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Economics of malaria control in China: cost, performance and effectiveness of Henan's consolidation programme

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Economics of malaria control in China: cost, performance and effectiveness of Henan's consolidation programme

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ABSTRACT

Government finance for Chinese healthcare declined during the 1990s. This coincided with the entry of Henan Province (90 million population) into the consolidation phase of malaria control in 1993, after a splendid effort over the previous 25 years that reduced transmission by 99%. Government support stopped for insecticide spraying and impregnated bednets, but vivax malaria persisted in the south. Knowledge of the economics of malaria control in Henan was lacking and this hampered strategic planning. Health officials had to make funding decisions without knowing the costs and benefits of expenditure on malaria control.

We analysed Henan's malaria control strategy using primary cost and performance data obtained prospectively over two years from the government and the community. Our study had features that related well to the 2000 WHO model for assessing health systems based on health attainment, stewardship, equity and fair financing. We focused on the cost-performance of case-management for suspected malaria cases in a southern area with continuing transmission, and we measured all community and government costs for malaria control.

Evaluation of case-management performance showed 63% of 12 325 sample cases were managed inadequately by our criteria (treatment delay, drug used, treatment duration). Most (62%) inadequate case-management was attributed to unsatisfactory treatment duration. Access to care, drug supplies and choice of drug were not problems. Management of suspected malaria cases accounted for 60% of total government expenditure. The annual government cost for anti-malaria work averaged US$99 790 during 1994-1995, protecting 3.4 million people at risk at US$0.03 per head. Other cost components in Henan's government control programme were mosquito surveillance (12%), blood surveys (25%) and contingencies and special projects (4%).

The Government's average cost per suspected malaria case was US$0.70; patients' average cost (direct and indirect) per case was US$3.48, equivalent to 10 days' farming income. Using these cost data and recent values recorded for the vectorial capacity of the local vector *Anopheles anthropophagus*, we estimated that excellent case-management would cost US$0.68 per case prevented and US$36.36 per DALY saved. So the case-management intervention is well inside the 'attractive' range according to WHO's 1996 cost-effectiveness guidelines for low income countries, even if only a tenth of the suspected cases actually have malaria. We suggest that Henan should focus on retraining and supervising village doctors to improve this important aspect of control.

If the government reduces funding, transmission will almost certainly increase, exposing Henan to recrudescent malaria with much greater costs in the future, as happened in south Asia in the 1970s. The residual vivax malaria problem in Henan is typical of many areas outside of Africa that have 'rolled back' *Plasmodium falciparum*, and is likely to be associated with considerable ongoing morbidity. Our findings would apply to most of the large malaria-receptive area in mainland China. Our methods will be useful for evaluating the economics of malaria and other health programmes in China today.

INTRODUCTION

Economic appraisals of health programmes are useful when deciding among new options or reforming existing activities, and could be used much more for low income countries (Appendix A). Such an economic analysis was lacking when market reforms swept across China's socialist health sector in the 1990s and officials pragmatically revised existing health programmes, especially those identified with the past such as malaria control. With this in mind, we conducted a cost-performance study of malaria control in Henan, China, in 1994 and 1995. This study arose after rural health system remnants of the socialist period had disappeared: barefoot doctors converted to private village doctors (VDs) after 1982 (Jackson et al. 1996), cooperative rural health insurance subsequently collapsed (Gu et al. 1995, Henderson et al. 1995, Hsiao and Liu 1997), and government finance for public health fell. By the mid-1990s, many disease control programmes began to depend on user fees and China's expenditure on pharmaceuticals rose to worrisome levels (World Bank 1997). Thus our malaria study was timely, enabling local officials to understand the economics of an old health programme threatened by reforms.

Henan Province reduced its anti-malaria investment in 1993, but it did so without knowing the economic cost of malaria control or the product mix purchased with government funds. Nor did the government understand the impact on providers of health services, now private VDs, and on uninsured rural residents in malarious areas. As stewards of the health system, the Henan government required a good understanding of the economics and operation of malaria control. To help gather the necessary data, we studied the costs and performance of malaria control in Henan's two worst counties (see figure 1 on page 10). This information facilitates strategic health planning in Henan. It sheds light on the impact of current health policies for a long established and historically successful malaria programme that covers an area of unstable transmission located in the heart of China's malaria zone.

The ongoing problems with malaria in Henan are typical of many of the 19 malaria endemic provinces, autonomous regions and municipalities in China, especially inland areas above latitude 25°N (Gilles and Warrell 1993). In 1999, China reported 29 039 malaria patients with 67 deaths, estimated that these represented only one-tenth of the actual cases occurring, and attributed about 10% of the national burden to Henan (Advisory Committee on Malaria, MOH, 2000). Officially, Henan has been in the consolidation phase since 1993 but still remains at risk of major malaria epidemics (Sleigh et al 1998) and still has pre-consolidation zones of annual vivax transmission in the south. So control activities must continue to avoid returning to the disastrous situation prevailing in the

1970s. Understanding the economics of ongoing malaria control should help secure continued government support.

Economic analyses of health programmes should compare inputs and outputs (Evans and Hurley 1995). So we measured input costs for each of the three malaria control outputs (products) – vector surveillance, population blood surveys and case-management. Also, we graded the quality of case-management, the only personal health service component of malaria control and the most expensive of the three outputs. Here we report the total cost of Henan's malaria control

programme and explore the potential to improve performance without more investment. We also estimate how much of the malaria cost is borne by the community and how much by the Henan government, and we consider whether investment in malaria control can be reduced further without risk of epidemics. Finally, we compare our economic results to those reported for malaria control elsewhere. And we estimate the potential cost per case prevented and per DALY saved for Henan's system of presumptive case-management, contrasting with comparable indices reported by others (Najera et al. 1993).

Our study points the way to eventual eradication of this 'old agenda' item of China's current burden of disease. This assumes additional relevance now that China has been ranked so low relative to other countries for overall health system performance (144th), health expenditure per capita (139th) and equity of financing (188th). These indicators reflect the impact of 1990s market reforms on health system performance in China. Population health is still quite good (61st), but must deteriorate unless the now inadequate health system (including disease control components) is improved (World Health Report 2000). Thus our report is well timed for health system reform, providing policy-makers with evidence not available before and showing them how such information can be collected.

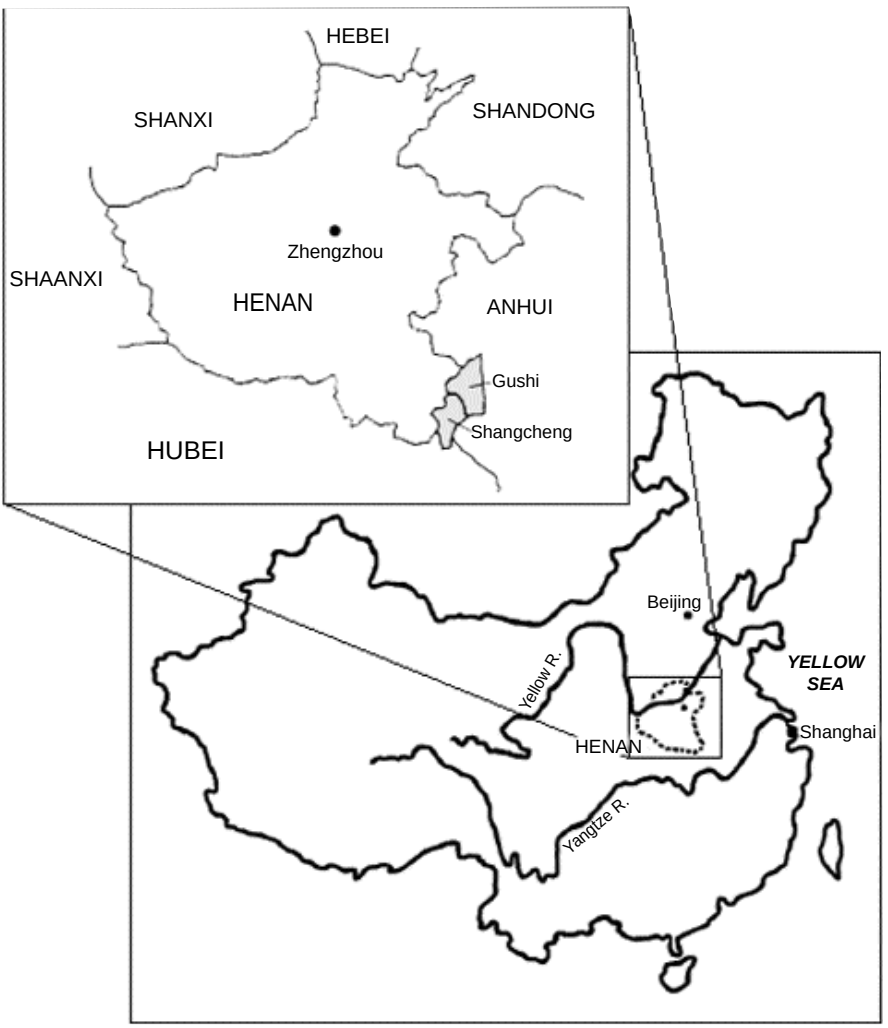
BACKGROUND

The annual malaria incidence rate reached 17% for the whole of Henan province in 1970 and was the highest in China that year, yielding 10.22 million cases. But by 1992, provincial malaria control had reduced the annual total of reported cases to only 318. Over this 20-year period, Henan's population grew from 60.3 million to over 90 million (*Statistical Yearbook of Henan* 1998, pp. 121) and the province's overall malaria incidence rate fell by 99.9% to reach 0.37 per 100 000. The rate approached zero in 90% of the 129 malaria counties (of a total of 170 counties in Henan). The low malaria incidence aggregated across the whole province enabled the provincial government to declare 'basic elimination' by 1993, a stage otherwise known as the consolidation phase (incidence <1/10 000 population), only one step away from eradication. At about this time the government decided to cut back investments in the malaria programme. Free insecticide impregnation of privately owned bednets stopped in 1992, and insecticide spraying of houses stopped in 1993. Bednet support was revived temporarily in the late 1990s to combat an epidemic of vivax malaria in southern Henan.

