

Resurgence of vivax malaria in Henan Province, China

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Henan Province (population, 90 million) in China has nonstable endemic malaria. After 1970 when 10.2 million cases of malaria were reported in the province, a huge control programme was undertaken, and in the mid-1980s indoor spraying and bednet impregnation with pyrethroids began. By 1992 only 318 cases were reported. In 1992 Henan declared "basic elimination of malaria" and in consequence spraying and bednet impregnation ceased after 1994. Subsequently, malaria broke out again in southern Henan.

In 1995 we conducted a household survey for malaria transmission in southern Henan. Blood smears and serum samples for immunofluorescent antibody (IFA) testing were collected from 2329 people and 3.1% (73/2329) were positive for infection with Plasmodium vivax and 13% (301/2329) positive for malaria (titre \geq 1:20). All age groups were affected.

Exophilic Anopheles sinensis occurs throughout the province; endo-anthropophilic A. anthropophagus, whose vectorial capacity is 20 times greater than that of A. sinensis, occurs mainly in southern Henan (S of latitude 33°N) and was greatly reduced in numbers during 1985–92. Comparison of 1995 entomological data with historical data showed that A. anthropophagus increased in proportion to other anophelines after spraying activities and impregnation of bednets ceased.

Over 10% of 9377 residents reported having malaria. The true number affected among the at-risk population of 700000 must be larger. We conclude that impregnated bednets and malaria surveillance should continue even after an area is declared to have "basically eliminated" malaria.

Introduction

Henan Province, whose population is 90 million, consists of 170 counties and covers over 167000 km² around the Yellow River in the centre of northern China (1). The Chinese civilization began on the banks of the Yellow River and the presence of malaria in Henan has been reported for at least 2000 years. In the twentieth century Henan has been an area of nonstable endemic vivax, malariae, and falciparum malaria, with recent major outbreaks occurring in 1954–55, the mid-1960s, and 1970 (2).

The 1970 epidemic affected the whole province, with 10.2 million cases reported. This was the highest annual incidence of malaria ever recorded in China, but over the next two decades the overall number

of malaria cases in Henan fell. In 1992 there were only 318 reported cases, a provincial incidence of 0.37 per 100000 (3), almost all of which were in the south, with county incidences below 1 per 10000. Falciparum malaria, primarily a problem in southern Henan, also decreased, with 2922 cases in 1984, 5 in 1987, and none subsequently.

The fall in malaria incidence after the 1970 epidemic resulted from a massive investment in malaria control by the province. The programme began with chloroquine–primaquine treatments for passively detected clinical cases during the transmission season, relapse prevention using chloroquine–primaquine between transmission seasons, and mass prophylaxis with pyrimethamine every 10 days during the transmission season if the area incidence exceeded 10%. From 1971 to 1984 the government dispensed 280 million treatment courses, 1.8×10^9 anti-relapse courses, and about 2×10^9 chemoprophylaxis courses (2).

From 1981 to 1984 the government began active case detection and examined more than 2 million blood smears for malaria parasites. Falciparum malaria persisted in some poor southern border counties in the early 1980s (Fig. 1). Over the period 1985–89 a total of 19.6 million more blood smears were performed, mostly in the south of the province. Also from 1985 to 1992 annual indoor spraying of houses and animal sheds with residual DDT was car-

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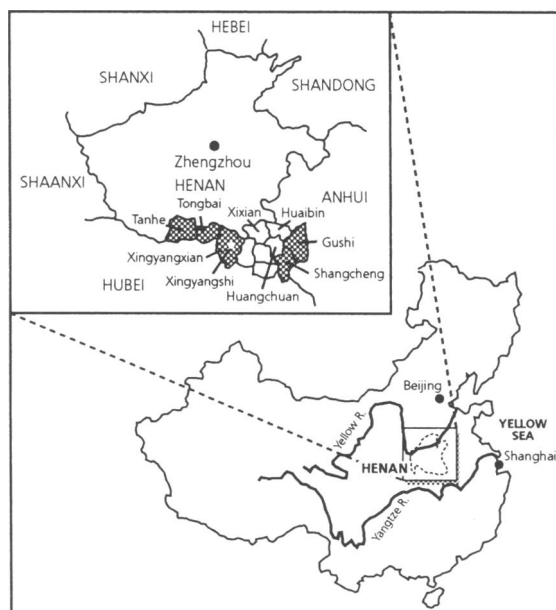
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Fig. 1. Map showing the resurgence of malaria (shaded areas) in Henan Province, China.



ried out in southern border counties, protecting over 1 million people at highest risk (2, 4). Over the period 1988–92 annual bednet impregnation with pyrethroids was added to the vector control activities because it was cheaper; 95% of the population of 2 million covered had bednets. Overall, southern areas of the province known to have *Plasmodium falciparum* or its vector *Anopheles anthropophagus* were exposed to a least 2 years of insecticide-based adulticidal mosquito control.

