of the malaria-risk areas and malaria cases had never been reported in these areas before 2000. In 2002, malaria cases in military personnel were also observed in Yeosu and Hoengseong Counties. Thus, the geographic distribution had been expanding in a southeast direction.

The annual number of cases of *P. vivax* malaria among civilians have showed a pattern similar to that of the soldiers. Cases among civilians in the eastern and central parts of the malaria-risk areas decreased sharply, but in the counties in the western parts, such as Goyang, Gimpo and Paju counties, the number of cases showed a smaller decrease. Even if malaria infection had spread southward since 1997, most of the cases were among the Republic of Korea military personnel stationed near the DMZ since the re-emergence in 1993, and the civilians cases in the malaria-risk areas lived south of the military establishments.⁶ The decreased number of malaria

TABLE 1

Annual incidence of *Plasmodium vivax* malaria among Republic of Korea army military personnel, veterans, and civilian personnel*

	2001	2002	2003	Total
Soldiers	673 (47.75%)	425 (36.85%)	282 (33.65%)	1,380
Veterans	754 (40.86%)	470 (37.67%)	277 (41.06%)	1,501
Civilians	1,111 (29.82%)	866 (22.05%)	605 (30.14%)	2,582
Total	2,538 (38.78%)	1,761 (30.61%)	1,164 (33.90%)	5,463

* Values in parentheses represent the rate of decrease compared with the annual incidence of the previous year.