But malaria incidence remained relatively high in four adjacent counties in southern Henan, with rates per 1000 population ranging from 3.91 to 41.3 in 1991 (Shang and Hou 1992, Liu et al. 1996). In part this was explained by abundance of *An. anthropophagus* (Sleigh et al. 1998). It has long been known that this species has a high vectorial capacity that varies during the transmission season. For example, in 1974 malariologists calculated that this species enabled a Basic Reproduction Rate for vivax malaria as high as 16.0 and averaging 7.1 new cases of malaria for each untreated infectious case (Liu Xi-Li and Li Peng, personal communication, 1999). Recent measurements of *An. anthropophagus* vectorial capacity are available (Henan Province Preventive Health Station 2000), and we use these parameters to estimate potential transmission-blocking effects of treatment of malaria cases in Henan and to relate these health benefits to measured case-management costs.

The malaria problem for the last decade in Henan has revolved around continuing *P. vivax* transmission. This organism has more robust transmission dynamics than *P. falciparum* and is now responsible for more than half the malaria transmitted outside of Africa (Mendis et al. 2001) and for most of the residual malaria problem in mainland China. Vivax malaria still causes considerable morbidty (Mendis et al. 2001). And there is good evidence linking it to past poverty in many rich countries now free of the disease (Reiter 2000), and to current poverty in many countries still affected today (Gallop and Sachs 2001).

FIGURE 1: MALARIA STUDY COUNTIES IN HENAN
(inset -shaded areas)



METHODS

In 1994 and 1995 we prospectively collected malaria control cost data from primary sources for both the government and the community. We calculate the total cost for each of the three products of Henan's malaria programme – mosquito surveillance, blood surveys of at-risk populations, and case-management of suspected malaria cases. The first two comprised government outlays only. However, case-management took in costs for both the government and the community. All costs were estimated and compared within two study counties, Gushi and Shangcheng, the two worst of the four remaining malaria counties. Community costs were estimated from the 12 325 reported cases of suspected malaria detected within the two study counties in 1994 and 1995. The 12 325 cases conformed to malaria case definitions described below and were also the basis for our study of the performance of case-management.

For government costs, we employed clerks to compile monthly summaries of all malaria inputs at four levels: (a) provincial – the capital, Zhengzhou; (b) prefectural - Xin Yang, the only prefecture then with malaria; (c) county – Gushi and Shangcheng, the worst malaria areas; and (d) township* (former commune) – all 55 within Gushi and Shangcheng. Most government inputs went to the four endemic malaria counties in Xin Yang prefecture, including Gushi and Shangcheng which together comprised 61.5% of the total endemic area population. So for costs arising above the county level we attributed 61.5% to Gushi and Shangcheng, reflecting their share of the total endemic area population. We added these to costs measured directly at the county and township levels. In addition, for administration inputs that embraced all three malaria control components, we followed Henan's budget allocation and attributed 10% to mosquito surveillance, 30% to blood surveys and 60% to case-management.

For community costs, we assessed all reported cases of suspected malaria in six townships (former communes) with a total population of 247 762, representing Gushi and Shangcheng counties (total population 2 093 100) (Henan Institute of Mapping 1996). In these areas, doctors use a standard criterion to diagnose fever – axillary temperature ≥37.5° C (Liu et al. 1996). Fever cases with all the typical features of malaria (chills, intermittent rigors and sweating), occurring during the transmission season (July–October) and with no other obvious cause, were diagnosed as suspected malaria and treated as if they had malaria. During 1994 and 1995, the 260 doctors in the six study townships managed a total of 12 325 suspected malaria cases. They fulfilled all of the above diagnostic criteria and were accepted on

* A township (former commune) is a rural area comprising a small town, surrounding villages and farms, and enterprises.

review by an experienced malariologist (Xi-Li Liu) as cases of clinical malaria for inclusion in our community cost study.

CLASSIFYING COSTS

Economists classify costs according to either (1) traceability (direct and indirect) to the object or activity (Kaewsonthi 1988), or (2) relationship to output (fixed and variable). Direct and indirect costs are used by health economists to classify (demand side) patient costs associated with illness (Cleverley 1992). Fixed and variable costs are used by microeconomists to model short-run production (Petersen and Lewis 1999, Mansfield 1999) and are appropriate categories for analysing supply (production) of health interventions such as malaria control.

In our study on the demand side, direct costs for all suspected malaria patients included consultation fees and payment for drugs as well as the 'non-health direct costs' for patient's transport and food. The indirect costs included lost productivity or lost incomes of patients and carers, and costs incurred by carers such as transport and food. On the supply side for malaria control, fixed costs are those that continue even when production stops, for example staff wages, staff housing, non-wage benefits and buildings. Variable costs, inputs that change with output, include government outlays for materials and drugs, electricity, casual labour and travel (Drummond et al. 1998).

IDENTIFYING COSTS FOR HEALTH AUTHORITIES

We identified all cost items known to us, but measuring costs in some cases was complex, as explained below. Government costs are separated into fixed and variable (Appendix B Tables 2-6).

Fixed costs

There were two fixed cost items:

Wages, medical benefits, and housing of administrative officials and professionals (Appendix B Table 3). At every level, the professionals were full-time in malaria work. However, administrative officials also worked in other health programmes (Appendix B Table 2). So we calculated their costs according to time spent on malaria work, converting their contribution to the equivalent of full-time positions.

Calculating subsidized housing costs without a real estate market in 1994-95 was a problem. We estimated by the simplest method. Staff housing was built by government; so we used available information on the average cost of construction (1400 yuan per m^2) and Henan's aver-

age housing per family (37.95 m^2)(*Statistical Yearbook of Henan*, 1995: 478 and 265). The replacement cost for one housing unit was 53 130 yuan or US$ 6641 (US$ 1 = 8 yuan) and we annualized on the assumption government housing lasted 30 years (i.e. 53 130/30 yuan or 1771 yuan per housing unit per year) (also see Appendix C). We assumed that each staff member or equivalent full-time member occupied one housing unit.

We summed the wages, other benefits and housing costs for malaria workers in Gushi and Shangcheng at the county and township levels. For those working at prefectural and provincial levels, we assumed 61.5% of their work was devoted to Gushi and Shangcheng, and added their costs accordingly to generate the final total for these two counties.

Government buildings

Because of the lack of reliable historical data and the non-market nature of government buildings in China, we calculated these costs using the building replacement method often applied in health finance analyses (Cleverley 1992). Total building space allocated to malaria control (at the province and Xin Yang prefecture levels, and the four malaria counties in Xin Yang including the 96 townships and three vector surveillance stations) was 2224 m^2. Estimating the average cost of construction at 1400 yuan per m^2 (see above for housing), we calculated the replacement cost at 3 113 600 yuan or US$389 200; we annualized on the assumption buildings lasted 30 years (3 113 600/30 yuan) to obtain 103 787 yuan or US$12 973. We calculated the building costs within Gushi and Shangcheng counties (103 787 x 61.5% or 63 829 yuan) to reflect their share of the total endemic area population.

Variable costs

Administration running costs

There were seven cost items associated with malaria operational activities: upgrading skills, travel, conferences and meetings, utilities (water, electricity and telephone), hospitality, office supplies and printing, and building maintenance and repairs (Appendix B Table 4).

Field labour and staff training

There were four cost items, including activities of the county level anti-epidemic stations (AES) and the township hospitals, and prefecture level training of microscopists for blood tests of suspected malaria patients. Labour costs of malaria microscopists were estimated as a proportion of their full-time work in the hospitals (Appendix B Table 5).

Cost of antimalarial drugs

The cost item for antimalarial drugs came from the purchase and distribution of the drugs (Appendix B Table 6). Each year, the Henan Institute of Parasitic Diseases dispatched the drugs, free of charge, to Xin Yang prefecture for distribution to lower administration levels. The storage, transport, paper work and other related activities are liable to transaction costs along the distribution system from Zhengzhou to southern Henan. Therefore, Xin Yang Prefecture Health Bureau charged a small fee

to distribute drugs to the county level anti-epidemic stations (AES). In turn, the AES distributed to its township hospitals, selling drugs at a small profit. Township hospitals stored the drugs and, as needs arose, dispatched them to village doctors. Malaria drugs were intended to reach patients at no cost but in practice a small charge applied because village doctors had to buy them from township hospitals.

Passive blood testing supplies

This cost item included slides, stains, depreciation of microscopes, and sundries used for passive blood tests of suspected malaria cases treated by village or township hospital doctors (Appendix B Table 6).

Contingencies and special projects

The Provincial Health Bureau each year sets aside funds for special or unforeseen circumstances associated with malaria work and research. During 1994 and 1995, a total of 38 000 yuan was allotted to Gushi and Shangcheng (Table 5).

DATA COLLECTION

Patient and community costs

We enlisted primary health care village and township hospital doctors to detect all suspected malaria cases seeking treatment during the July-October transmission seasons of 1994 and 1995. With a small payment for effort and time, the doctors recorded information on patient treatment-seeking costs (direct and indirect). We trained the doctors to collect the data on pro formas but did not train them to change their case-management behaviour. They recorded on a pro forma at the time they treated suspected malaria cases.

During the two years, a total of 12 325 suspected malaria cases were recorded by the 260 village and hospital doctors in the six townships (Chengjiao, Huzu and Nan Daqiao in Gushi county; and Shang Shiqiao, He Fengqiao, and Fengji in Shangcheng county). We assumed the 12 325 reported cases represented proportionally 11.84% of all suspected malaria cases in Gushi and Shangcheng (based on relative populations, 247 762 out of 2 093 100, or 11.84%).

Case-management performance

Village doctors used a pro forma to report their management of 12 325 suspected malaria cases. For analysis, we used three criteria to assess case-management (drug used, delay for treatment, duration of treatment), and graded the performance quality for each criterion as satisfactory, moderate or unsatisfactory. We also investigated passive blood tests carried out but found the procedure was too infrequent and unreliable for inclusion in the performance evaluation. Chinese policy does not require passive blood testing for suspected malaria cases, except in an area known to have a malaria epidemic. To collect the performance data, we used Henan's existing system for reporting malaria cases, operating at the level of administrative villages (formerly brigades within a

commune). Each administrative village has about nine natural villages (formerly production teams) under its jurisdiction and appoints one village doctor to specialize in preventive health. All village doctors must report infectious diseases, including malaria, to the preventive village doctor. The preventive village doctor then reports to the township hospital preventive doctor who supervises that rural catchment area.