The disappearance of falciparum malaria in southern Henan Province since 1987 was a result of the integrated vector control (4). In the past, *P. vivax* malaria had been predominant in these southern counties, but outbreaks of *P. falciparum* malaria occurred in the early 1980s (2, 4–6). Those southern counties (S of latitude 33°N) harboured the endo-anthropophilic vector *A. anthropophagus*, which was responsible for the *P. falciparum* transmission (2, 6). The density of *A. anthropophagus* was greatly reduced by the vector control over the period 1985–92 (4), but the exophilic *A. sinensis* vector persisted. *A. anthropophagus* has a vectorial capacity 20 times that of *A. sinensis* and is therefore a much more dangerous malaria vector (2, 4–6).

By 1994 the whole of Henan Province, including the southern area, was held to have fulfilled the

Chinese Ministry of Health criteria for “basic elimination of malaria” (see below) (7), and provincial support for the indoor spraying and the impregnated bednet programme ceased (4). At this time it was thought that residual threats would come mainly from the inefficient but widespread exo-zoophilic vector of vivax malaria, *A. sinensis*, coupled with cross-border importation of exogenous malaria and humans who slept outdoors during the hot season (5, 8, 9).

In 1995 an outbreak of malaria was detected in the southern hilly areas of Henan that had been the focus of the previous vector control: Gushi, Shangcheng, Tongbai, Tanhe, Xinyangxian counties and Xinyangshi city (Fig. 1). The population of these areas is over 700000. Here we present evidence that vivax malaria became rapidly resurgent in these southern counties, and that the *A. anthropophagus* population had recovered quickly once vector control ceased.

“Basic elimination” and “Basic eradication” of malaria

The Chinese Ministry of Health criteria of “Basic elimination” and “Basic eradication” of malaria (7) are summarized below.

Basic elimination of malaria

- Using the county (or municipality) as the grass-roots unit, the annual incidence of malaria should remain below 1 per 10000 population for three consecutive years; and it should not exceed 5 per 10000 population at the township level.
- Good health infrastructure, appointment of people responsible for malaria prevention, very good malaria case management and surveillance for cases.

Basic eradication of malaria

- No malaria cases reported for three consecutive years; effective malaria surveillance and vector control.

Methods

During the 1995 malaria transmission season, the Epidemiology Case Report Information System detected malaria cases in Gushi, Shangcheng, Tongbai, Tanhe, Xinyangxian, and Xinyangshi counties (11).

Henan Province Institute of Parasitic Diseases (HPIPD) surveyed households in Gushi, Shangcheng, and Tongbai counties in June–October 1995 for evidence of malaria transmission. We also carried

out surveillance for malaria vectors in 1995 in Gushi and Shangcheng counties, and in three other high-risk adjacent counties not affected by this epidemic (Fig. 1) and compared the findings with historical surveillance data obtained in the same counties by HPIPD before (1984), during (1989) and shortly after the vector control period (1994).

Xinyang Prefecture Anti-epidemic Station also carried out a household survey in Xinyangxian county and Xinyangshi town; Tanhe County Anti-epidemic Station performed a similar survey in Tanhe (Fig. 1). The surveys in Xinyangxian, Xinyangshi and Tanhe counties did not record age, sex, or the exact year of infection (1994 or 1995) and did not obtain blood smears.

The inhabitants of all these southern Henan counties are familiar with malaria. Cases of malaria were therefore taken to be individuals who reported fever and malaria symptoms, or had recovered after taking antimalarials in 1994 or 1995. The survey teams went from house to house in areas reported to have the most malaria and sought information on the entire household. The most detail was obtained in the HPIPD survey of Gushi, Shangcheng and Tongbai counties. For these counties thick and thin blood smears and serum samples for immunofluorescent antibody (IFA) testing were obtained for all respondents and brought back to HPIPD, Zhengzhou, for examination. The smears were stained with Giemsa and validated by a malaria specialist.

