Malaria in Pregnancy in the Solomon Islands: Barriers to Prevention and Control

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Abstract. A study of malaria in pregnancy (MIP) was undertaken in Marovo Lagoon, Solomon Islands, to evaluate pregnancy-specific control strategies for malaria. Peripheral parasitemia was present in 18% (19/106) of women: 15 Plasmodium falciparum and 4 P. vivax. Primigravidae were twice as likely to be parasitemic as multigravidae (31% versus 14%; relative risk: 2.24; 95% confidence interval: 1.01–4.96; P = 0.05). Although ante-natal clinic attendance was high, women booked late (mean, 19.7 weeks) and attended irregularly. Free insecticide-treated nets (ITN) were not distributed despite government policy. Primigravidae were less likely to have an ITN in their homes than multigravidae (relative risk: 2.13; 95% confidence interval: 1.03–4.40). Coverage with chloroquine prophylaxis was low. This study revealed barriers to control of MIP at both the health service and client level. To develop an evidence-based malaria control policy in pregnancy for this region, further study of the epidemiology of malaria and its effects, including social and behavioral aspects, is needed.

INTRODUCTION

The risk that malaria poses to the pregnant woman and her infant is significant. The effects of malaria in pregnancy (MIP) depend on the immunity of the mother. The adverse effects for immune women are mainly anemia and infant low birthweight. In semi- or non-immune women, the risk of maternal morbidity and mortality, preterm delivery, abortion, and stillbirth are increased.1 Research studies on malaria in pregnancy in malaria-endemic countries have largely focused on sub-Saharan Africa, where the burden of falciparum malaria is high. Relatively few studies of malaria in pregnancy have been undertaken in the malaria-endemic countries of the southwest Pacific region, including Papua New Guinea (PNG), Vanuatu, and Solomon Islands, areas where Plasmodium falciparum and P. vivax are co-endemic. Studies conducted in this region have predominantly been undertaken in PNG, in locations with a high burden of falciparum malaria, where the effects of malaria in pregnancy have been observed to parallel those observed in sub-Saharan Africa.2–5 For example, it is estimated that in malaria-endemic areas of PNG, 40% of cases of low birthweight in babies may be attributed to malaria. Furthermore, the level of maternal anemia has been shown to be higher in malaria-endemic areas compared with non-endemic areas of PNG.6

In Solomon Islands, where malaria transmission varies,7–11 few data are routinely collected regarding malaria in pregnancy, and research has been minimal. Maternal and placental P. falciparum and P. vivax infection has been reported,12,13 as has an association between malaria control through residual spraying and increased mean birth weights.7 Available data indicate that the prevalence of malaria infection in pregnancy varies between 4% and 24% in different regions in the Solomon Islands.

Recommended control strategies for malaria in pregnancy in areas where malaria is endemic include effective case management of clinical episodes of malaria, the use of insecticide-treated nets (ITNs), and intermittent preventative treatment (IPT).14 In many settings, ante-natal services are seen as the mechanism to deliver these interventions.15 In relatively few studies has the appropriateness of the ante-natal clinic to provide this service been explored. Furthermore, it is important that such studies be conducted in different cultural settings.

Because of the lack of information surrounding malaria and malaria control in pregnancy in the Solomon Islands, an observational study was undertaken in Marovo Lagoon, Western Province. The study objectives were to measure the prevalence of malaria infection in pregnant women, to evaluate the implementation of current control strategies for malaria in pregnancy, and to describe the knowledge, attitudes, and practices associated with malaria control during pregnancy.

MATERIALS AND METHODS

Study area. An observational mixed method study was carried out from January to March 2003, in the catchment area of five health clinics in the isolated area of Marovo Lagoon, Western Province, Solomon Islands. The population numbers 14,000,16 living in 40 small villages along the coastal area of volcanic islands and on small atolls within or fringing the lagoon. Although no transmission studies have been carried out in this area, cases of falciparum and vivax malaria occur year round in the study site in all age groups, with a peak in the wet season (January to May). For 2003, this region had a reported incidence of microscopically diagnosed malaria cases of 300/1,000 population (36.5% P. falciparum) (L. Honiola, Chief Monitoring Officer, Vector Bourne Disease Control Program, personal communication). Pooled non-random active case detection data for 2000 to 2002 for Western Province showed parasite rates of 7.5% (57.8% P. falciparum) for the wet season (January to May) and 7.4% (40.2% P. falciparum) for the dry season (August to November)17; no specific rates for infants or children were reported. Pregnant women can attend an ante-natal clinic (ANC) at all clinics in the area. The recommended schedule is 15 visits from 8 weeks of gestation until delivery; the frequency of visits varies according to gestation.

