

Local Transmission of *Plasmodium vivax* Malaria in Singapore

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Abstract

A localised outbreak involving 19 cases and two carriers of vivax malaria was reported at Dairy Farm from May to June 1996. Epidemiological investigations showed that the outbreak was caused by the introduction of two foreign workers with imported relapsing vivax malaria into this malaria-receptive area. Transmission of infection occurred amongst 17 other foreign workers residing in the locality and two local residents staying at a condominium nearby. The outbreak was rapidly brought under control through active case finding, isolation and treatment of infected persons, epidemic vector control measures, and improved drainage to prevent *Anopheles maculatus* breeding. Were it not for the very thorough epidemiological investigations in this episode, foreign workers and local residents with a recent travel history would have been misclassified as imported and the outbreak missed. Medical practitioners should always consider the possibility of malaria in a foreign worker presenting with fever and notify the case as soon as the disease is suspected.

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Key words: *Anopheles maculatus*, Imported relapsing malaria, Introduced malaria, Mosquito-borne, Outbreak

Introduction

Malaria used to be endemic in Singapore at the turn of the century.¹ In 1911 when malaria control activities began with the construction of a comprehensive drainage system in Telok Blangah,² 2930 fatal cases were reported.³ The drainage system, together with an anti-larval oiling programme, was extended to many areas of Singapore^{4,5} and successfully reduced malaria mortality.⁶⁻¹¹ However, epidemics resumed during the World War II when these activities were totally disrupted. In 1945 alone, 2771 deaths were reported.¹² After the war, the malaria situation was quickly brought under control. No more deaths were reported and indigenous malaria was believed to have been eradicated in the main island of Singapore in the 1950s.¹³ In 1964, a localised outbreak of 29 cases occurred at Fuyong Estate and this led to a review of the existing malaria control strategies.¹⁴⁻²¹ In the 1970s, indigenous malaria re-emerged because massive land development resulted in the deployment of large numbers of labourers from malarious countries and created environmental conditions favourable for vector breeding.²² Following an outbreak of 82 cases at Whampoa/Kallang in 1974 to 1975, epidemiological and vector surveillance activities were further strengthened.²²⁻²⁴ After intense scrutiny by the World Health

Organization, the country was certified in November 1982 to be free of indigenous malaria.²²

Despite its achievements, Singapore remains both vulnerable and receptive to the reintroduction of malaria; vulnerable, because of the constant influx of travellers and foreign workers from malaria endemic countries and receptive, because of the presence of *Anopheles* vectors.^{22,25,26} Over the past two decades, the incidence of imported malaria has risen from 218 cases in 1976 to 329 cases in 1996.^{22,27} Vivax malaria, caused by the protozoan parasite *Plasmodium vivax*, was the most common form of malaria reported, accounting for 67% to 80% of all cases. One significant trend of concern has been the increasing proportion of imported cases involving work permit/employment pass holders who constituted only 2.3% of the cases in 1976 but rose to 43.8% in 1996. Parasite carriers among the foreign workers have given rise to malaria transmission in receptive areas from time to time.^{22,28}

Since 1982, two localised outbreaks of mosquito-borne vivax malaria have been reported. The first outbreak of 27 cases occurred at Punggol Point during the period April to May 1993,²⁹ while the second involved 43 cases at Tanjong Rhu/East Coast Park between September 1993 and January 1994.³⁰ We report here on the epide-

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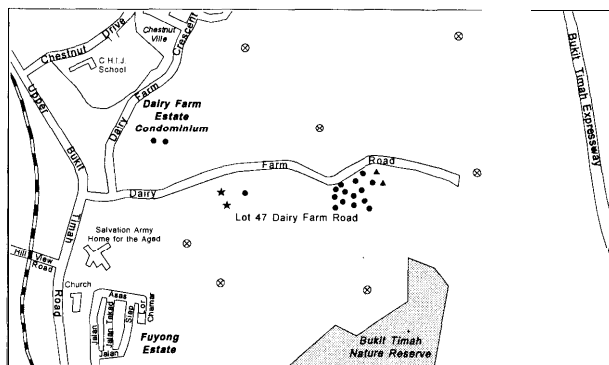
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miological and entomological aspects of another localised outbreak of malaria which occurred at Dairy Farm from May to June 1996.