Results

Malaria incidence and treatment

The reported incidence by county over the 2-year period ranged from 2% to 29% (Table 1). The three townships surveyed within Tongbai county had the highest malaria incidence: no household was malaria free and in some households all inhabitants had the disease.

In Gushi, Shangcheng and Tongbai counties we recorded the age and sex of 2329 of the 2658 respondents, and for 364 of the 585 who reported having had malaria in 1994 and/or 1995. Males were as likely as females to report having had malaria: 50% of respondents (1162/2329) and 54% (196/364) of cases were male. Overall, 64% of respondents (1478/2329) and 48% of cases (174/364) were below 15 years of age; 8% (186/2329) of respondents and 11% of cases (40/364) were aged ≥ 50 years. The malaria incidence was lowest and highest in the youngest and oldest age group, respectively: 7% (9/138) among 0–4-year-olds and 22% (40/186)

Table 1: Malaria incidence in Henan Province, China 1994–95

County	No. investigated	No. of malaria cases
Gushi	837	103 (12.3) ^a
Shangcheng	775	177 (22.8)
Xinyangshi	150	3 (2.0)
Xinyangxian	6319	351 (5.6)
Tongbai	1046	305 (29.2)
Tanhe	250	8 (3.2)
Total	9377	947 (10.1)

^a Figures in parentheses are percentages.

for those aged ≥ 50 years. For all other age groups the incidence was similar, ranging from 13% to 17%. Overall, 141 cases reported treatment with antimalarials: 66 had taken chloroquine, 65 had received quinine injections, and 10 both chloroquine and primaquine.

Blood examination

Blood samples were collected and examined from 2329 people with age–sex records surveyed in Gushi, Shangcheng, and Tongbai, counties; 3% (73/2329) were smear positive for *P. vivax*; and 44% (32) of the 73 smear positives reported a history of malaria. Overall, 13% (301/2329) were IFA-positive for malaria (titre $\geq 1:20$). The geometric mean reciprocal titre (GMRT) for positives was 49.9 and of such individuals 46 (15%) had a titre $\geq 1:160$. Among the 301 IFA positives, 152 (51%) were male and 95 (32%) were under 15 years of age. Positive IFA tests occurred in all age groups except for infants (Table 2). Among the 73 smear positives, 41% (30) were IFA positive; for the 2256 smear negatives only 12% (271) were IFA positive.

Table 2: Age distribution of 301 individuals with positive IFA titres in Henan Province, 1995

Age group (years)	Reciprocal titre				Total
	20	40	80	≥ 160	
1–9	14	25	5	1	45
10–14	15	20	6	9	50
15–34	25	27	10	10	72
35–49	19	25	14	12	70
≥ 50	13	20	17	14	64
Total	86	117	52	46	301

Table 3: Densities of *Anopheles anthropophagus* and *A. sinensis* in four counties^a in Henan Province before and after the vector control programme

Year	No. of bednets	No. of anophelines caught	<i>A. anthropophagus</i>		<i>A. sinensis</i>	
			No. caught	No. per 30 nets	No. caught	No. per 30 nets
1984 ^b	8517	3088	2078	7.3	1010	3.6
1989 ^c	2691	972	11	0.1	961	10.7
1994 ^c	3081	1052	15	0.1	1037	10.1

^a Gushi, Shangcheng, Huangchuan, and Xixian.

^b Before the impregnated bednet vector control programme.

^c Soon after or during at least two consecutive years of vector control.

Vector surveillance

In 1989 and 1994, HPIPD vector surveys in Gushi, Huaibin, Shangcheng, Huangchuan and Xixian counties detected *A. anthropophagus* at only 10 of the 22 capture sites studied, with indoor densities that were much lower than that of *A. sinensis*. In sharp contrast, captures at the same sites in 1984 — before the residual DDT spraying or impregnated bednet scheme — yielded high densities of *A. anthropophagus*, which was then more abundant indoors than *A. sinensis* (Table 3). Two of these counties (Gushi and Shangcheng) were involved in the 1994–95 epidemic of vivax malaria.

Vector surveillance was carried out again in mid-June 1995 at 17 sites in Gushi, Shangcheng, Huaibin, Huangchuan, and Xixian counties. The results for 1995 showed that *A. anthropophagus* was present at 7 of the 17 sites (Table 4). At that time the ratio of the number of *A. anthropophagus* to that of other anophelines, although low, was much higher than it had been during the 1989–94 period during or just after the vector control programme (4). In some areas of the 1995 vector surveillance, the re-appearance of *A. anthropophagus* correlated positively with a high reported incidence of malaria (e.g. Caomiao in Gushi county and Shangshiqiao in Shangcheng county). In other areas such correlation did not occur (e.g. Wuqiao in Shangcheng county and Liji in Gushi county). In Fenshui (Gushi county) *A. anthropophagus* was not detected in 1995 and little malaria occurred.