Qualitative data collection and analysis. Five semi-structured interviews (SSIs), four with antenatal clinic nurses
and one with a malaria field officer, provided information about health services, the study site, and women’s groups in this area. Two focus group discussions (FGDs) were held with women to obtain information on women’s views and knowledge about risks in pregnancy. In each of the five study clinics, unstructured observations of the health service were made. Informal interviews and opportunistic discussions were held with health staff, users of the health facilities, and village women. Data and notes from SSI and FGD were translated from Solomon Islands Pidgin or Maro’o to English by the researcher who had undertaken the interview (MT or BA). Transcripts were analyzed for responses to pre-set topics. Information derived from these interviews was also used to develop the structured questionnaire.

**Cross-sectional study of pregnant women.** A cross-sectional study was carried out with pregnant women from the study site. Using data extrapolated from the 1999 census, it was estimated that 281 births would occur in the study site. With 211 (281 \times 9/12) women pregnant at any one time, and assuming women will only make themselves known to us as pregnant after 2 months of pregnancy, our population is 164 women. A random sample of 61 pregnant women would be required to detect a prevalence of malaria between 12% and 20% with 80% power and within a 95% confidence interval (CI).

We aimed to recruit all pregnant women in the site. Recruitment was carried out through the health service and through community contact. On enrollment into the study, thick and thin blood films and filter paper blood samples were collected by finger prick from all women using standard methods. Women with malaria parasitemia were offered treatment through the health service. Slides were examined in a blinded fashion a second time by a different microscopist. Slides with conflicting results were examined by a third microscopist. Parasite density was determined per 200 white blood cells (WBCs), assuming 8,000 WBCs per microliter of blood. Those who had been enrolled before their interview had a second blood slide taken on the day of interview.

A structured questionnaire (SQ) was used to collect information on personal demographics; malaria knowledge, including protection against and prevention of malaria; use of medicine during pregnancy; use of health service, health problems during pregnancy; antenatal care; past pregnancies and their outcomes; and episodes of malaria confirmed by blood slide examination and anemia in the current pregnancy. The obstetric history of the current pregnancy of study subjects, including ante-natal attendance and anemia status, were obtained from clinic records. Urine specimens were obtained from each woman on the day of interview and stored in an ice chest until tested for chloroquine using an immunochromatographic dipstick.

Parasite DNA was extracted from the filter paper blood samples using Chelex-100. A \( pfcr \) fragment flanking codons 72, 74, 75, and 76 was amplified using primers D1/D3 and sequenced. Sequence chromatograms were read to determine whether parasites carried a chloroquine susceptible wild-type \( pfcr \) or chloroquine-resistant mutant \( pfcr \).

**Statistical analyses.** All data from the SQs, antenatal and delivery records, and malaria and chloroquine analyses were double entered into Epi-Info Version 6 (Centers for Disease Control, Atlanta, GA). Relative risk (RR) with CIs and \( \chi^2 \) tests were used to test for differences in proportions. Differences in means were tested using the Student \( t \) test for normally distributed data and the Wilcoxon rank sum test for data that was not normally distributed. Results for SSIs and FGDs were analyzed against topics. Qualitative and quantitative data were analyzed separately and then combined.

**Ethics.** Ethical approval was obtained from the Human Ethics Committee of The University of Queensland and from the National Health Research Ethics Committee, Solomon Islands. Permission to carry out the study was obtained from national, provincial, and local health authorities and community leaders. Informed consent was obtained from all participants. Witnessed consent was gained from all illiterate participants, and parental or legal guardian consent was gained for all participants under the age of 18 years.

**RESULTS**

A total of 128 pregnant women were enrolled into the cross-sectional study. Twenty-two were not available at the time of interview. Of the 106 interviewed, the mean age of the study cohort was 26.7 years (range, 15–41 years); 2 women did not know their ages (Table 1, Figure 1). The average parity was 2.2, with 40% of women in their first or second pregnancies and one in her eighth pregnancy. All women, except one, had some primary education; most (75/106; 71%) had no secondary education. At the time of administration of the questionnaire, 14 (13%) women had delivered; 1 miscarriage occurred at 3 months of gestation. At the time of the miscarriage, the mother had clinical and parasitologically confirmed P. falciparum infection. One delivery was premature and one ended in neonatal death at Day 1. Neither were attributed to malaria by the clinic nurse.