We relied on the township hospital preventive doctors in the six study townships. They collected the completed pro formas from all village preventive doctors in the township catchment areas, and checked the information for accuracy. The performance data were collected monthly during the transmission season of July to October, and bi-monthly during the rest of the year. The township hospital preventive doctors were given an allowance for this task as permitted by their counties.

Costs for Henan government

We prospectively recorded government costs during 1994 and 1995. The forms were collected every two months in the six study townships, and every six months for the other 49 townships located in Gushi and Shangcheng. Data were also obtained for the three higher levels: (a) Gushi and Shangcheng AES; (b) Xin Yang Prefecture AES and Health Bureau; and (c) Henan Provincial Health Bureau and Henan Provincial Institute of Parasitic Diseases.

Data analyses

Data were processed with SPSS, EpiInfo and Excel software. All data were double entered and checked for consistency and accuracy. For patients, we calculated the average costs. For the government, we calculated the total cost and cost breakdowns for the three products of Henan's malaria control programme. The proportions of variable costs relative to total costs indicated the potential for short-run savings if malaria is eradicated. The fixed cost proportion for each of the three malaria control components indicated whether discontinuance was likely to save money. Finally, we averaged (1) both community cost (Table 1 footnote) and government cost (Table 5 footnote) per reported case of suspected malaria, and (2) the annual government cost of malaria control for Gushi and Shangcheng counties, and for the whole province (Table 5 footnote). Thus we have calculated the overall community and government cost for each component of malaria control in Henan – case-management, vector surveillance and active blood surveys.

We analysed the performance of case-management by grading delays to diagnosis and treatment, noting choice of drugs and their combinations, and measuring the duration of treatment. Also, by relating our cost estimates to the known vectorial capacity of *An. anthropophagus*, we could calculate the costs per case prevented and per disability adjusted life year (DALY) saved as well as the benefit-cost ratio of controlling malaria transmission with excellent case-management.

RESULTS

PATIENT COSTS

We identified 12 cost items incurred by 12 325 suspected malaria cases seeking treatment from village and township hospital doctors (Appendix B Table 1). The total cost in 1994 and 1995 for all cases was 343 248 yuan, averaging 171 634 yuan per year (US$ 21 454 at US$1 = 8 yuan). Patient cost per suspected malaria case was 27.85 yuan (US$ 3.48). As the per capita daily income for Gushi and Shangcheng averaged 2.74 yuan, the average cost incurred by each suspected malaria patient was equivalent to 10 days income.

Direct costs

Although village doctors were not supposed to charge consultation fees, 63% of the 12 325 patients paid an average of 1.18 yuan (Table 1). Village doctors took blood tests from only 16% of suspected malaria patients, charging an average of 1.69 yuan. As doctors no longer received a government allowance for blood tests, they charged patients for dispatching blood slides to microscopists in township hospitals, although the tests were nominally free of charge.

Almost all the 12 325 patients (96%) were treated with antimalarial drugs costing an average of 1.11 yuan (Table 1). As well, almost all (95%) bought other drugs and injections, paying on average 9.27 yuan, equivalent to 3.5 days income. Only 8% took self-medication before visiting the doctor; the average cost of self-medication was 4 yuan. Overall, 10% of patients bought food averaging 8.80 yuan and only 9% incurred transport costs averaging at 2 yuan.

Indirect costs

A major indirect cost was patient's income loss, affecting 52% of the 12 325 malaria cases. Income losses averaged 20 yuan (Table 1); about one third of cases (32%) were accompanied by carers whose income loss averaged 10.81 yuan. Carers' food averaged 6.65 yuan and transport costs averaged 2.62 yuan, affecting 11% and 10% respectively of the cases.

Intangible costs

There are non-monetary costs for patients suffering with illness. Such intangible effects of malaria include pain, discomfort and stress. These effects are subjective and it is difficult to fix prices (Klarman 1974:334). We did not study intangible costs.

Table 1: Costs in yuan for 12 325 suspected malaria patients seeking treatment in Gushi and Shangcheng counties, 1994 and 1995*

Cost item	Number of cases incurring cost item A	Total cost for all cases incurring cost item B	Average cost for cases incurring cost item B/A	% of cases incurring cost item 100x A/12 325	Average cost per case for each cost item B/12 325
Consultation fees	7 807	9 172.64	1.18	63	0.74
Blood Examination	1 924	3 244.90	1.69	16	0.26
Antimalarial drugs	11 787	13 085.63	1.11	96	1.06
Drugs/ Injections	11 744	108 838.94	9.27	95	8.83
Self-treatment before doctor visit	984	3 943.33	4.01	8	0.32
Transport	1 076	2 128.40	1.98	9	0.17
Food during Treatment	1 173	10 295.75	8.78	10	0.84
Patient's income loss	6 456	129 470.90	20.05	52	10.50
Income loss of companion	3 997	43 217.8	10.81	32	3.51
Transport of companion	1 245	3 260.70	2.62	10	0.27
Food for companion	1 390	9 245.30	6.65	11	0.75
Other costs of companion	1 205	7 343.70	6.09	10	0.60
All 12 cost items		**343 247.99**			**27.85**

Compiled from Appendix B Table 1.
* Average cost per case was 343 248/ 12 325 = 27.85 yuan (US$3.48 at US$1 = 8 yuan)

GOVERNMENT COSTS

Malaria case-management

Malaria case-management, accounting for nearly 60% of total government costs, was the most expensive of malaria control products (Table 2). During 1994 and 1995, case-management costs totalled 582 454 yuan (US$72 807), an annual average of 291 227 yuan (US$ 36 403). Adjusting for population and extrapolating from observations of the two study counties (see Methods), we estimated that the Henan government's average cost per suspected malaria case was 5.60 yuan or US$ 0.70 (see footnote Table 2).

To supply antimalarials for the whole province, the Henan Institute of Parasitic Diseases paid 150 000 yuan in 1994 and 40 000 yuan in 1995. Blood test supplies accounted for only 1.5% of the cost of case-management. There were no blood tests for 10 390 of the 12 325 cases. Only 1935 cases had blood tests and microscopists reported on 1928, with 24 positive and 1904 negative. We expect that many (probably most) negative smears were misleading due to poor slide preparation, inadequate staining, low quality microscopy, low parasite counts in symptomatic non-immunes, or pre-smear antimalarial treatment. All these are notorious problems if passive blood smear surveillance for malaria is integrated into primary health care in poor rural areas, and are common problems for slides taken by village doctors in Henan.

Table 2: Total government costs for malaria case-management in Gushi and Shangcheng, 1994 and 1995*

Item	1994	1995	Total	Average/year
Wages, benefits and housing (fixed)**	109 238	101 354	210 592	105 296
Government buildings (fixed)**	38 297	38 297	76 594	38 297
Administration running**	98 473	65 070	163 543	81 772
Field labour and training (variable)**	16 304	18 003	34 307	17 154
Malaria drugs	58 069	31 716	89 785	44 893
Passive blood tests supplies	4 367	3 266	7 633	3 817
Total cost for 55 townships (yuan)	**324 748**	**257 706**	**582 454**	**291 227**

* Total government cost of case management in Gushi and Shangcheng, 1994 + 1995 = 582 454 yuan. Cases in six townships (pop = 247 762, n=12 325) represented 11.84% of the total for Gushi and Shangcheng, or 11.84% of 582 454 yuan resulting in 68 963 yuan (see Methods). So government cost per suspected malaria case = 68 963/12 325 or 5.60 yuan (US$0.70).

** 60% of the equivalent cost item in Table 5.

Blood surveys

Henan carries out (active) blood surveys at the end of each transmission season (October) by use of rotating household samples in Gushi and Shangcheng. Sampling households was labour intensive, with 50% of the costs spent on fixed and variable labour inputs (Table 3). Blood surveys in Gushi and Shangcheng accounted for 25% of total government costs, with an average annual cost of 122 260 yuan (US$ 15 283) during 1994 and 1995.

Table 3: Government costs for blood surveys in Gushi and Shangcheng, 1994 and 1995

Item	1994	1995	Total	Average/year
Wages, benefits and housing (fixed)*	54 619	50 677	105 296	52 648
Government buildings (fixed)*	19 149	19 149	38 298	19 149
Administration running*	49 236	32 535	81 771	40 886
Field labour and training (variable)*	8 152	9 002	17 154	8 577
Supplies (slides, stain, etc)	0	2 000	2 000	1 000
Total yuan	**131 156**	**113 363**	**244 519**	**122 260**

* 30% of the equivalent cost item in Table 5.

Vector surveillance

The total cost of vector surveillance for Gushi and Shangcheng in 1994 and 1995 averaged 58 481 yuan (US$7 310) (Table 4). In 1995, vector surveillance included a special survey for *An. anthropophagus* in Gushi

Table 4: Government costs for vector surveillance in Gushi and Shangcheng, 1994 and 1995

Item	1994	1995	Total	Average/year
Wages, benefits and housing (fixed)*	18 206	16 892	35 098	17 549
Government buildings (fixed)*	6 383	6 383	12 766	6 383
Administration running*	16 412	10 845	27 257	13 629
Field labour and training (variable)*	2 717	3 001	5 718	2 859
Equipment depreciation	95	28	123	62
Vector surveillance supplies	5 000	18 000	23 000	11 500
Special *An. anthropophagus* surveys	4 000	9 000	13 000	6 500
Total yuan	**52 813**	**64 149**	**116 962**	**58 481**

* 10% of the equivalent cost item in Table 5.

and Shangcheng, and similar surveys were conducted in three other counties inside Xin Yang prefecture following a malaria outbreak. Results showed *An. anthropophagus* was found in seven sites, of which five were located in Gushi and Shangcheng. The re-appearance of this vector correlated with reported incidence of malaria in Gushi and Shangcheng (Sleigh et al 1998).