Geographical Description Of Dairy Farm

Dairy Farm is a forested hilly area located in the central part of Singapore adjacent to the Bukit Timah Nature Reserve. It is relatively undeveloped and sparsely populated with private residential premises, the largest being the Dairy Farm Estate condominium. Most of the area comprised stateland which had been leased for use by two nurseries. Natural springs and seepages found in the hills were exploited by the nurseries for the purpose of watering plants. There were also some construction activities in the periphery of Dairy Farm. The local resident population there was estimated at just over 1000 with most of them staying in the Dairy Farm Estate condominium. The other residents in the vicinity consisted of about 120 foreign workers who were employed by the two nurseries along Dairy Farm Road and had their living quarters within the nurseries (Fig. 1).



★ One imported case
● One introduced case
▲ One parasite carrier
⊗ One *Anopheles maculatus* breeding habitat

Fig 1. Geographical distribution of reported malaria cases and carriers and *Anopheles maculatus* breeding habitats at Dairy Farm, May to June 1996.

The Outbreak

On 7 June 1996, the Quarantine & Epidemiology Department, Ministry of the Environment, was notified of two cases of vivax malaria involving Indian foreign workers staying at Dairy Farm. Both of them reported a history of similar illness prior to their arrival in Singapore in November 1995 and were therefore classified as imported relapsing cases. The index cases were among a group of foreign workers who stayed in one of the two nurseries along Dairy Farm Road and were deployed during the daytime to various parts of Singapore as general workers cum gardeners. On 21 June 1996, another case of vivax malaria in a Thai worker staying in the vicinity was notified. As soon as local transmission was suspected, epidemiological and vec-

tor surveillance were stepped up and epidemic control measures implemented to prevent further transmission of infection.

Materials and Methods

Epidemiological Surveillance

An active search for other unreported cases was carried out from 21 June 1996 at the nurseries and in the surrounding neighbourhood. Mass blood surveys were organised to collect blood films from both symptomatic and asymptomatic foreign workers. Foreign workers who were repeatedly screened for malarial parasites included not only those who were resident within the area but also those employed in the construction sites nearby. Fever surveys were also conducted among local residents who lived in the vicinity of Dairy Farm. Those found to be suffering from fever had their blood films taken and examined for malarial parasites.

All confirmed malaria cases notified to the Environment Ministry in the year prior to and during the period of the outbreak were reviewed to determine if they could be epidemiologically linked to local transmission at Dairy Farm. In view of the synchronous occurrence of the two index cases, the possibility of an earlier case was investigated. During our patient interviews and active case finding, the information on all cases were scrutinised to confirm the dates of symptom onset and diagnosis, movements and all known contacts prior to their illness, and the absence of risk factors for malaria acquisition such as a history of recent travel to endemic areas. Wherever possible, the information provided by foreign workers who had language difficulties were verified through interpreters.

We defined a case in this outbreak as a person who had lived, worked or been in the vicinity of Dairy Farm, developed a fever during the period between May and June 1996, and was subsequently diagnosed to have *Plasmodium vivax* infection by blood film examination. Based on epidemiological findings, the reported malaria cases were classified as imported (as shown by tracing the case to its origin in a malarious area outside Singapore), relapsing (a relapse of a pre-existing infection as shown by the history of the case and the absence of any associated cases in the neighbourhood of its origin), and introduced (directly secondary to a known imported case).³¹ A person in whom *Plasmodium vivax* infection was detected in the blood film but with no symptoms was classified as a carrier.

Entomological Surveillance

Vector surveys were carried out from 21 June 1996. An entomologist and several environmental health officers surveyed the neighbourhoods covering an area of one kilometre radius from the reported cases for *Anopheles* larval breeding sites. Adult trappings for anopheline

vectors were also conducted. Two light traps and one human bait trap were set up from 25 June 1996 near the foreign workers' quarters and potential breeding sites within the two nurseries to capture adult mosquitoes. The light traps were electrically operated from 1900 to 0700 hours. The human bait trap was manned by two environmental health officers from 1900 hours until midnight for five nights. All larvae collected and adult mosquitoes trapped were examined at the Vector Control and Research Laboratory to identify their species.

Prevention and Control

All infected persons were promptly isolated and treated at the Communicable Disease Centre, Tan Tock Seng Hospital, and followed up after discharge from hospital to ensure that there was no relapse. Routine blood examination of all contacts for malaria parasites was also carried out. Members of the public were alerted of the outbreak through the mass media, and medical practitioners advised to exclude the possibility of malaria in any febrile patient who had recently been to the outbreak area.

Anopheline larvae detected were destroyed and larvicidal oil applied to all potential breeding sites. From 25 June until 1 July 1996, residual spraying and thermal fogging, both with pirimiphos-methyl, were implemented to destroy any adult vectors present. Improvements were also made to the drainage system to prevent water-logging in the area.