Two focus groups were held, each from a different women’s church group: one consisted of six women and the other of seven. The average age was 39 years (range, 25–58 years), and average parity was 4.1 (range, 1–7). Seven (56%) had primary education; six (46%) had some secondary education.

**Malaria prevalence and incidence.** Among the 106 subjects, 19 (18%) women had malaria parasites present on blood film at enrollment: 15 (14.8%) had P. falciparum and 4 (3.8%) had P. vivax (Figure 2). Subsequent polymerase chain reaction (PCR) analysis showed that three of the four vivax cases were co-infected with P. falciparum (Table 2, Subjects 8, 10, and 17). These cases were the only cases reported by nurses to be symptomatic. The geometric mean parasite density among the microscopically diagnosed P. falciparum–positive slides was 506/μL.
blood (range, 400–720 μL). The prevalence of both malaria parasitemia and *P. falciparum* parasitemia was >2-fold higher among primigravidae than among multigravidae (malaria: 8/26 [31%] versus 11/80 [14%]; RR: 2.24; 95% CI: 1.01–4.96; *P* = 0.05; *P. falciparum*: 7/26 [27%] versus 8/80 [10%]; RR: 2.69; 95% CI: 1.08–6.71; *P* = 0.03).

Of participants that were positive for parasites, 4 (19%) had a wild-type *pfcrt*, 16 (76%) had mutant (CQ-resistant) *pfcrt*, and 1 had a mixture of wild-type and mutant *pfcrt* (Table 2). All parasitemic primigravidae that were PCR positive for *pfcrt* (*N* = 6) were infected with mutant strains. Six of 10 parasitemic multigravidae women were infected with a *pfcrt* mutant strain. In addition, among five slides microscopically negative for *P. falciparum*, three tested positive for *pfcrt*: one mutant and two wildtype. Two mutations were observed in the *pfcrt* fragment, resulting in changes C72S and K76T. The mutation pattern is identical to that observed in parasites from PNG.

Among the 106 current pregnancies, encompassing 625 months of pregnancy, 39 cases of symptomatic malaria were reported by the mother as having been confirmed by blood film examination, giving an incidence of 0.71 cases/person-year. The species reported were 24/36 (67%) *P. falciparum* and 12/36 (33%) *P. vivax*.

**Ante-natal service.** Of the 28 women who were yet to attend ANC, the reported gestation was between 8 and 26 weeks (mean, 15.6 weeks). Of these women, 21 (75%) reported that it was not yet time to attend. Others reported they had forgotten (*N* = 1), or were attending boarding school (*N* = 1). However, 62/66 (93.9%) women had started attending ANC before the third trimester. The four nurses interviewed reported universal attendance of ANC among pregnant women. However, they reported that most women did not attend early enough during gestation or frequently enough.

Of the 17 women who had delivered, the average number of ANC visits was 5.9 (range, 1–11). Fourteen (82%) of these had made five or more ANC visits during their pregnancy. Of 40 women in their third trimester and whose health cards were available, 35 (87.5%) had visited ANC at least twice. When attendances were compared with guidelines, 45/70 (64%) of women had made 50% or less than the recommended number of ANC visits (Table 1). No difference was observed in ANC attendance between primigravidae and multigravidae.

Of women who had previously attended ANC, 38/77 (49%) reported they had received health education at their first ANC visit, but malaria was discussed with only 2 (2.6%). Nurses at one clinic stated that health education was not usually carried out because there was insufficient time to cover all required topics. Nurses reported that many women rush their ANC visit as they had “many things to do” on their visit to the village or that transport was waiting for them. Nurses also stated that they were understaffed. These comments were supported by informal observations at two clinics.

All four nurses viewed malaria as the most common health problem that pregnant women faced. SQ respondents graded the problem of malaria during pregnancy compared with when not pregnant as follows: 45/100 (45%) less of a problem, 31/100 (31%) a bigger problem, and 24/100 (24%) the same.

**Control and treatment of malaria in pregnancy.** All four nurses identified CQ prophylaxis, bed nets, and education as strategies for controlling malaria in pregnant women. Nurses in clinics with a microscopist stated that they would take a blood film for diagnosis only after a history of illness and physical examination of the patient had been completed and other causes of illness ruled out. If a microscopist was not available, presumptive treatment was given based on a clinical diagnosis.

