INTRODUCTION

Malaria in Henan Province, People’s Republic of China can be classified as seasonally unstable and epidemic. Anopheles sinensis and An. anthropophagus are the main vectors and poor farming communities bear the greatest burden of disease. A major epidemic of Plasmodium vivax malaria occurred in the 1960s and at the beginning of 1970s. Malaria incidence in Henan increased to 16,944/100,000 in 1970. After control efforts that lasted several decades, malaria was gradually brought under control. By 1992, malaria had been nearly eliminated (incidence less than 1/100,000), with only 318 malaria cases observed in the province. This was the lowest level of malaria incidence since records were kept. However, in 1993 there was a dramatic upsurge in the number of cases due initially to transfusions with infected blood. Malaria outbreaks then appeared successively in southern Henan Province in areas where An. anthropophagus was present. Plasmodium vivax malaria is now well established in 12 counties and the malaria situation is considered highly unstable and is characterized by focal outbreaks and epidemics. This report presents the results related to malaria prevention and control in Henan between 1993 and 2004.

MATERIALS AND METHODS

Resource materials. Data of three types of fever cases, including clinically diagnosed malaria cases, suspected cases, and cases with fever of unknown origin, were analyzed. Slide-positive cases were also considered. Malaria investigation tables, infectious disease reporting tables, annual reports, and malaria prevention and treatment summaries, as well as epidemic reports, were considered. Population data were provided by the Henan Provincial Statistics Bureau.

Examination of blood of fever cases. Microscopic blood examination was carried out for clinically diagnosed malaria cases, suspected malaria cases, and cases with fever of unknown origin.

Investigation of parasite-positive rates. Microscopic examination of blood samples was conducted among residents and pupils of primary schools in selected sentinel townships and villages in epidemic areas and parasite-positive rates were calculated.

Serologic surveillance. Post-transmission season immunofluorescent antibody tests (IFATs) were carried out on selected people at sentinel sites during October and November.

Vector surveillance. Density and spatial distribution of the various vector species were surveyed. Night collections were made from baited cows and humans and early morning collections were made from bed nets. Vectorial capacity was calculated according to the method of MacDonald.

Measures for prevention and treatment. A strategy of scientific prevention and treatment was carried out in which measures were selected according to local circumstances. The integrated measures included eliminating infectious sources and vector control in areas with both An. sinensis and An. anthropophagus. In areas with only An. sinensis malaria control measures were based only on radical cure of infectious sources.

Radical cure of infectious sources. Newly diagnosed patients with P. vivax malaria were treated with chloroquine (1.2 grams for 3 days) and primaquine (180 mg for 8 days). A total of 33,250 patients were treated between 1993 and 2004. The coverage rate for treatment of reported cases reached 100% and the rate of proper treatment reached at 95% each year. People with a history of infection during the past year and their families and neighbors were given pre-transmission season treatment with chloroquine and primaquine for the radical cure of P. vivax malaria. A total of 503,717 people were treated during the 12-year period and the coverage rate of pre-transmission season treatment was greater than 80% each year. In areas where An. anthropophagus was present, malaria prophylaxis was given during the transmission season to 574,900 people at high risk for malaria in villages with malaria incidences greater than 10%.

Insecticide-treated nets (ITNs). From 1996 to 1998 and in 2000 ITNs impregnated with deltamethrin were used in areas where there had been a resurgence of malaria. A total of 258,700 people in 1997 and 358,500 people in 1997 were protected by ITNs in six counties where An. anthropophagus was present. In 1998, 116,700 people were covered in five counties and in 2000 an additional 381,000 people were covered in four counties.

Abstract. We analyzed malaria prevalence and evaluated the effect of malaria control measures in Henan Province, People’s Republic of China between 1993 and 2004. Data relating to malaria epidemics, malaria control measures and their effects, and vector surveillance between 1993 and 2004 were collected and analyzed. Mean malaria incidence during this period was 2.96/100,000. After integrated vector control measures and appropriate treatment of malaria cases were carried out, the number of malaria cases in Henan Province decreased from 4,815 in 2000 to 2,112 in 2004. The parasite-positive rate and the density of Anopheles anthropophagus were also reduced. Malaria control measures were effective and malaria incidence decreased in Henan. However, there are still more cases in this province than in 1992. Local malaria outbreaks and epidemics have occurred in areas where Anopheles anthropophagus and An. sinensis are present. Thus, malaria control measures should be strengthened.
Local professional health care workers including technicians were trained in malaria prevention and control in the main malaria-epidemic areas. Residents in epidemic areas gained knowledge of malaria through a range of media such as radio and TV broadcasts, newspaper articles, and posters. The importance of prophylaxis and ITNs were strongly promoted.