Discussion

In Henan Province transmission of vivax malaria resurged in counties that bordered Hubei and Anhui Provinces in 1994 and 1995. The delay in recognizing this could have been as long as one year and relates to official reluctance to report malaria after the

disease had been declared as “basically eliminated” from the area in 1994.

In the 1995 household survey reported here, serological evidence based on IFA tests detected 15 times more cases than were detected by examining blood slides and, based on reported histories and/or serology, well over 600 people were infected with malaria in Gushi, Shangcheng and Tongbai counties. In the other affected counties — Xinyangshi, Xinyangxian and Tanhe (without blood examina-

Table 4: Results of vector surveillance in five counties in Henan Province, 1995

County/capture sites (townships)	No. of anophelines caught	No. of <i>Anopheles anthropophagus</i>
<i>Gushi</i> ^a		
Liji	42	7 (16.7) ^b
Sanhe	118	0 (0)
Wangliu	137	1 (0.7)
Huzu	76	4 (5.2)
Duanji	126	0 (0)
Fenshui	44	0 (0)
Caomiao	168	14 (8.3)
<i>Huaibin</i>		
Zhangzhuang	67	0 (0)
Tuying	122	0 (0)
<i>Shangcheng</i> ^a		
Liji	402	0 (0)
Wuqiao	116	0 (0)
Shuangpu	264	0 (0)
Shangshiqiao	369	9 (2.4)
<i>Huangchuan</i>		
Shangyougang	160	2 (1.3)
Lailong	195	0 (0)
Taolin	144	2 (1.4)
<i>Xixian</i>		
Balicha	147	0 (0)

^a These counties had epidemic malaria in 1994–95. The other three counties had vector surveillance sites but no detectable malaria transmission.

^b Figures in parentheses are percentages.

tions) — another 362 cases were reported. Overall, more than 10% of the 9377 residents surveyed in the six counties reported having malaria at least once in 1994–95. Clearly a large epidemic occurred and the true number affected among the 700 000 population at risk must have been much greater.

The apparent excess of cases among those aged ≥ 50 years, and the apparent deficit of cases among children aged < 5 years, may have been due to a reporting bias with adults recalling their own events better than they did for their children. The IFA tests showed that all age groups were affected, as would be expected in a population whose immunity was low because of successful malaria control in the past. Because many positives were aged 5–14 years or ≥ 50 years, groups unlikely to have travelled much beyond their own villages, it seems certain that the cases of malaria resulted from local transmission.

The 1995 entomological data showed that at the time of the epidemic the population of *A. anthropophagus* was increasing relative to that of other anophelines, an increase that followed the withdrawal of state support for adulticidal vector control in 1992. During the final years of vector control most activity focused on annual impregnation of bednets with alphasmethrin or deltamethrin. Once this activity stopped endoanthropophilic vectors such as *A. anthropophagus* would be expected to recover, and our data suggest that this was happening.

Between 1989 and 1992 the use of impregnated bednets as well as malaria surveillance satisfactorily protected over 2 million of the southern Henan population. However, after “basic elimination” of malaria was announced, and government support for the impregnated bednets ended in 1994, people quickly became vulnerable to cross-border or indigenous resurgent malaria. A large outbreak of vivax malaria occurred almost immediately.

Information available to us suggests that malaria control in the border areas of southern Henan is influenced by cross-border epidemiology. In view of the extensive and growing cross-border movement promoted by reforms and growth in the Chinese economy, cross-border malaria threats will continue and even increase.

Control of malaria in Henan should not have led to withdrawal of protective measures. It would help if the government could anticipate and prevent the adverse consequences of “basic elimination” by providing incentives to village doctors and other officials to continue reporting suspected malaria cases (10); maintaining impregnated bednet-based protection; and supporting expert entomological surveillance. Only the last-mentioned was carried out.

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Résumé

Résurgence du paludisme à vivax dans la province du Henan, Chine

La province du Henan (90 millions d'habitants), dans le nord de la Chine, connaît un paludisme endémique non stable à vivax et à falciparum. De graves flambées ont été enregistrées en 1954–1955, au milieu des années 60, et en 1970, date à laquelle 10,2 millions de cas ont été notifiés, l'incidence la plus élevée que la Chine ait connue.