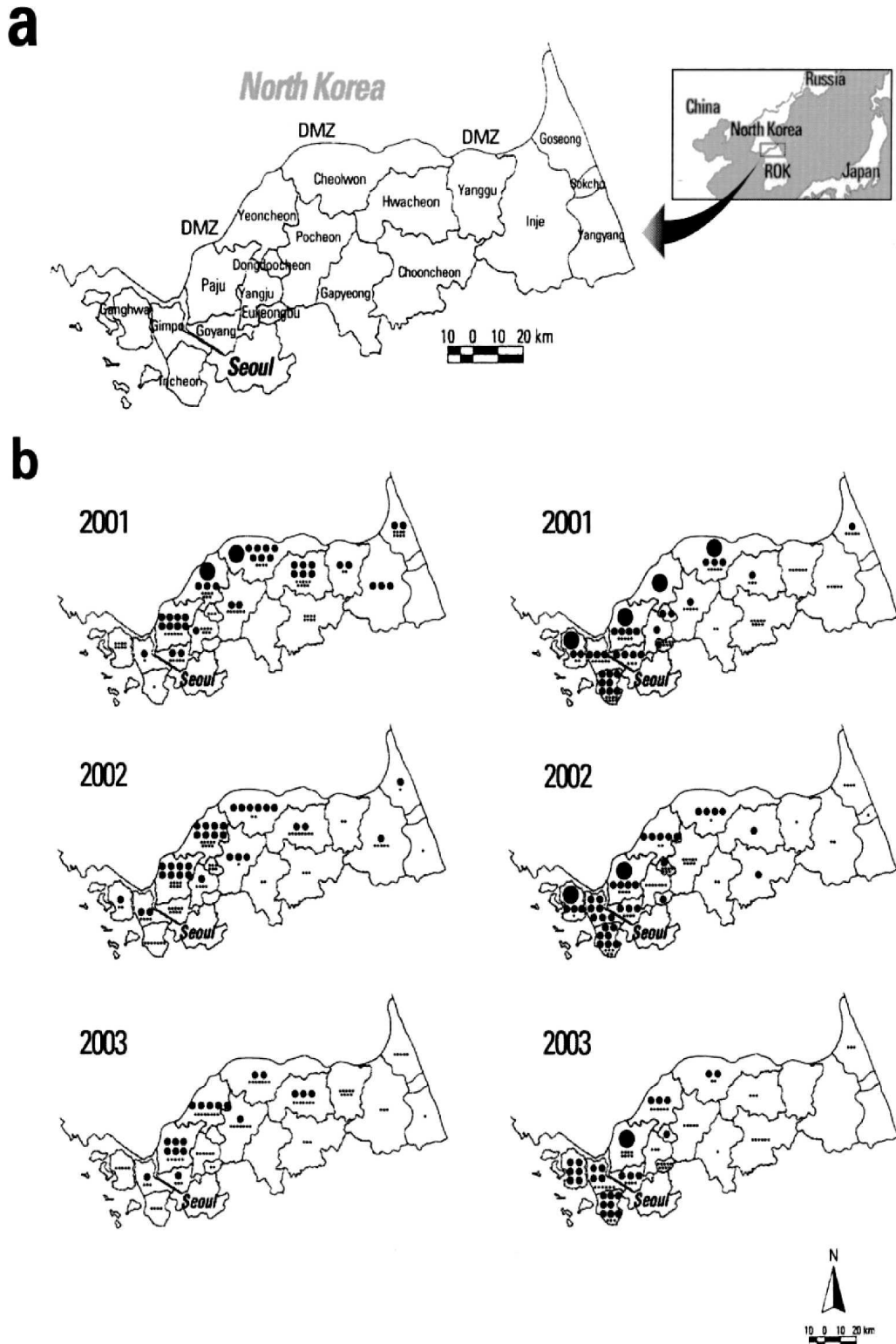


FIGURE 1. Distribution of reported malaria cases among the Republic of Korea (ROK) military personnel and civilians north of Seoul/Han River in the Republic of Korea. **a**, Political boundaries of the Republic of Korea north of the Han River. DMZ = Demilitarized Zone. **b**, Annual malaria cases among military personnel (**left panels**) and civilians (**right panels**). Large dots represent 100 cases, medium dots represent 10 cases, and small dots represent 1 case.

cases among civilians that occurred to a lesser extent than in military personnel means that local transmission actively took place in the southern side of the area in which soldiers were stationed along the DMZ during this period. These areas are

different from the other parts of malaria-risk areas, which are rural areas. In these counties, urbanization has been under way and the population densities are higher than those in other counties in the malaria-risk areas. Therefore, special

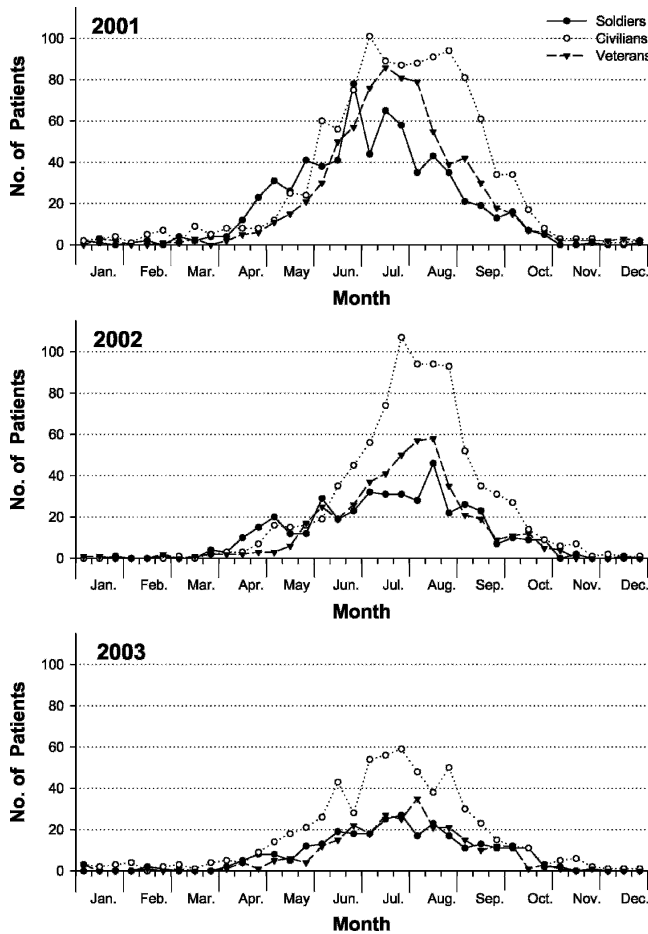


FIGURE 2. Number of malaria cases of each group, reported at 10-day intervals, from 2001 through 2003 in the Republic of Korea.

attention should be paid to prevent focal epidemics in these areas.

The markedly low level of *Anopheles* mosquitoes in 2001 was attributed to the abnormally dry weather conditions. In 2001, a drought had continued for more than four months until late June and the relative humidity was far lower than the average relative humidity during the last 30 years. These conditions might have inhibited the formation of water pools that are a prerequisite for the growth of the larvae of the mosquitoes, and this resulted in a low level of mosquitoes. We believe that this factor was also responsible for the large reduction in malaria cases in 2001.