RESULTS

Malaria situation and malaria epidemic trends. Between 1993 and 2004, 33,250 malaria cases were reported in Henan Province and the prevalence of malaria infection was 2.96/100,000 (Table 1). Eight percent of these malaria cases were concentrated in 10–12 counties where the vector An. anthropophagus was present.

In 1993, there was a malaria resurgence in Henan. A total of 1,010 cases were reported and 61.5% of the patients had a recent history of blood transfusions. In Jiaozuo City, there were 116 malaria cases and all had had a recent transfusion. A total of 56% had received plasma and 44% received whole blood. Clinical signs appeared between 3 and 15 days post-transfusion. During a subsequent investigation of 7,335 donors in Kaifeng City, seven carriers were found (parasite positive rate = 0.10%).

In 1995, malaria outbreaks occurred in a number of villages in four counties where An. anthropophagus was present. Malaria incidence reached 37.8% in one outbreak village. Because of serious misreporting and under-reporting, some outbreaks were not found by the routine reporting system but through reviews and investigations after the epidemic season.

In 1996, the number of cases reported in Henan increased to 2,693 (2.96/100,000), which was 2.5 times higher than the number reported in the previous year. More than 90% of the cases during the next three years were in four counties where An. anthropophagus was present. Small local outbreaks appeared and malaria epidemics spread from the Tongbai Mountains to other areas from 1996 to 1999. For example, malaria incidence reached 17.3% in Laojie Village in Tongbai County and 286 cases were found in Mazhenfu Township in Tanghe County (23.8 times higher than that in 1996). In Longji Township in Pingqiao County, no cases were reported in 1997 but 104 cases were found in 1998 and an outbreak appeared in Ershilihe Village in 1999 in which malaria incidence increased above 15%; 7.4% of local people were Plasmodium positive.

From 2000 to 2004 malaria epidemics spread from area with An. anthropophagus to nearby areas with An. sinensis. Malaria cases rapidly increased in 12 counties of 5 adjacent cities. In Sheqi County, malaria cases were 6.75 times higher than the 36 cases seen in 2000. In Shangshui County, 1,777 cases were found in 2001 (incidence = 0.15%) compared with zero in 2000.

Both P. vivax and P. falciparum malaria had been prevalent for a long time in Huaiibin County. Integrated measures of eliminating infectious sources and vector control resulted in the elimination of P. falciparum malaria a reduction in the incidence of P. vivax malaria to its lowest level since 1987. However, in 2002 there was a resurgence of P. vivax malaria; 628 cases were reported. Malaria incidence in Huaiibin County increased to 2.3% but in some towns or villages the incidence was as high as 7.8%. In 2003, the number of cases increased to 1,107 (a 76% increase from the previous year). During this year, Huaiibin County accounted for 45.2% of all malaria cases in the province. In Wanggang Township, an outbreak occurred in which malaria incidence increased to 743/100,000.

Investigation of parasite-positive rate. In 1996, the parasite-positive rate was 4.3% (117 of 2,719) in an investigation of pupils and local residents in 10 townships of 5 counties. The parasite-positive rate was 11.6% (43/370) in Shihe and 15.9% (33 of 207) in Tongbai. In 1999, the parasite-positive rate among local pupils was 1.0% (17 of 1,666) in Pingqiao, Shihe, and Tanghe Counties. No positive individuals were found among 1,080 residents including pupils in Shihe County in 2001.

Examination of blood of fever cases. During 12-year study period, 5,992,008 fever patients were tested and 9,943 (0.17%) were positive. This accounted for 29.9% (9,943 of 33,250) of all malaria cases.

Serologic surveillance. A total of 3,749 residents including pupils were tested by IFAT in the counties of Pingqiao, Shihe, Tongbai and Tanghe in 1996–1999 and 231 (6.2%) were positive. In 2001, 500 residents including pupils were tested and 4 (0.8%) were positive.

Investigation on malaria vectors. The main malaria vectors in Henan province are An. sinensis and An. anthropophagus. Anopheles sinensis were present throughout the province but its density was related to breeding places. It accounts for 48.4–85.7% of the vectors in the Tongbai Mountains and other hilly areas (36.4% of the vectors in rooms and 83.6% of the vectors in cowsheds). Anopheles anthropophagus was found in areas between 32°41'N and 31°48'N and 112°51'E and 115°40'E. It is found mainly in gullies, puddles, pools, and flooded fields. Its abundance peaks in June and August each year and activity peaks between 10:00 pm and midnight each evening. The human blood indices for An. sinensis and An. anthropophagus are 0.0608 and 0.3143, respectively. Because of the higher human blood index of An. anthropophagus, its vectorial capacity was estimated to be approximately 20 times higher than that of An. sinensis.