Au cours des 20 dernières années, l'incidence du paludisme dans la province a chuté. En 1992, seuls 318 cas de paludisme ont été notifiés, principalement dus à *Plasmodium vivax*. Le paludisme à falciparum, que l'on trouve dans le sud de la province, est également tombé de 2922 cas en 1984 à 5 cas en 1987 pour disparaître ensuite. Ces réductions ont été dues à un investissement massif dans la lutte antipaludique: de 1971 à 1984, le gouvernement de la province a distribué 280 millions de traitements curatifs, 1,8 milliard de traitements anti-rechute et 2 milliards de traitements prophylactiques. De 1981 à 1989 il a été procédé à un dépistage actif des cas, au cours duquel plus de 20 millions de frottis sanguins ont été réalisés.

L'espèce exophile *Anopheles sinensis* est présente dans toute la province, mais *A. anthropophagus*, espèce endo-anthropophile dont la capacité vectorielle est 20 fois supérieure à celle de *A. sinensis*, se rencontre surtout dans le sud du Henan, au sud du 33° parallèle. De 1985 à 1992, des pulvérisations annuelles à l'intérieur des habitations ont été réalisées avec du DDT à effet rémanent dans le sud de la province. De 1988 à 1992, des imprégnations annuelles des moustiquaires par pyréthrinoïdes ont également été effectuées. Cette méthode est moins chère que les pulvérisations intradomiciliaires et 95% des habitants possèdent une moustiquaire. Le gouvernement a interrompu son soutien au pro-

gramme en 1994, date à laquelle la région a été déclarée indemne de paludisme.

Les résultats de l'enquête que nous avons effectuée en 1995 dans les foyers du sud du Henan ont montré une résurgence rapide du paludisme à vivax après l'arrêt des mesures de lutte et la récupération rapide de *A. anthropophagus* dans certaines régions. La flambée de paludisme a touché six départements dans lesquels des mesures de lutte antivectorielle avaient été appliquées. Plus de 10% des 9377 habitants interrogés ont indiqué avoir souffert de paludisme au moins une fois en 1994–1995 et le nombre réel de personnes atteintes dans cette région à risque parmi la population résidente de 700 000 habitants est probablement beaucoup plus élevé.

Dans trois départements, des frottis sanguins et des échantillons de sérum pour immunofluorescence (IFA) ont été recueillis chez 2329 personnes. Au total, 3,1% des échantillons (73/2329) étaient positifs pour *P. vivax* et 13% (301/2329) pour le paludisme en général (titre $\geq 1:20$); tous les groupes d'âge étaient touchés. Nous n'avons pas obtenu de frottis sanguins pour les trois autres départements.

En 1995, nous avons également effectué une surveillance des vecteurs dans deux des six départements étudiés et dans trois autres départements adjacents à haut risque mais non affectés par l'épidémie. Nous avons comparé ces données aux données historiques pour ces mêmes départements en 1984, 1989 et 1994, peu après la période de lutte antivectorielle.

En 1984, avant les campagnes de pulvérisations et d'imprégnation, *A. anthropophagus* était plus abondant à l'intérieur des habitations que *A. sinensis*. En 1989 et 1994, la situation s'était inversée, la densité de *A. anthropophagus* étant inférieure à celle de *A. sinensis*. En 1995, le rapport de *A. anthropophagus* aux autres anophélinés, bien que faible, était plus élevé que pendant ou juste après le programme de lutte antivectorielle.

Les données entomologiques de 1995 montrent que la densité de *A. anthropophagus* a augmenté par rapport à celle des autres anophélinés après l'arrêt des mesures de lutte contre les vecteurs adultes en 1992. Les dernières années, la lutte était surtout axée sur l'imprégnation des moustiquaires par l'alphaméthrine ou la deltaméthrine. Une fois ces mesures stoppées, les

vecteurs endo-anthropophiles comme *A. anthropophagus* ont récupéré, comme cela était prévisible, et une flambée de paludisme à vivax a suivi presque immédiatement. Etant donné les migrations transfrontalières dues aux réformes et à la croissance économique rapide de la Chine, la résurgence du paludisme constitue une grave menace. Lorsque cette région sera redevenue indemne de paludisme, le gouvernement devra encourager la notification locale des cas de paludisme et poursuivre le programme d'imprégnation de moustiquaires et les activités de surveillance.

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