Results

Epidemiological Findings

Between 25 June 1996 and 22 July 1996, 13 mass blood surveys were carried out among the foreign workers at Dairy Farm and 1147 blood films obtained for examination for malarial parasites. Of these, eight foreign workers (six febrile, two asymptomatic) were found to be positive for *Plasmodium vivax*. All the positive slides came from the workers staying at one nursery. Seven febrile local residents picked up during six fever surveys between 25 June and 5 July 1996 also had their blood films taken and examined for malarial parasites. None of them were positive.

A total of 19 cases were confirmed to have *Plasmodium vivax* infection with onset of symptoms between 19 May and 27 June 1996. Two of these cases were local residents of Dairy Farm Estate condominium while the rest comprised of one Thai, five Bangladeshi and 13 Indian workers staying in the two nurseries along Dairy Farm Road. All the infected persons were males except for one local resident. Their ages ranged from 19 to 39 years. In addition to the two index cases, four other foreign workers gave a past history of fever prior to their arrival in Singapore. The Thai worker, who had been employed in Singapore since 1993, also travelled back to rural Thai-

land in January 1996. We investigated the possibility of an earlier case giving rise to synchronous occurrence of the two index cases but could not establish any epidemiological evidence for this.

The symptoms reported by the cases were fever (100%), rigors (94.7%), chills (89.5%), headache (78.9%), sweating (42.1%), vomiting (26.3%), dark-coloured urine (10.5%), and stomach or body aches (5.3%). The clinical presentation of the two local residents did not appear to be more serious than that of the workers from endemic countries. The dates of onset of fever of the reported cases, detection of the two carriers, and the prevention and control measures taken are shown in Figure 2.

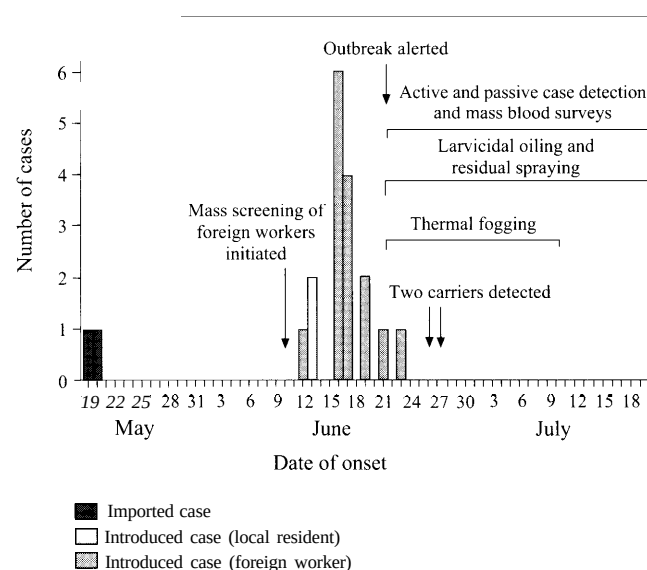


Fig. 2. Time distribution of 19 reported vivax malaria cases at Dairy Farm, May to June 1996

Entomological Findings

Larvae of *Anopheles maculatus*, a principal vector of malaria,³² were found in seven habitats consisting of four seepages, one ground puddle, one earth drain and one antimalaria drainage well between 21 and 26 June 1996 (Fig. 1). The larval densities were low in each habitat, ranging from one larva per dip to one larva per 50 dips. All larvae collected were in the third to fourth instar stages, approximately one week in age.

A total of 49 adult mosquitoes (none of them human malaria vectors) were caught in the light trap and human bait traps set up between 21 June and 4 July 1996. They comprised 41 *Culex quinquefasciatus*, five *Armigeres* sp, and one each of *Culex gelidus*, *Culex vishnui*, and *Culex* sp. No anophelines were caught.

Discussion

There has been a regular and rising incidence of malaria imported into Singapore over recent years. With

the increased incidence, the risk of outbreaks of malaria occurring from autochthonous transmission has become correspondingly higher. In this particular outbreak, the origin was traced to two foreign workers who were infected with *Plasmodium vivax* and developed a relapse within seven months of arrival in Singapore. Foreign workers with relapsing vivax malaria had been implicated as the source of infection in other localised outbreaks, including the 1974 to 1975 outbreak at Whampoa/Kallang²³ and the 1993 outbreak at Tanjong Rhu/East Coast Park.³⁰ These foreign workers from malaria-endemic countries provided a reservoir of *Plasmodium* gametocytes for the transmission of infection in malaria-receptive areas.³³⁻³⁵