Nurses reported that case management of malaria in pregnancy was guided by Reproductive Health Division guidelines, the Standard Adult Treatment Book, advice from senior nurses, the Vector Borne Disease Control Program, and doctors. However, these guidelines were not consistent. Malaria treatment regimens used in pregnancy in the site varied; all four nurses gave presumptive CQ treatment of suspected falciparum or vivax malaria when there was no microscopist. However, one would only give CQ up to 20 weeks of gestation, after which she would admit and treat with quinine. Two nurses also treated pregnant women with quinine and sulfadoxine-pyrimethamine (SP), but would not give SP after 12 weeks of gestation.

### Table 1

**ANC attendances and age, parity, and gestation at first visit**

<table>
<thead>
<tr>
<th>ANC attendance</th>
<th>Number of respondents (%)</th>
<th>Mean age in years (range)</th>
<th>Mean gravidity (range)</th>
<th>Weeks gestation at first ANC visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>None at time of interview</td>
<td>28/106 (26)</td>
<td>27.1 (15–40)</td>
<td>3.5 (1–7)</td>
<td>–</td>
</tr>
<tr>
<td>Previous</td>
<td>78/106 (74)</td>
<td>26.5 (16–41)</td>
<td>3.1 (1–8)</td>
<td>19.7 (10–34)</td>
</tr>
<tr>
<td>≥ 50% the recommended number</td>
<td>45/70 (64)</td>
<td>27.2 (17–39)</td>
<td>3.4 (1–8)</td>
<td>20.6 (10–34)</td>
</tr>
<tr>
<td>&gt; 50% the recommended number</td>
<td>25/70 (36)</td>
<td>25.9 (16–41)</td>
<td>2.9 (1–7)</td>
<td>18.3 (10–25)</td>
</tr>
</tbody>
</table>
have bed nets in their houses compared with primigravidae (RR: 2.13; 95% CI: 1.03–4.40). Among those who had bed nets in their house, 51/84 (61%) reported having used bed nets the night before the interview. The most common reasons reported for not using ITNs (with multiple responses allowed) were as follows: they were too hot (14/31; 45%); they did not want to use them or could not be bothered (9/31; 29%); and they were claustrophobic (6/31; 19%). No significant association was observed between presence of bed nets, sufficient bed nets in homes, or use of bed nets and parasitemia (data not shown). Among pregnant women who had bed nets, 50/84 (62%) reported having washed their nets an average of 36 times (range, 1–78) per year (3 times/mo). Most (60/76; 79%) bed nets had not been retreated within the last 6 months.

ITNs were available for sale only through the malaria officers at Seghe, a 10-minute walk from the Seghe clinic. Two nurses from other clinics had not received bed nets from the malaria control program since 1995. No stores in the study area sold bed nets during the period of the study. Although the malaria field officer commented that the current national policy for malaria control for pregnant women was the provision of free bed nets, he stated that he had not distributed nets because he had not been given authority to do so.

**CQ chemoprophylaxis.** Most of the women (74/78; 95%) reported being prescribed prophylactic CQ at their first ANC visit. In both FGDs, women identified CQ as a means of protection against malaria. However, there was confusion over whether CQ was given for prophylaxis or treatment. Seven of 106 questionnaire respondents were similarly confused about the treatment and prophylactic uses of CQ. One focus group reported that women take one half the required prophylaxis dose because of side effects.

Thirty-one of 106 (29%) interview respondents reported that they would not take CQ during pregnancy because of side effects (11/31; 36%), such as nausea or bitter taste (5/31; 16%). One woman reported that she would not take CQ because someone had told her that it damages the fetus. In informal discussions in three villages, village women commented that pregnant women were not taking CQ prophylaxis. A mother of one respondent asked why her daughter should be taking CQ every week because neither mother nor daughter knew the reason.

Of the women who had previously attended an ANC, 51/74 (69%) reported that they took CQ prophylaxis always, 11/74 (15%) said sometimes, and 7/74 (9%) said never during the current pregnancy. The reasons given by women who took prophylaxis sometimes instead of always included that they forgot (5/11; 45%) or it caused side effects (4/11; 36%), such as nausea or bitter taste (5/11; 16%). One woman reported that she would not take CQ because someone had told her that it damages the fetus. In informal discussions in three villages, village women commented that pregnant women were not taking CQ prophylaxis. A mother of one respondent asked why her daughter should be taking CQ every week because neither mother nor daughter knew the reason.