Total government cost for malaria control activities

For Gushi and Shangcheng counties, the total government cost of malaria control was 528 718 yuan (US$66 090) in 1994 and 453 217 yuan (US$56 652) in 1995 (Table 5). The average annual cost was 490 968 yuan (US$61 371). As Gushi and Shangcheng cover 61.5% of the malaria endemic population (see Methods), we estimate the annual total government cost for malaria control in Henan Province to be 490 968/0.615 or 798 322 yuan (US$99 790). We measured costs concurrently with activities under way and found nearly 60% of government spending actually went to case-management, 25% to blood surveys, 12% to vector surveillance, and nearly 4% to contingencies and special projects.

Table 5: Total government cost of malaria control in Gushi and Shangcheng, 1994-1995*

Item	1994	1995	Total	Average/year (94 & 95)
Wages, benefits and housing (fixed)	182 064	168 923	350 987	175 494
Government buildings (fixed)	63 829	63 829	127 658	63 829
Administration running	164 121	108 450	272 571	136 286
Field labour and training (variable)	27 173	30 005	57 178	28 589
Malaria drugs	58 069	31 716	89 785	44 893
Passive blood tests supplies	4 367	3 266	7 633	3 817
Contingencies and special projects	20 000	18 000	38 000	19 000
Equipment depreciation	95	28	123	62
Vector surveillance supplies	5 000	18 000	23 000	11 500
Special *An. anthropophagus* surveys	4 000	9 000	13 000	6 500
Active blood tests supplies	0	2 000	2 000	1 000
Total yuan	**528 718**	**453 217**	**981 935**	**490 968**

* Assuming that Gushi and Shangcheng required 61.5% of the total investment in malaria control (see Methods) we calculated the total annual government cost for Henan province as 490 968 yuan/0.615 = 798 322 yuan (US$99 790).

PERFORMANCE ANALYSIS

Criteria for case-management performance

The measured product was management of 12 325 consecutive suspected malaria cases reported by 260 village and township hospital doctors in 1994 and 1995. Our evaluation of management performance is based on three criteria relating to the quality of treatment for suspected malaria cases at the consolidation stage of malaria control: (a) type of drug used; (b) delay in malaria treatment; and (c) duration of course of schizonticidal antimalarials. For the 12 325 cases, we classified the type of drug chosen as satisfactory or unsatisfactory. For delay in malaria treatment, and duration of the antimalarial course, we classified case-management as satisfactory, moderately satisfactory or unsatisfactory. Finally, we graded the overall performance for management of each case by combining the evaluations for each of the above three criteria as excellent, mediocre or inadequate (see below).

Type of drug used

In 1994 and 1995, various drugs were used for the 12 325 cases: 10 586 received a single type of antimalarial and 1137 received two types in various combinations. Overall 11 697 cases, or 95%, received satisfactory (schizonticidal) treatment and 602 received only non-malarial drugs (Table 6). None received three antimalarials; 672 were given one or two antimalarials with non-malarials including traditional medicine, antibiotics, sulphonamide and others (cough mixture, anti-virus); 5.4% (671) took other medicines before seeking treatment.

Table 6: Case-management performance for drug used to treat 12 325 suspected malaria cases in Gushi and Shangcheng counties, 1994 and 1995

A. Single type of antimalarial drug used	**Number of cases**	**Management performance**
Quinine tablets	1 204	Satisfactory
Quinine injections	6 500	Satisfactory
Chloroquine tablets	2 857	Satisfactory
Primaquine tablets	25	Unsatisfactory
Pyremethamine tables	0	Unsatisfactory
Cases using single malarial drug	10 586	
B. Two types of antimalarial drug used	**Number of cases**	**Management performance**
Quinine tablets + quinine injections	139	Satisfactory
Quinine tablets + chloroquine tablets	46	Satisfactory
Quinine injection + chloroquine tablets	652	Satisfactory

B. Two types of antimalarial drug used	Number of cases	Management performance
Quinine tablets + primaquine tablets	164	Satisfactory
Quinine tablets + pyremethamine tablets	2	Satisfactory
Quinine injection + pyremethamine tables	1	Satisfactory
Chloroquine tablets + primaquine tablets	132	Satisfactory
Chloroquine tablets + pyremethamine tablets	0	Satisfactory
Primaquine tablets + pyremethamine tablets	1	Unsatisfactory
Cases using two antimalarial drugs combination	1 137	

C. Performance for choice of drug	Number of cases
Unsatisfactory antimalarial drug choice	26
Satisfactory antimalarial drug choice	11 697
Total number using an antimalarial drug	11 723
Total number using only non-malarial drugs	602

Delay in malaria treatment

There is a negative externality for delay in schizonticidal treatment with chloroquine or quinine because these drugs also kill vivax gametocytes, decreasing the risk of transmission from one person to another. As well, delay in schizonticidal treatment increases morbidity for all forms of malaria, and increases mortality for falciparum malaria. Therefore we evaluated delay in malaria treatment using two case-management performance indicators. The first indicator revealed the time from fever onset to VD diagnosis measured by the number of days until clinical consultation. The second indicator revealed whether patients received fast treatment after clinical diagnosis.

For the first indicator, patient-derived delay was minimal, 0-2 days, for nearly 98% of the suspected malaria cases (Table 7). The mean +/- SD delay to diagnosis for the 12 325 cases was 1.13 +/- 0.43 days. So both the speed of seeking VD advice and access to care were satisfactory for virtually all cases.

Our second indicator for delay to treatment after diagnosis was as follows: satisfactory (within 1-2 days); moderately satisfactory (3-4 days); unsatisfactory (more than 4 days) (Table 8). These categories reflect our view that delay in dispensing antimalarials due to clinical doubt in an endemic area should not last beyond two days, especially during the consolidation of malaria control – and clinically it takes as long to observe responses to other therapies before deciding they are ineffective.

Table 7: Delay to diagnosis and quality of health-seeking behaviour for 12 325 suspected malaria fever cases in Gushi and Shangcheng counties, 1994 and 1995

Delay in days from fever onset to VD diagnosis				Quality of health-seeking behaviour		
Days	No of cases	Percentage	Cumulative %	Satisfactory	Moderate	Unsatisfactory
0	33	0.3	0.3			
1	11 041	89.6	89.8	0-2 days 12 025 cases		
2	951	7.7	97.6			
3	252	2.0	99.6		3-4 days 292 cases	
4	40	0.3	99.9			
5	7	0.1	100.0			>4 days 8 cases
6	1	0.0	100.0			
Total	**12 325**	**100**		**97.6%**	**2.4%**	**0.1%**

Table 8: Case-management performance: delay from diagnosis to antimalarial treatment in Gushi and Shangcheng counties, 1994 and 1995

Delay in days between diagnosis and treatment				Case-management performance		
Days	No of cases	Percentage	Cumulative %	Satisfactory	Moderate	Unsatisfactory
1	3 529	28.6	28.6	1-2 days 7 216 cases		
2	3 687	29.9	58.5			
3	3 973	32.2	90.8		3-4 days 4 943 cases	
4	970	7.9	98.7			
5	135	1.1	99.7			>4 days 166 cases
6	31	0.3	100.0			
Total	**12 325**	**100**		**59%**	**40%**	**1%**

Overall, the time from diagnosis to schizonticidal treatment varied from one to six days, with a mean of 2.24 days. Management of 59% of cases was satisfactory, with only a 0-2 days delay between diagnosis and treatment. For another 40% of cases, management was moderately satisfactory with 3-4 days delay, and for only 1% of cases was unsatisfactory with >4 days delay.

Course of antimalarial treatment

Chinese policy requires a 5-day course of treatment for suspected malaria cases in endemic areas with a malaria prevalence below one per 1000 blood slides taken on regular surveys. But in this study, only 1% of the 12 325 suspected malaria cases actually received a 5-day course (Table 9).

Table 9: Case-management performance: duration of anti-malarial treatment in Gushi and Shangcheng, 1994 and 1995

Course of anti-malarial treatment				Case-management performance		
Days	No of cases	Percentage	Cumulative %	Unsatisfactory	Moderate	Satisfactory
1	3 409	27.7	27.7	1-2 days 7 693 cases		
2	4 284	34.8	62.4			
3	4 296	34.9	97.3		3 days 4 296 cases	
4	162	1.3	98.6			
5	172	1.4	100			>3 days 336 cases
6	2	0.0	100			
Total	**12 325**	**100**		**62.4%**	**34.9%**	**2.7%**

The usual course of chloroquine treatment for malaria lasts 3-5 days (Bruce-Chwatt, 1980:188), so we graded treatment duration as satisfactory (if >3 days), moderately satisfactory (3 days) and unsatisfactory (1-2 days). The mean duration of treatment of the 12 325 cases was only 2 days. Nearly two-thirds (62.4%) of antimalarial courses were unsatisfactory, lasting <3 days.

Overall performance levels for quality of case-management

Many blood tests were delayed by several days and were obtained after treatment began. As mentioned already, the low rate of positives (24 cases, or 1.2%, of those tested) may reflect poor quality slide preparation and microscopy, low parasite counts, parasite clearance after treatment, or fever due to conditions other than malaria. We cannot distin-

guish here among these choices but we note that an epidemic of malaria was detected in the south of Henan, including the study area, beginning in 1995. Experienced malariologists in Henan are confident that most of these 12 325 persons studied indeed had malaria.

We derived performance levels to indicate the overall quality of case-management based on combined results for the three criteria above (delay to treatment, drug used, duration of treatment). Keeping the procedure as simple as possible, we record three levels of overall management performance: (1) Excellent – satisfactory performance for all three criteria; (2) Mediocre – moderately satisfactory performance for at least one of the three criteria, and no criterion with unsatisfactory performance; and (3) Inadequate – unsatisfactory performance for at least one of the three criteria. Only 1.1 % (131) of the 12 325 cases had excellent case-management; 35.8% (4414) were managed in a mediocre manner; and 63.1% (7780) were inadequately managed. Most (62.4%) of inadequate case-management was attributable to unsatisfactory duration of treatment (Table 9). But if duration of treatment had been satisfactory (>3 days), 41% of all cases would still need to be treated with less delay (Table 8) for overall case-management to reach an excellent level.