Based on the epidemiological evidence, *Anopheles maculatus* was the vector responsible, even though no infected adults were caught. The species had also been responsible for outbreaks of malaria involving 29 cases at the nearby Fuyong Estate in 1964¹⁴ and 25 cases at Pulau Tekong in 1969.³⁶ It breeds in slow flowing, clear and sunlit seepage waters. The detection of *Anopheles maculatus* larvae during the outbreak period showed that bloodfed females must have been present in the vicinity of Dairy Farm. These anophelines are zoophilic and tend to bite in large numbers outdoors,^{37,38} but when there is a scarcity of large mammals, they would feed on humans,³⁹ usually entering the premises between 2100 hours and midnight.^{40,41} As their bites could be extremely painful, they typically elicit an avoidance reflex response from the human host and have to bite repeatedly, possibly from more than one host, to complete a full bloodmeal. The mosquitoes probably became infected after feeding on one or both of the index cases before they were isolated and treated.

Under optimum tropical conditions, the life-span of adult *Anopheles* mosquitoes may exceed four weeks.⁴² We believe that the secondary cases acquired malaria around early June 1996 because most of them became ill during the third week of that month, allowing a known incubation period of 14 days and another 11 to 14 days for the sporogonic cycle in the mosquito to be completed.

The focus of infection was rapidly eliminated with the implementation of epidemic control measures. The low yield from the adult mosquito trappings was probably due to the effective kill achieved by the night fogging operations. Transmission was interrupted within a week after the outbreak was alerted and only one crop of introduced cases secondary to the two imported cases occurred. Four foreign workers with onset of symptoms between 17 and 23 June 1996 and a past history of fever prior to their arrival in Singapore were considered to be introduced cases rather than imported relapsing cases. The last case with onset of fever on 17 June 1996 was detected and isolated on 19 July 1996.

Epidemiological and entomological surveillance continued at Dairy Farm, and two of the foreign workers with malaria in June 1996 were found to have a clinical relapse on 18 January and 13 February 1997, respectively. Both had been treated with chloroquine (1500 mg over 48 hours) in hospital but defaulted on the two-week follow-up medication with primaquine (15 mg daily). In January 1997, relapsing vivax malaria was identified in another foreign worker. Close enquiry showed that he had been investigated for fever in June 1996 but his blood films were repeatedly negative for malarial parasites. He developed fever again on 20 January 1997 and was confirmed to have *Plasmodium vivax* infection on 28 January 1997. No *Anopheles* breedings were detected in the area.

From this episode, we identified three challenges to the prevention of reintroduction of malaria into Singapore posed by foreign workers with relapsing vivax malaria. Firstly, while all work permit applicants are required to be clinically examined for evidence of malaria and a blood test carried out in those with enlarged liver or spleen, the pick-up rate for malarial parasites in the absence of symptoms is extremely low at around 0.1%.⁴³ It was noted that five cases in this outbreak had been screened earlier in May 1996 but found to be negative. Four of the cases underwent six to thirteen consecutive blood tests before malarial parasites were finally detected, indicating that a single blood film collection might not result in any detection of malarial parasites. Secondly, the practice of lodging foreign workers en masse in poor-quality rural accommodation, and the development of Singapore's forested land reserves, may lead to the increasingly frequent juxtaposition of potential human reservoirs of malaria and potential breeding sites of anopheline vectors. There is also a high degree of mobility among these workers who may be staying or working in malaria-receptive areas because they are usually deployed by their employers on day-to-day projects scattered throughout the island. Finally, as these workers are only paid for the work done, they have limited access to healthcare services and tend not to report sickness unless seriously ill. By that time, transmission would have already occurred. The failure of two of the workers to complete treatment with primaquine also pointed to an undesirable socio-economic environment that may affect compliance with medication in this group of patients.

The risk of malaria transmission in our highly susceptible population following introduction of an imported case into malaria-receptive areas cannot be underestimated.²⁵ Previously malaria-free areas in the USA such as New Jersey and New York City had also reported local transmission.^{33,34} A high degree of vigilance over the disease and vector situation remains the key to the prevention and control of malaria in Singapore. Medical

practitioners should exclude malaria in any febrile patient who has recently been to a malarious country. Besides investigating those with fever where there is no discernible cause or with prolonged fever, especially soon after arrival in Singapore, they should always consider malaria in the differential diagnosis of all foreign workers presenting with fever. Cases detected should be promptly notified. Any case of malaria which cannot be readily classified as imported will be treated as locally acquired and acted upon promptly to prevent further transmission of infection.

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