Two nurses commented that provision of malaria chemoprophylaxis to women with information about its use was standard procedure for all women attending ante-natal care. When asked whether women comply with CQ prophylaxis, two ANC nurses responded that most women do not comply, and the third felt that only some comply. Although the nurses reported that the women forget, another nurse stated that this was an excuse and “they just do not want to take it.” Chloroquine was not detected in the urine of two of nine women who had reported that they had taken a prophylactic dose of chloroquine within the last week.

**DISCUSSION**

Here we show, for the first time for Solomon Islands, that the prevalence of malaria infection in primigravidae (31%) is
twice as high as in multigravidae (14%). In a study carried out in PNG, in an area of high transmission, the prevalence of malaria was high among both primi- and secundigravidae, at 40.6% and 33.9%, respectively, compared with 22.8% among multigravidae.23 In this study, after taking into account the PCR results, all except one woman with malaria had falciparum infection. The prevalence of infection is significantly higher than that documented in mass blood survey incidence data, a finding that mirrors that observed in Brazil.16,24,25

Compared with \textit{P. falciparum}, relatively less research has been undertaken on the effect of \textit{P. vivax} infection on pregnancy. In a study undertaken in a meso-endemic refugee setting,26 \textit{P. vivax} infection was associated with mild maternal anemia and an increased risk of low birth weight. Given that \textit{P. vivax} is endemic in Solomon Islands and accounted for 4/19 (21%) of the cases of malaria in our study, further research into the effects of \textit{P. vivax} in settings with a range of endemicity is required.

Findings here indicate high ante-natal coverage, mirroring national census data and health activity reports.27 A number of impediments to malaria control were identified in the ANC setting. These include understaffing, late and infrequent attendance, little knowledge of the risk of MIP, little counseling on malaria and malaria in pregnancy, and lack of case management guidelines for pregnancy.

Although ITNs remain the mainstay of the SI Vector Borne Disease Program, three other issues indicate ITNs must be complemented with other methods of protection against malaria for pregnant women. First, the only vector for malaria transmission in Western Province, \textit{Anopheles farauti}, has its peak biting period in the early evenings28,29 when ITNs are not in use. Second, the nets in use in the study site were washed frequently, without the required insecticide retreatment. The use of commercially available bed nets where the insecticide is incorporated during manufacture and is more resistant to washing, such as the PermaNet or OlysetNet, would help overcome the problem caused by frequent washing. Third, ITN ownership and use was low in the study site. Of significance, nulliparous women, at greatest risk of infection, were significantly less likely to own ITNs. Despite national guidelines mandating free ITNs distribution to pregnant women, this policy was not being implemented. Yohannes and others30 reported, in a study in Malaita province, that younger children were considered vulnerable to malaria and thus given priority in bed net use. Perhaps this accounts in part for the lack of bed nets in the houses of nulliparous women in this study.

At the time of this study, CQ prophylaxis was being prescribed at ANC for protection against malaria for pregnant women. Our findings of late and irregular ANC attendance, and conflicting data on chloroquine use, suggests that coverage with a complete regimen of CQ prophylaxis during pregnancy is very low in this site. Furthermore, our and other data (Genton and others, unpublished data) indicate high prevalence of the \textit{pfcrt} mutation in \textit{P. falciparum} that confers chloroquine resistance. Although CQ prophylaxis has been shown to reduce the frequency of \textit{P. vivax} relapses during pregnancy,31 the prevalence of CQ-resistant \textit{P. vivax} is increasing across Melanesia.32 Given the high ANC use in the Solomon Islands, IPT using SP may be a cost-effective intervention, especially among primigravidae. With varying transmission levels, and high levels of \textit{P. vivax} in the Solomon Islands, the introduction of IPTp with SP will require further study to define its efficacy.

The effects of MIP in malaria-endemic areas are well documented. Although this study is small and the relevance of its findings outside the study site may be limited, it showed a number of barriers to malaria control in pregnancy and highlighted gaps in malaria control policy in the Solomon Islands. With only partial protection using bed nets, in the setting of low efficacy of CQ prophylaxis (chloroquine resistance and low coverage) and low knowledge of MIP risk, pregnant women at this site are poorly protected against malaria infection. Existing control strategies are not being appropriately implemented, and other appropriate malaria intervention strategies have not been introduced. A single policy may not be suitable in a country with varying intensities of transmission such as the Solomon Islands, and the challenge is to define the most appropriate interventions for different regions. Further study into the burden and the social and behavioral aspects of malaria in pregnancy in Solomon Islands is needed for the development of an evidence-based treatment and control policy specifically for pregnant women to reduce the impact of malaria on pregnant women and their infants.

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