In conclusion, our study has demonstrated that the number of cases of *P. vivax* malaria has decreased annually from 2001 through 2003. Control activities in North Korea, chemoprophylaxis in the Republic of Korea army, and the low level of *Anopheles* mosquitoes in 2001 may have been responsible for the decreasing number of cases that were reported during this period. The number of cases among civilians was approximately half of the total cases during this period, which was different from the situation before 2000. In spite of the decrease of total cases, a large number of cases still occurred in the urban areas of the malaria-risk areas more than 30 km south of the DMZ. Continued intervention and surveillance are warranted to prevent the malaria infection from re-expanding and also to help eliminate this disease in the Republic of Korea.

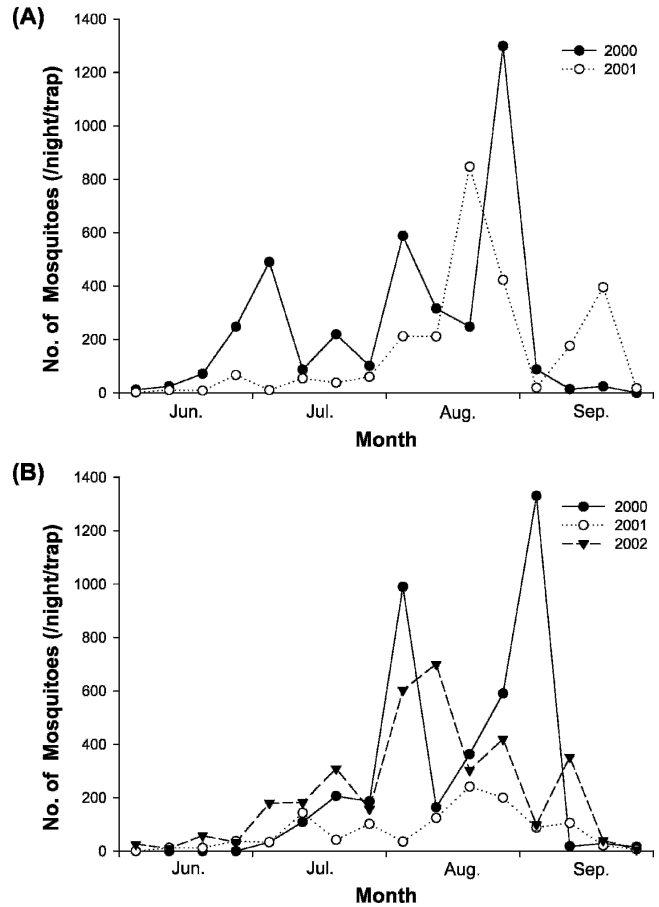


FIGURE 3. Weekly number of *Anopheles* mosquitoes in the malaria-risk areas in two counties in the Republic of Korea from 2000 through 2002. A, Weekly number in Yeoncheon county during 2000 and 2001. B, Weekly number in Cheolwon County from 2000 through 2002. Data for the weekly number of mosquitoes for Yeoncheon County in 2002 were not available.

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Authors' address: Joon-Sup Yeom, Department of Internal Medicine, Kangbuk Samsung Hospital, Sungkyunkwan University School of Medicine, 108, Pyung-dong, Jongno-gu, Seoul 110-746, Republic of Korea, Telephone: 82-2-2001-2472, Fax: 82-2-2001-2049, E-mail: seahawks@skku.edu. Seung-Ho Ryu, Department of Occupational Medicine, Kangbuk Samsung Hospital, Sungkyunkwan University School of Medicine, 108, Pyung-dong, Jongno-gu, Seoul 110-746, Republic of Korea, Telephone: 82-2-2001-2634, Fax: 82-2-2001-2626. Se-jong Oh, Korean Armed Forces Medical Command, Yool-dong, Boondang-gu, Seongnam-si, Gyeonggi-do 463-040, Republic of Korea, Telephone: 82-32-460-2184, Fax: 82-32-930-5088. Won-Ja Lee, Department of Medical Zoology, Korea Center for Disease Control and Prevention, 5, Nokbun-dong, Eunpyeong-gu, Seoul 122-701, Republic of Korea, Telephone: 82-2-380-1507, Fax: 82-2-380-1560. Tae-Seon Kim, Ki-Hwan Kim, Young-A Kim, Sun-Young Ahn, Je-Eun Cha, and Jae-Won Park, Department of Microbiology, Gachon Medical School, 1198, Kuwol-dong, Namdong-gu, Incheon 405-760, Republic of Korea, Telephone: 82-32-460-2184, Fax: 82-32-930-5088, E-mail: seorak@dreamwiz.com.

Reprint requests: Jae-Won Park, Department of Microbiology, Ga-

chon Medical School, 1198, Kuwol-dong, Namdong-gu, Incheon 405-760, Republic of Korea.

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