DISCUSSION AND CONCLUSIONS

Little research is reported on the cost-outcomes relationship for this stage of malaria control in low income countries. One study conducted in Sri Lanka in 1995 compared the cost per person protected amongst various preventive and curative interventions (Konradsen et al. 1999). On the assumption that outcomes were equally effective, the study estimated that impregnating bednets with insecticide was less than half the cost of spraying houses, but eliminating breeding sites was cheaper than other preventive measures. The cost of curative treatment for households increased in inverse proportion with government costs: a village treatment centre was cheaper for the household but was a more expensive option for the government. An earlier study in Thailand reported on the cost and performance of malaria detection and reporting (Kaewsonthi 1983). That two-year retrospective study of expenditures under the government malaria budget also estimated patient costs under a variety of curative situations from inpatient and outpatient hospitals and malaria clinics. A review was made on performance of a wide range of antimalaria services such as house visiting, active case detection, laboratory work and monitoring. Although comprehensive in range, the performance review did not explore quality. Both these studies were in tropical endemic malaria areas and as such have limited relevance to the situation in mainland China.

Our study of the cost-performance of malaria control differs in important ways from those described above for Thailand and Sri Lanka. We collected primary cost data prospectively from the field for two years, and our analysis extended to management of presumptive malaria cases, an understudied aspect of the economics of malaria control (Mills 1991 and 1999). Our cost definitions were different as we had to probe into the unique bureaucratic structure underlying Chinese programmes that derive from a centralized socialist system set up in the 1950s. We were concerned with sub-tropical malaria control at the consolidation stage, unlike Thailand and Sri Lanka where tropical malaria is endemic. Accordingly, we were dealing with the control and treatment of robust vivax malaria in an area where falciparum is 'rolled back', a situation infrequently studied although it accounts for >50% of malaria cases occurring outside of Africa (Mendis et al. 2001). We studied the malaria problem now typical of most of mainland China, an area which originally had the greatest burden in Asia. Unlike on the Indian subcontinent, China has not yet lost the gains achieved over the last 40 years and has so far prevented any major recrudescence, although this remains a constant threat while large groups of the population remain poor and migratory. We did not consider the existing operational malaria control activities (case-management, vector surveillance and blood surveys) to be substitutable options. Thus our economic evaluation is formative – shedding light on how to value and modify an existing programme rather than how to choose from alternative new projects.

We did not focus primarily on cost-benefit, cost-effectiveness or cost-utility – all functions that are difficult to estimate when infections are close to eradication. Instead, knowing that malaria control must continue in Henan, we studied its cost-performance. Thus we focus on cost allocation, noting how performance could improve without further government investment and measuring the proportion of costs borne by suspected malaria cases and their families.

Many features of our study of malaria control relate to the WHO model put forward by Murray and Frenk (2000) for assessing health system performance based on health attainment, stewardship, responsiveness, equity and fair financing, and efficiency. We will now consider each of these features in turn.

HEALTH ATTAINMENT

Malaria control in Henan over the last 30 years led to a 99.9% reduction in incidence, a splendid achievement. But as a vector-borne infection with a high basic reproduction rate, malaria can reappear from a low base and threaten populations unless control programmes are maintained. This occurred in southern Henan in 1996, but was detected early enough to enable rapid control (Sleigh et al. 1998). Thus overall health attainment for malaria is good, but could improve, as shown by the continued risk of epidemics. Eradication is optimal for Henan but remains out of reach unless importation of infection ceases, which depends on malaria control in other provinces. Thus the malaria control programme in Henan must continue indefinitely to prevent and abort epidemics and maintain the health already attained. But if improvements suggested here could also be adopted in the other malarious provinces, coordinated eradication would be feasible. Meanwhile, Henan must maintain the excellent outcomes achieved to date by continuing to invest in malaria control at the current level.

STEWARDSHIP AND RESPONSIVENESS

The Henan government supported this study, and our results are being disseminated widely to help set strategic goals for the future. Overall, this indicates good stewardship of this component of the health sector and builds on the excellent leadership of the past 30 years. If there is government uptake of the suggested reforms for case-management, and subsequent evaluation, malaria control will continue to benefit from good stewardship at the government level. Further operational research is needed to respond to the needs of village doctors and ensure that suspected malaria cases receive prompt treatment with drug therapy that continues at least three days. And the cost of treatment for patients needs to be monitored periodically.

EQUITY AND FAIR FINANCING

Community access to diagnosis and treatment for malaria in Henan is excellent – 98% of the 12 325 cases were diagnosed within two days of the onset of fever. But the average total cost borne by each case of suspected malaria (27.85 yuan) was equal to ten days average income in rural areas. Also, many patient costs were indirect and would not be obvious to policy-makers. Overall, for each suspected malaria case, the government contribution to costs was low (5.60 yuan, see footnote Table 2), 17% of the total cost of 33.45 yuan. If intangible costs could be estimated, the expenses borne by patients becomes even higher.

The government contributions include some important preventive functions that cannot be borne by patients. These include population blood surveys, notable for their high fixed costs and accounting for 25% of Henan's expenditure on malaria control. They should continue because they can detect epidemics that may arise in the consolidation stage, as shown recently in southern Henan (Sleigh et al. 1998). Another preventive function is vector surveillance. It has the highest proportion of variable costs but is not burdensome, accounting for only 12% of total government costs. Malariologists would support it to maintain strategic knowledge. For example, vector surveillance in 1995 detected the re-emergence of *An. anthropophagus* in southern Henan, and helped explain the epidemic that resulted (Sleigh et al. 1998). Knowledge of local vectors is crucial to successful malaria control in any setting, especially when concern about the disease fades due to successful control.

Government support for the impregnated bednet programme was revived in 1996 in response to the epidemic that year. However, given the exophilic nature of the usual vectors, it is not thought that bednets will yield great benefits at this stage of malaria control and government support for that programme has now been withdrawn again.

CASE MANAGEMENT

Good case management is both curative for the patient and preventive for transmission; it is the major cost of malaria control activities in Henan for both the government (60% of expenditure) and the community (the equivalent of 10 days income expended or foregone per case of suspected malaria). Thus the quality of case-management is crucial to the efficient deployment of antimalaria resources. Our analyses of case-management performance for 12 325 suspected malaria cases in the areas of Henan with the most persistent malaria revealed high quality management for choice of drug, but inefficiencies in the other two criteria for management performance (delay to treatment, duration of therapy).

Choice of drugs

For choice of drug, we found village doctor performance was sound for 95% of cases, also noting very low rates of substitution by alternative medicines. In only 5% of cases was treatment ineffective for symptomatic malaria, using only primaquine or no antimalarial. Overall, Henan's drug distribution system has ensured a reliable flow of drugs for malaria case-management – a remarkable achievement. The government officially provided chloroquine, primaquine and pyremethamine. Perhaps Henan should re-consider the need for primaquine. Radical primaquine therapy to abolish liver stages may be both impractical and ineffective in this setting: short-course primaquine is of doubtful efficacy to prevent relapse (Signorini et al. 1996, Kimura et al 1996, Rowland and Durrani 1999, Gogtay et al. 1999). In any case few patients comply with the five-day regimen, and methaemoglobinaemia is a common adverse effect because the short course is also high-dose. Primaquine may also be unnecessary. Chloroquine kills infectious *P. vivax* gametocytes as well as illness-inducing red cell schizonts, and so prevents transmission and cures relapses as well as first attacks. Given these pharmacological effects, it may be better to focus case-management on adequate chloroquine treatment (three days) aiming for a high compliance. This would minimize confusion introduced by addition of other drugs. Also, pyremethamine is unsatisfactory alone and will lead to resistance. So it may be best to restrict the government supply to chloroquine alone, and to discourage the use of quinine which is effective but not necessary in this setting. Henan health authorities have moved on some aspects of drug reform, restricting local production of quinine that was the source for the drug used to treat patients in this study, and now no longer purchasing supplies of pyremethamine for distribution to village doctors. But the continued use of primaquine remains a matter for national policy-makers (see below).

Delay to treatment

Correct drug use alone does not hasten malaria eradication unless treatment is given with minimal delay and for sufficient duration. Vivax patients often have gametocytes circulating when they first develop symptoms, especially those with relapses. The delay in administering antimalarial drugs noted in Henan may reflect moral hazards (profits made from prescription of non-malarial treatments) or clinical doubt (trial of other anti-fever therapies for patients in which alternative diagnoses seem possible). Clinical doubt should not persist beyond two days. Great effort should be made now to educate VDs to commence treatment within two days of diagnosis. In the future, dipstick testing to diagnose malaria may become affordable in China and remove this problem altogether. At present, a novel Australian dipstick test is available in Henan but it costs 15 yuan per test, and the charge to patients is 20 yuan. This is at least 20 times too expensive for public health use in low income countries and reveals the need to develop cheaper tests. But progress on such research is slow, with no immediate prospects of affordable dipsticks for Henan's malaria control programme (WHO 2000).

Duration of treatment

Treatment duration was too short by standard chloroquine regimens (three days) for 62.4% of cases, and, for nearly 99%, did not fulfill the Henan policy (aimed at eradication) of five days double-drug treatment using chloroquine and primaquine. This is an issue for national policy-makers to consider carefully. What is gained by advocating five days of treatment with the two drugs? Would it be wiser to re-set the standard to three days with one drug? Such reforms must be enacted at the national level and involve debates and technical leadership that are beyond the scope of this paper - and would require a scientific and managerial consensus. At present, the latest trend in China is to develop standard five-day primaquine-chloroquine drug blister packs and sell them for 1.15 yuan each; if they are adopted widely in Henan they should be evaluated for compliance and adverse effects.

The monetary incentives provided for the lower levels to distribute drugs promptly work well and guarantee drug supply from Zhengzhou, the capital in the north, to needy patients in the far south of the province. At the prefecture, county and township levels, the modest revenue received for distributing drugs is used to supplement wages and bonuses. This pragmatism reflects the grave financial problems facing China's epidemic prevention programmes, now forced to charge for some services after withdrawal of many government subsidies (World Bank 1997).