A total of 1,004 anopheles mosquitoes were caught in Tongbai and Shihe Counties in 1996 and 37.4% (375) were An. anthropophagus. It accounted for 16.67% (29 of 174) of the mosquitoes in Tanghe County in 1998. No An. anthropophagus was found among 106 Anopheles mosquitoes collected in Shihe County in 2001. A survey showed 0 and 9 An. anthropophagus were found in Pingqiao and Tongbai Coun-

<table>
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<tr>
<th>Year</th>
<th>No. of cases</th>
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<td>1993</td>
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<td>1994</td>
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<td>1995</td>
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ties, respectively, in 2003 (making up 5.6% of the *Anopheles* captured). A mosquito-human landing investigation in Shangshui County in 2001 yielded 37 *An. sinensis* per hour.

**DISCUSSION**

After the near elimination of malaria from Henan province in 1992, there has been a dramatic resurgence. The numbers of malaria cases increased from 318 in 1992 to 4,815 in 2000. Integrated malaria control measures based on eliminating infectious sources and vector control controlled this malaria epidemic and the number of cases in the province decreased to 2,112 in 2004. However, there are still more malaria cases in this province than in 1992.

The initial resurgence has been attributed to blood-to-blood infections in 1993. Malaria caused by blood-to-blood infection is well documented, but has never been reported on the scale described herein. Instances of cross-contamination during the processing of blood collected, separated, and returned to blood donors were found in some illegal blood transfusion stations. After the closure of illegal transfusion agencies and enforcement of proper management procedures, blood-to-blood malaria infection was effectively controlled within two years.

*Anopheles anthropophagus* is only found in China and is mainly distributed in low hills, hillocks, and shallow hilly plains between 22°N and 33°N. Because of the higher human blood index of *An. anthropophagus*, its vectorial capacity was estimated to be approximately 20 times higher than that of *An. sinensis*. *Anopheles anthropophagus* is considered the primary malaria vector and a secondary vector in Henan. Malaria epidemics are more pronounced in areas with *An. anthropophagus* than in areas with *An. sinensis*. The morphology of *An. anthropophagus* is similar to that of *An. sinensis*, but the width of eggs is a distinctive differential marker and some morphologic differences between the adult mosquitoes can be used for identification. Molecular identification using a polymerase chain reaction based on sequence differences in ribosomal DNA internal transcribed spacer can easily distinguish these two mosquitoes.

At the beginning of the 1990s in Henan Province, malaria control based on integrated measures for eliminating infectious sources and vector control was effective. The density of *An. anthropophagus* decreased greatly. Investigations in four counties between 1986 and 1992 showed that no *An. anthropophagus* were caught after the introduction of ITNs. However, due to the high cost of ITNs and limited financial resources for malaria control efforts, vector control measures could not be maintained. As a result, the density of *An. anthropophagus* increased. By 1996,*An. anthropophagus* accounted for 37.4% of the *Anopheles* mosquitoes captured in Tongbai County. The increasing number of malaria outbreaks has been attributed to the increasing density of vectors, as well as to the accumulation of infectious sources. Malaria epidemics have even spread to adjacent areas where only *An. sinensis* is present. This spread has been attributed to the increasing availability of suitable breeding places, which has resulted from changes in agricultural land use and expansion of irrigation projects. Delays in the diagnosis and treatment of imported cases are also believed to have played a role.

Migration between malaria-endemic areas and non-endemic areas has promoted malaria spread and transmission and even caused some outbreaks in economically developed areas. In August 1997, an imported malaria outbreak occurred in Changying Township in Taikang County; 38.7% (48 of 124) of the malaria-positive patients were found among farmers who had worked and returned from malaria-endemic areas in Hainan Province. Subsequently, some outbreaks related to these imported cases took place with endemic foci developing in some areas. Thus, malaria surveillance of migrants should be enhanced.

Many malaria cases failed to be reported through the routine reporting system in many provinces. A survey showed that the rate of under-reporting was 77.5% among 27,442 persons in 64 areas and 32 township hospitals in 8 counties between the Yangtze River and the Huai River.

Under-reporting is almost the same in Henan Province. A total of 752 cases were reported in Xinyang County in 1996, but 2,035 cases were eventually found in a one-year investigation. This was 2.7 times higher than the number of reported cases. A total of 178 cases were reported in Tongbai County in 1997, but 686 cases were eventually found. This was 3.9 times higher than the number of reported cases. A total of 331 cases were found in Tanghe County in 1997 (6.1 times higher than the number of reported cases). No cases was reported in 2000 but 1,777 cases were found in 2001. Under-reporting is clearly an important contributory cause of the deteriorating malaria situation in some areas because it leads to an accumulation of infectious sources. It is crucial for effective malaria control that the routine reporting system in Henan and elsewhere in China be strengthened so that the level of under-reporting is decreased.

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**REFERENCES**