COSTS AND BENEFITS

As the consolidation stage of malaria control approaches, the cost per case detected becomes increasingly expensive. Illness that appears to be malaria may be due to another cause and other diseases compete for limited health sector funds. However, cases of suspected malaria must be treated as if they are malaria unless a rapid diagnostic system is available, and this is usually not the case. In Henan, variable government inputs to malaria case-management were proportionally large (51% of 582 454 yuan for Gushi and Shangcheng in 1994-1995), and case-management attracted 60% of government expenditure, so substantial savings would accrue if malaria was eradicated and no more cases occurred. Also, variable inputs made up three-fifths (59%) of the total cost of vector surveillance, indicating further potential for government savings with eradication. But vector surveillance is the least costly, accounting for only 12% of total government expenditure on malaria control. Furthermore, it generates strategic knowledge that must be maintained and periodically updated in malaria-receptive zones even after eradication.

Vector surveillance has other uses as well. For example, it generates local data on vectorial capacity and Henan transmission dynamics. Assuming excellent case-management, we can combine the entomological and cost data to calculate the cost per case prevented, the cost per DALY saved, and the economic benefit for a given cost outlay on malar-

ia control in Henan. Such estimates are necessarily crude and were not the primary focus of our study, which concentrated on cost-performance. Nevertheless, recent vectorial capacity measurements are available for Henan and have been used below to make cost-effect, cost-utility and cost-benefit estimates which may be accurate to one order of magnitude (see section below on limitations and sensitivity of findings). These estimates could be useful for strategic planning of malaria control under similar epidemiological and climatic conditions to those prevailing in Henan. Such conditions are typical of most of the huge malaria zone in mainland China.

For a crude estimate of potential costs saved per dollar spent on malaria case management, we must make some assumptions. First, we assume that cases detected in our case management study truly had malaria. Next we assume that an episode of malaria completely disables the patient for one week (Najera et al. 1993, Mendis et al. 2001). This is reasonable, given a delay of two days to seek care after symptom onset, two days for diagnosis, and three days for treatment to resolve symptoms. We also assume that the cases are not fatal, which is true for Henan as long as *P. falciparum* remains eliminated. Thus each person with an episode of vivax malaria in our study loses one week of healthy life, to be added towards an eventual calculation of the overall disability adjusted life years lost (DALYs).

Next we must estimate how many sporozoite inoculations of other persons would arise per day from one infectious person. For the local vector *An. anthropophagu*s, this 'vectorial capacity' has been estimated as 0.4096 by entomologists trapping mosquitoes in the summer of 1999 in Datian Village, southern Henan (Li Peng, personal communication, 2000; Henan Province Preventive Health Station 2000). The methods and parameters used to calculate this figure were those of Macdonald (1973) and Gilles and Warrell (1993). Such estimates vary substantially across the transmission season in sub-tropical locations, depending in part on the vector's survival during the temperature dependent extrinsic cycle of malaria, and can be much higher (by a factor of 10) when seasonal factors are propitious. In Henan, there are many summer periods of high temperature and high humidity, but there are also other summer periods that are less suitable for vector abundance and survival and rapid sporogony. The average vectorial capacity calculated in 1999 for the other local vector, *An. sinensis*, was much lower (0.0183), but it also can be an order of magnitude higher if seasonal factors are optimal.

In our study area, we expect virtually all transmission to be caused by *An. anthropophagus*. We know there were 12 325 cases of suspected vivax malaria among non-immunes and, if they were not treated, they could remain infectious for 80 days or more (Mendis et al. 2001). Conservatively, we could say each case would infect others for at least 20 days, and given the vectorial capacity of the local vector (0.4096), we would expect each untreated case to infect 0.4096 x 20 others, or 8 persons. If the 12 325 cases were detected and treated quickly (say

within five days – including two days to consult village doctors, two days to decide on treatment, one day for gametocytes to clear after starting chloroquine treatment), then excellent case-management would prevent at least 75% of the secondary cases, or 0.75 x 8 x 12 325, i.e. 73 950, cases. Those prevented cases would have experienced a loss of 517 650 days of production (seven days per case). Assuming they were each completely disabled for one week, they would lose 1417 person-years of healthy life, equivalent to 1417 disabilty adjusted life years, or DALYs.

In 1995 dollars, malaria control cost the Henan government US$0.70 per case treated; this totals to US$8628 for the 12 325 cases, saving the 1417 DALYs at US$6.09 per DALY and costing the government US$0.10 per case prevented. Each person with malaria spent 27.85 yuan (US$3.48) on direct and indirect expenses for their own (usually rapid) diagnosis and treatment; so the community spent US$30.27 per DALY saved (3.48 x 12 325/1417), and US$0.58 per case prevented (3.48 x 12 325/73 950).

Given that the average income in our study area was 2.74 yuan (US$0.34) per day, the yearly income expected per capita is US$125. Each DALY must be worth at least that amount in community income and was purchased with a combined government and community investment of US$36.36 (US$6.09 plus US$30.27), an excellent benefit-cost ratio of US$125 to US$36.36, or 3.4 to 1. It is important to note that 83% of the public health benefit of malaria case-management in Henan was financed by the community members who became sick, but the service and standards enabling this were created by government investment in the health infrastructure. Thus the government created the village doctor system, and now certifies the training of VDs, regulates many aspects of their work, supplies them with antimalaria drugs, sets treatment standards, and periodically involves them in training programmes. This infrastructure is an integral part of the health system and cannot exist without government support.

LIMITATIONS AND SENSITIVITY OF FINDINGS

It was impossible to study all the suspected malaria cases in the whole of the Xin Yang prefecture, the only prefecture in Henan with malaria at the time of our research. But our results came from a substantial and informative sample, although we cannot know how many of the suspected malaria cases actually had malaria. Passive blood tests are impractical for management of clinical malaria in southern Henan because slides are often taken after treatment, transport from scattered villages is usually delayed, and quality control is always poor. False negative results are very common when slides are evaluated locally. However, we do know that these cases were detected during the transmission seasons, that malaria was present in the area and became epidemic in 1996 (Sleigh et al. 1998), and that each case was considered typical of malaria on evaluation by an experienced malariologist.

Uncertainty regarding the actual malaria status of our 12 325 suspected malaria cases has an unavoidable impact on our estimates of the costs and effects for health outcomes assuming excellent case-management. If only 10% of the suspected malaria cases truly had malaria and all were treated promptly (allowing gametocytes to circulate for five days or less), then the total cost we estimated per DALY saved would increase from US$36.36 (quite near the US$30 cut-off proposed by WHO as 'highly attractive') to about US$360 – somewhat above the US$150 cut-off of 'attractive' cost-effects (Mills 1999, WHO 1996). But the vectorial capacity for *An. anthropophagus* at times is several times higher than the average figure used here, and our estimate of 20 days for the period of infectiousness of untreated vivax is conservative compared to the 120 day figure recently used by Akhavan et al. (1999). Both these factors would boost the number of secondary cases per index case well above the levels we estimated, countervailing any errors due to overdiagnosis of malaria. It seems reasonable to conclude that excellent management of suspected malaria cases in southern Henan would yield a true cost per DALY saved that is well within WHO's 'attractive' range for cost-effectiveness of health interventions.

CONCLUSIONS

We studied the costs and performance of a malaria control programme in mainland China and explored ways to improve it. We are confident that costs were measured as accurately as possible and we made a special effort to do so prospectively, using specific instruments to measure costs rather than depend on existing records. We could not measure the intangible costs so we have underestimated the total cost of malaria in Henan. The standards and criteria we set for the analysis of case-management performance may seem rather simple for such a complex disease. However, this device made the problem tractable, enabling us to make the first economic appraisal of the cost and performance of malaria control in China.

Our research assessed the costs of vivax malaria, an understudied and very important cause of malaria outside of Africa (Mendis et al 2001). Recently, contemporary and historical evidence has been presented that *P. vivax* causes considerable morbidity and is an important cause of poverty (Mendis et al. 2001, Gallop and Sachs 2001, Reiter 2000). Some health benefits not measured by us may have been considerable (e.g. prevention of co-morbidity and improved cognitive development). Nevertheless, we found that malaria control and case-management is a good buy in Henan, with balanced community and government costs and benefits (Table 10 on next page).

Table 10: Summary indicators of costs and outcomes of malaria control in Henan

Indicator	Community	Government	Total
Annual cost* (1994-1995)		99,790	
Population protected			>3.4 million
Cost per person protected		0.03	
Cost per case treated	3.48 (83%)	0.70 (17%)	4.18 (100%)
Government expenditure			
Vector control		12%	
Blood surveillance		25%	
Case-management		60%	
Contingencies/special projects		4%	
Cost per case prevented**	0.58	0.10	0.68
Cost per DALY saved**	30.27	6.09	36.36
Benefit:cost ratio**			3.4 to 1

* All costs are expressed in 1995 US$

** Assuming excellent case management, one week debilitating illness, 20 days of infectious gametocytaemia if untreated, and a vectorial capacity of 0.4096 for local *An. anthropophagus*

We expect the information provided here will assist in the maintenance and improvement of malaria control in all of China's 19 endemic provinces. In Henan, malaria control has brought great benefits to the population and officials now know the true cost of the control programme, and how to make it more efficient. The annual government investment of 798 322 yuan (US$99 790) protected at least 3.4 million people in the four counties with persisting malaria – a modest amount of US$0.03 per head. It was matched by nearly seven times that amount for community costs arising from illness and its management; this seems quite well balanced, with good benefit-cost ratios and great scope to improve the efficiency of case-management by health education and village doctor training.

The standard drug treatment (three days of chloroquine and five days of primaquine) needs to be re-considered. The primaquine component is poorly tolerated due to methaemoglobinaemia, and compliance with a full course is almost unattainable. Short-course primaquine may be less effective than thought for prevention of relapses. Rapid case detection and adequate chloroquine treatment may be a better option and should help interrupt transmission.

If the Henan government reduces investment in malaria control, transmission of *P. vivax* will certainly increase and *P. falciparum* may return, leading to much greater expenditure in the future by both government and residents of malarious counties, and to a fall in benefit-cost ratios. This problem affected the Indian subcontinent when malaria became resurgent in the 1970s; the disease is now much more serious and costly than it was when control had succeeded a few years before. Good stewardship in Henan today calls for continued government expenditure on malaria control, improved performance of case-management (more rapid diagnosis and longer duration chloroquine treatment), and national advocacy of better coordination across all endemic provinces to improve the overall performance.

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Xi-Li Liu
Project Principal Investigator,
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APPENDIX A

TYPES OF ECONOMIC EVALUATION

An indication that health economics is at a relatively immature stage of its disciplinary development is that the use of terms is still irresolute and often open to different interpretations. A helpful work on evaluation in health economics is Green's (1992). He distinguishes between an evaluation with the purpose of adopting alternative new projects, which he defines as an economic appraisal, and an evaluation with the purpose of deciding whether an existing project should continue or should be modified, which he defines as a formative evaluation (Green 1992:234). Our work should be described as 'formative evaluation' according to Green.

Drummond et al. (1998) use the term 'economic evaluation' to describe 'the comparative analysis of alternative courses of action in terms of both their costs and consequences' (1998:8-9). They are referring to a comparison of alternative projects. Indeed, the literature has largely concentrated on how and why choices were made between two or more programmes, and economic evaluation is often discussed with reference to new projects.

Earlier in 1962, the Proceedings of the Conference on the Economics of Health and Medical Care suggested a comprehensive analytic structure for research, consisting of seven major agendas (Rothenberg 1964) in health economics. One is the economic evaluation of ongoing individual public health programmes by comparing costs with outcomes (Rothenberg 1964:312, 314-315).

Making efficiency inference on an ongoing single project is akin to studying a single firm or organization by analyzing its costs and outputs, based on the principles of managerial economics (Mansfield 1999, Petersen and Lewis 1999). For malaria control, a comparison of costs to outcomes will help decision-makers to decide the extent they should revise the programme, as ineconomies of scale drive up costs at the stage of consolidation.

In the section below we will briefly distinguish between the well-known economic evaluation methods: cost-benefit analysis (CBA), cost-effectiveness analysis (CEA) and cost-utility analysis (CUA). This will help to explain why we have devised our own economic evaluation method.

EVALUATION COMPARING TWO OR MORE PROJECTS

If the problem is finding the best possible resource allocation, then we must simultaneously engage in (a) a comparison of two or more pro-

jects or interventions, and (b), consider both costs (inputs) and outcomes (outputs) of these alternatives (Drummond et al 1998). There are three well-known techniques of economic evaluation to assist in decision-making: cost-benefit, cost-effectiveness, and cost-utility.

Cost-benefit is suitable when the two or more alternatives do not have a single common outcome or effect; the common denominator used to measure benefits is money (Rienhardt 1997). A total monetary sum (positive or negative) would indicate the net benefit or net loss, but the result may also be expressed as a ratio of dollar costs to dollar benefits.

Until recently, this technique was not commonly applied to health care because it is difficult to confer a monetary value to a health outcome. A recent innovation, still in an experimental stage, is to measure the benefits of better health by the consumers' willingness to pay in monetary terms (Evans and Hurley 1995:505).

Cost-effectiveness is suitable when the two or more alternatives have common outcomes or effects, and therefore could be measured in physical units (Reinhardt 1997). Examples of intermediate outcome indicators are the number of detected malaria cases, and the number of malaria positive blood slides; examples of final outcome indicators are the number of disability days avoided, and life-years saved (Evans and Hurley 1995: 505). The limitation of the cost-effectiveness technique is that it only measures one-dimensional changes such as morbidity. When it is necessary to measure two-dimensional changes, such as morbidity and mortality at the same time, one of the other two techniques (cost-benefit and cost-utility) should be used (Evans and Hurley 1995: 507).

Cost-utility is suitable for comparing changes in both morbidity and mortality of health care programmes that also produce different effects or outcomes. It is necessary to find a common measure for the different outcomes which could be measured in terms of the various degrees of satisfaction or dissatisfaction, known as 'utility'. An example of utility is the individual's preferences for certain favourable outcomes. Utility measurement is useful in health care because it provides the common denominator for comparing several interventions under different conditions that produce different physical outcomes. However, the problem here is the lack of a generally accepted set of variables to express the patient's satisfaction or dissatisfaction (Evans and Hurley 1995: 505). Measures that are becoming popular are the 'number of quality-adjusted life years' (QALYs) and the 'disability adjusted life years' (DALYs).

Appendix B Table 1: Costs of patients seeking malaria treatment in Henan, 1994-1995 (Part I)

Cost item	County	No. of cases	Total cost of cases	Average cost for total number of cases	Percentage of total sample population (12 325 cases) incurring cost item	Average cost for total sample population (12 325 cases)
Consultation fees	Gushi '94	2396	1148.5	0.48		
	S.Cheng '94	1538	1713.7	1.11		
	Gushi '95	1722	2976.74	1.73		
	S.Cheng '95	2151	3333.70	1.55		
		7807	**9172.64**	**1.18 yuan**	**63%**	**0.74 yuan**
Drugs/injections	Gushi '94	3357	22837.9	6.8		
	S.Cheng '94	1781	13814.6	7.76		
	Gushi '95	3711	49023.06	13.21		
	S.Cheng '95	2895	23163.38	8.0		
		11744	**108838.94**	**9.27 yuan**	**95%**	**8.83 yuan**
Blood examination	Gushi '94	752	809.8	1.08		
	S.Cheng'94	206	444.1	2.16		
	Gushi '95	935	1910	2.04		
	S.Cheng '95	31	81	2.61		
		1924	**3244.9**	**1.69 yuan**	**15.61%**	**0.26 yuan**
Antimalarial drugs	Gushi '94	3446	2467	0.72		
	S.Cheng '94	1482	2056	1.39		
	Gushi '95	3724	3223.04	0.87		
	S.Cheng '95	3135	5339.59	1.7		
		11787	**13085.63**	**1.11 yuan**	**95.64%**	**1.06 yuan**
Transport	Gushi '94	522	474.7	0.91		
	S.Cheng '94	157	315.7	2.01		
	Gushi '95	309	1114	3.61		
	S.Cheng '95	88	224	2.55		
		1076	**2128.4**	**1.98 yuan**	**8.73%**	**0.17 yuan**
Food during treatment	Gushi '94	446	1214.8	2.72		
	S.Cheng '94	221	2543.6	11.51		
	Gushi '95	246	3100.85	12.61		
	S.Cheng '95	260	3436.5	13.22		
		1173	**10295.75**	**8.78 yuan**	**9.52%**	**0.84 yuan**

Appendix B Table 1: Costs of patients seeking malaria treatment in Henan, 1994-1995 (Part II)

Cost item	County	No. of cases	Total cost of cases	Average cost for total number of cases	Percentage of total sample population (12 325 cases) incurring cost item	Average cost for total sample population (12 325 cases)
Pre-visit drugs (self-treatment)	Gushi '94	375	760.7	2.03		
	S.Cheng '94	85	349	4.11		
	Gushi '95	473	2680.23	5.67		
	S.Cheng '95	51	153.4	3.01		
		984	**3943.33**	**4.01 yuan**	**7.98%**	**0.32 yuan**
Income loss	Gushi '94	1582	14678.1	9.28		
	S.Cheng ;94	932	19157	20.55		
	Gushi '95	2005	41969.6	20.8		
	S.Cheng '95	1937	53666.2	27.71		
		6456	**129470.9**	**20.05yuan**	**52.38%**	**10.50 yuan**
Transport of patient's companion	Gushi '94	667	865.4	1.3		
	S.Cheng '94	231	712.6	3.08		
	Gushi '95	313	1525.2	4.87		
	S. Cheng '95	34	157.5	4.63		
		1245	**3260.7**	**2.62 yuan**	**10.1%**	**0.27 yuan**
Food for patient's companion	Gushi '94	800	2798.5	3.5		
	S.Cheng '94	216	2599	12.03		
	Gushi '95	315	3092.8	9.82		
	S. Cheng '95	59	755	12.8		
		1390	**9245.3**	**6.65 yuan**	**11.28%**	**0.75 yuan**
Income loss of patient's companion	Gushi '94	1669	9664.2	5.79		
	S.Cheng '94	705	11534	16.01		
	Gushi '95	1077	13226.1	12.28		
	S.Cheng '95	546	8793.5	16.11		
		3997	**43217.8**	**10.81yuan**	**32.43%**	**3.51 yuan**
Other costs of patients's companion	Gushi '94	745	3071	4.12		
	S.Cheng '94	90	1098.5	12.21		
	Gushi '95	308	2593.2	8.42		
	S.Cheng '95	62	581.0	9.37		
		1205	**7343.7**	**6.09 yuan**	**9.78%**	**0.60 yuan**

Appendix B Table 2: Malaria control in Henan Province: Total workforce, 1994 and 1995

	1994				1995			
	Administrative officials[1]		Professional staff[2]		Administrative officials[1]		Professional staff[2]	
	total number	total working days	total number	total working days	total number	total working days	total number	total working days
Provincial level: (1) Henan Health Bureau	23	140	-	-	16	33	-	-
Provincial level: (2) Inst. of Parasitic Diseases	21	140	14 (full-time)	5 040	8	32	15 (full-time)	5 400
Prefecture level: (3) Xing Yang Health Bureau	39	165	3	1 141	25	132	3	1 260
Total of (1) (2) and (3) in four malarial counties	83	445	17	6 181	49	197	18	6 660
County level: Gushi Health Bureau and Anti-endemic Station	22	121	5 (full-time)	1 800	17	65	5 (full-time)	1 800
Township level in Gushi: Township hospitals (33 townships)	161	196	33 (not exclusively in malaria)	770	70	161	33 (not exclusively in malaria)	369
County level: Shangcheng Health Bureau and Anti-endemic Stations	47	190	4 (full-time)	1 440	23	83	4 (full-time)	1 440
Township level in Shangcheng: township hospitals (22 townships)	300	454	22 (not exclusively in malaria)	786	109	173	22 (not exclusively in malaria)	339
Total in two malarial counties	**530**	**961**	**64**	**4 796**	**219**	**482**	**64**	**3 948**

1. Administrative officials also worked on other health programmes; their time devoted to malaria control was recorded by individual self-report.
2. Professional staff in malaria control: full-time included rest days and public holidays. Total no. of days (a) at prefecture level was recorded by statistics clerk and (b) at township hospitals by preventive doctors themselves.

Appendix B Table 3: Malaria control in Henan Province: Wages, medical benefits and housing (fixed) costs, 1994 and 1995 (in yuan)

	1994						1995					
	Administrative officials[1]			Professional staff			Administrative officials[1]			Professional staff		
	Wages and bonuses	Medical benefit	Housing	Wages and bonuses	Medical benefit	Housing	Wages and bonuses	Medical benefit	Housing	Wages and bonuses	Medical benefit	Housing
Provincial level: (1) Henan Health Bureau	2 652	36	673	-	-	-	650	9	159	-	-	-
Provincial level: (2) Inst. of Parasitic Diseases	2 895	36	673	101 142	1 310	24 794	1 179	8	159	109 062	1 040	26 565
Prefecture level: (3) Xin Yang Health Bureau	1 759	132	797	16 374	913	5 313	2 278	106	638	20 680	1 008	5 313
Total cost of (1) (2) and (3) in four malarial counties with total population of 3 405 500	7 306	204	2 143	117 516	2 223	30 107	4 107	123	956	129 742	2 048	31 878
	Total = 9 653			**Total = 14 9846**			**Total = 5 186**			**Total = 163 668**		
Proportional cost of (1) (2) and (3) in Shangcheng and Gushi Counties	4 490	125	1 317	72 225	1 366	18 504	2 524	76	588	79 739	1 259	19 592
(4) County level: Gushi Health Bureau and Anti-endemic Station	2 268	36	584	13 156	540	8 855	1 367	20	319	13 156	540	8 855
(5) Township level in Gushi: township hospitals (33 townships)	2 749	80	956	5 907	231	3 737	1 967	48	779	3 980	122	1 789
(4) County level: Shangcheng Health Bureau and Anti-endemic Station	2 064	38	921	15 600	288	7 084	1 160	17	407	15 696	288	7 084
(5) Township level in Shangcheng: township hospitals (22 townships)	5 254	91	2 196	7 437	157	3 808	1 953	35	832	3 016	68	1 647
Total cost in two malarial counties with population = 2 093 100	16 825	370	5 974	114 325	2 582	41 988	8 971	196	2 925	115 587	2 277	38 967
	Total = 23 169			**Total = 158 895**			**Total = 12 092**			**Total = 156 831**		

1. Administrative officials also worked on other health programmes.
2. Employee medical benefit was not the same for all levels. According to the Financial Department of HIPD, the cost per person per day was calculated as: provincial level at 0.26 yuan, prefecture level at 0.8 yuan, Gushi County at 0.3 yuan, Shangcheng County at 0.2 yuan.

Appendix B Table 4: Malaria control in Henan Province and in two of its counties: Administration running (variable) costs,1994 and 1995 (in yuan)

	1994							1995						
	Skills upgrade	Travel	Conference and meeting	Electricity water and phone	Hospitality	Office stationery printing etc.	Buildings mainten-ance and repairs	Skills upgrade	Travel	Conference and meeting	Electricity water and phone	Hospitality	Office stationery printing etc.	Buildings mainten-ance and repairs
Provincial level: (1) Henan Health Bureau	-	8 400	-	900	N/A	-	-	-	1 258	-	-	N/A	-	-
Provincial level: (2) Inst. of Parasitic Diseases	-	28 103	8 960	7 761	N/A	91 040	-	6 196	27 840	42 830	8 586	N/A	26 170	-
Prefecture level: (3) Xin Yang Health Bureau	400	9 404	2 500	834	8 550	130	-	-	4 912	-	770	7 400	150	-
Total cost of (1) (2) and (3) in four counties with population of 3 405 500	400	45 907	11 460	9 495	8 550	91 170	-	6 196	34 010	42 830	9 356	7 400	26 320	-
Proportional cost of (1) (2) and (3) in Gushi and Shangcheng Counties with population = 2 093 100	246	28 214	7 043	5 836	5 255	56 033	-	3 808	20 903	26 323	5 750	4 548	16 176	-
(4) County level: Gushi Health Bureau and Anti-endemic Station	-	2 987	2 313	238	6 013	9 078	560	-	2 005	180	655	2 516	983	-
(5) Township level in Gushi: township hospitals (33 townships)	50	1 554	782	627	5 289	579	697	-	85	222	304	1 976	180	-
(4) County level: Shangcheng Health Bureau and Anti-endemic Station	110	3 355	2 030	293	11 055	6 115	-	110	2 716	560	461	5 977	15	-
(5) Township level in Shangcheng: township hospitals (22 townships)	6	1 141	446	200	5 870	75	31	-	270	496	169	11 062	-	-
Total cost in two counties	412	37 251	12 614	7 194	33 482	71 880	1 288	3 918	25 979	27 781	7 339	26 079	17 354	-
Total cost in two counties	**Gushi and Shangcheng Counties total cost in 1994 = 164 121 yuan**							**Gushi and Shangcheng Counties total cost in 1995 = 108 450 yuan**						

Appendix B Table 5: Malaria control in two counties of Henan Province: Training and field labour (variable) costs, 1994 and 1995 (in yuan)

	1994						1995					
	Briefing doctors	Training microscopists		Labour costs microscopists		Surveillance station staff allowance and travel	Briefing doctors	Training microscopists		Labour costs microscopists		Surveillance station staff allowance and travel
		Passive blood tests	Active blood tests	Passive blood tests	Active blood tests	Case detection / Vector surveillance		Passive blood tests	Active blood tests	Passive blood tests	Active blood tests	Case detection / Vector surveillance
Provincial level: Inst. of Parasitic Diseases												
Prefecture level: Xin Yang Health Bureau		291										
County level: Gushi Anti-endemic Station	913	3 717	1 760	2 341 (mostly validation)	10	416 / 216				841 (mostly validation)	-	326 / 144
Township level in Gushi: township hopitals (33 townships)	1 100	108	6	3 180	15					4 754	-	
County level: Shangcheng Anti-endemic Station	-	1 346		2 085 (mostly validation)	46		450			3 320 (mostly validation)	-	
Township level in Shangcheng: township hospitals (22 townships)	42	963		8 610	8		30			20 140	-	
Total cost in two counties population=2 093 100	2 055	6 425	1 766	16 216	79	416 / 216	480	-	-	29 055	-	326 / 144
Total cost in two counties	**Total in 1994:** case management = 24 696 yuan; active blood tests = 1 845 yuan; vector surveillance and case detection = 632 yuan						**Total in 1995:** case management = 29 535 yuan; active blood tests = 0 yuan; vector surveillance and case detection = 470 yuan					

1. Microscopists also worked on other health programmes; their time working for malaria control was recorded by township hospital preventive doctors. Active blood tests were conducted by team of professionals from HIPD, prefecture and county health bureaux; blood slides were taken back to HIPD. Microscopists assisted in the field.
2. Surveillance station in Gushi: labour costs for case detection included travel allowance. In 1994 and 1995, Henan Province had only three surveillance stations - Gushi, Luyi and Shuiping.

Appendix B Table 6: Malaria control in two counties of Henan: Costs of drug procurement and other supplies, 1994 and 1995 (in yuan)

	1994					1995				
	Procurement of malaria drugs				Microscopes, slides, forms, stain regimen procurement	Procurement of malaria drugs				Microscopes, slides, forms, stain regimen procurement
Provincial level: Institute of Parasitic Diseases	Malaria drugs procurement for whole province = 150 000 yuan Estimate of drugs allocated to Gushi and Shangcheng was 46 075					Malaria drugs for whole province = 0 Estimate of drugs allocated to Gushi and Shangcheng was 24 600				
	Quinine	Quinine injection	Chloro-quine	Prima-quine	Passive blood tests	Quinine	Quinine injection	Chloro-quine	Prima-quine	Passive blood tests
Prefecture level: Xin Yang Health Bureau					2 113					
County level: Gushi Anti-endemic Station	-	-	3 552	-	357 (mostly validation)	-	-	-	-	181 (mostly validation)
Township level in Gushi: township hospitals (33 townships)	-	4 288	1 450	55	414	20	3 456	580	-	642
County level: Shangcheng Anti-endemic Station	-	-	575	460	765 (mostly validation)	-	-	-	-	2 250 (mostly validation)
Township level in Shangcheng: township hospitals (22 townships)	100	38	856	620	718	100	-	1 580	1 380	193
Total in the two counties population	100	4 326	6 433	1 135	4 367	120	3 456	2 160	1 380	3 266
	Total cost of drugs = 58 069 yuan					**Total cost of drugs = 31 716 yuan**				

APPENDIX C

COST ESTIMATION FOR HOUSING AND GOVERNMENT BUILDINGS

In this monograph we have used the simplest approach, the 'straight line' method, to estimate the average annual cost of staff housing and government buildings. Over 30 years one average housing unit cost 1771 yuan per year (53,130 ÷ 30) and government buildings cost 103,787 yuan (3,113,600 ÷ 30).

With the above method we calculated annual costs for housing and buildings based on an estimated 30-year lifespan. Some health economists would also add the opportunity cost of the invested capital, usually at an interest (discount) rate of 3 % per year. If we allow for both building lifespan and foregone interest, we can annualize by dividing the invested capital by a composite figure called the 'annuity factor'. For example, with a 30-year lifespan and 3% annual interest (discount) rate the annuity factor is 19.6004. The annuity factor is easily obtainable in health economics textbook such as Drummond et al. 1998 (Annex 4.2 Discount Table 2 on page 95).

Using 3% and a lifespan of 30 years, the annual cost for an average housing unit would be 2,711 yuan (53,130 ÷ annuity factor 19.6004) and the annual cost of government buildings would be 158,854 yuan (3,113,600 ÷ annuity factor 19.6004).

Appendix C Table 1: Government costs of malaria control

Average annual government costs (US$)	Straight line method	Annuity factor method
Gushi & Shangcheng counties		
total costs	61,371	68,583
case-management	36,403	40,731
blood surveys	15,283	17,446
vector surveillance	7,310	8,032
Henan Province		
total costs	99,790	111,516
cost per suspected malaria case	0.70	0.78
cost per head of population protected*	0.03	0.03

*assuming 3.4 million people were protected.

The higher cost values obtained by the annuity factor method would influence all government activities that have staff housing and buildings as component costs. Patient costs are not affected. Government activities will rise by a small amount as shown above.

In this monograph, we have presented the costs in their undiscounted form to make the calculation transparent and permit other investigators to add the effect of discounting as they wish.

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