Changing Malaria Epidemiology in Four Urban Settings in Sub-Saharan Africa

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I have always loved the desert. One sits down on a desert sand dune, sees nothing, hears nothing. Yet through the silence something throbs, and gleams…

"What makes the desert beautiful," said the little prince, "is that somewhere it hides a well…"

SUMMARY

Background

An estimated 200 million persons in sub-Saharan Africa (SSA) live currently in urban centres in malaria endemic areas. The epidemiology and control of urban malaria poses a number of specific challenges in comparison to rural areas, most notably the heterogeneous spatial distribution of transmission and the low state of immunity in the population. Interestingly, much less is currently known about malaria in urban settings than in rural areas. As a result there is an essential need for more information on disease burden, distribution and control strategies. In this multi-country study we undertook to study systematically key malariological features in four large SSA cities: Abidjan (Côte d'Ivoire), Ouagadougou (Burkina Faso), Cotonou (Benin) and Dar es Salaam (United Republic of Tanzania).

Objectives

The general objective of this series of case studies was to further our understanding of malaria transmission and epidemiology in the urban environment in SSA, in view of developing and implementing effective control measures.

Study methodology

The basic study design of RUMA in each site included six components: 1) An extensive literature review and contacts with national malaria experts, 2) The collection of routine health statistics, disaggregated by sex, age and residence, 3) The mapping of health facilities and the identification of the main breeding sites on the basis of existing maps, 4) School parasitaemia surveys (200 school children aged 5-10 years in 3-4 schools, 5) Health facility-based fever surveys (200 fever cases and 200 non-fever controls in 3-4 facilities) and 6) A systematic description of the health care delivery system. For components 4 and 5 we categorized each city into 3-4 areas (centre, intermediate, periphery and rural areas), and randomly chose one clinic and one nearby school from each area. All work was completed within six to ten weeks on-site.

The main emphasis was put on describing the burden of malaria (components 1, 2, 4), transmission patterns (components 1, 2, 3, 4) and the diagnosis of malaria in urban settings (component 5, 6). Finally, key risk factors for infection were explored (components 4 and 5).

Key results

Abidjan: The field work was carried out in August-September 2002 during the rainy season. According to national statistics, approximately 240,000 malaria cases were reported by health facilities in Abidjan in 2001 (40.2% of all consultations). The peak malaria incidence was in July-September. In the health facilities of the Yopougon commune, the malaria infection rates in presenting fever cases were 22.1% (under 1 year-old), 42.8% (1-5 years-old), 42.0% (6-15 years-old) and 26.8% (over 15 years-old), while those in the control group were 13.0%, 26.7%, 21.8% and 14.6%. Malaria prevalence in health facilities was homogenous in the different areas of Yopougon. The malaria-attributable fractions (MAFs) among presenting fever cases were 0.12, 0.22, 0.27 and 0.13 for the age groups listed above, suggesting that malaria played only a low to moderate role in fever episodes during the rainy season.

Among all patients, 10.1% used a mosquito net (treated or not) the night before the survey and this was protective (OR=0.52, 95% CI 0.29-0.97). Travel to rural areas within the last three months was frequent (31% of all respondents) and associated with a malaria infection (OR=1.75, 95% CI 1.25-2.45). The health facility and breeding site mapping, as well as the school surveys could not be carried out because of political troubles.

Ouagadougou: The field work was carried out in November-December 2002 at the start of cold and dry season. Seasonal variations in reported clinical malaria cases were marked. The highest incidence rate was reported from July to September and incidence rates went down in October-December until a low point during the dry season, from January to March. In 2001, there were 203,466 simple malaria cases (29.3-41.4% of consultations) and 19 deaths reported among 596,365 consultations in all public health facilities. A further 20,071 complicated malaria cases were reported.

The malaria infection rates in presenting fever cases were 12.1% (under 1 year-old), 25.9% (1-5 years-old), 37.1% (6-15 years-old) and 18.0% (over 15 years-old), while those in the control group were 14.3%, 14.4%, 34.5% and 19.8%. The MAFs among presenting fever cases were 0.00, 0.13, 0.04 and 0.00 for the age groups cited above, suggesting that malaria played only a small role in fever episodes at the start of cold and dry season. The school parasitaemia prevalence was rather high (overall: 48.3%) and there was heterogeneity between the 3 surveyed schools (31.6%, 37.6%, 73.1%). The mapping of *Anopheles* sp. breeding sites correlated with this gradient of endemicity between the urban centre and the periphery of Ouagadougou. We found a link between malaria infections and urban agriculture activities and the availability of water supply. In total 42.0% of patients used a mosquito net the night before the survey and this was protective (OR=0.74, 95% CI 0.54-1.00). Travelling to a rural area (8.7% of all respondents) did not increase the infection risk (OR=1.14, 95% CI 0.70-1.90).

Cotonou: The field work was carried out in February-March 2003. In 2002, there were 100,257 reported simple malaria cases and 12,195 complicated malaria cases reported for 289,342 consultations in the public health facilities of Cotonou. Between 1996 and 2002, on average 34% of total consultations were attributed to simple malaria and 1-4.2% to complicated malaria cases. There was no clear seasonal pattern.

The malaria infection rates in presenting fever cases were 0% (under 1 year-old), 6.8% (1-5 years-old), 0% (6-15 years-old) and 0.9% (over 15 years-old), while those in the control group were 1.4%, 2.8%, 1.3% and 2.0%. The MAFs among presenting fever cases were 0.04 in the 1-5 years-old and 0 in the over 15 years-old. MAFs could not be calculated for the other two age groups. Hence, malaria played only a small role in fever episodes at the end of the rainy season. In the school parasitaemia surveys, a malaria infection was found in 5.2 % of all samples. The prevalence of parasitaemia in the centre, intermediate and periphery areas was 2.6%, 9.0% and 2.5%, respectively. In total 69.2% of patients used a mosquito net the night before the survey (OR=0.61, not significant). Traveling to a rural area (5.8% of all respondents) did not increase the infection risk since none of those who had traveled had parasitaemia. No mapping of health facilities and breeding sites could be carried out.

Dar es Salaam: The field work was carried out in June-August 2003. An estimated 1.1 million annual malaria cases were reported in 2000 from a total of 2,200,000 outpatient visits in the health facilities (49% of all consultations). A clear seasonal pattern of clinical malaria was recorded, with high rates from March to June and a low point in July-August.

The malaria infection rates in presenting fever cases were 2.0 % (under 1 year-old), 7.0% (1-5 years-old), 7.2 (6-15 years-old) and 4.2 % (over 15 years-old), while those in the control group were 3.4%, 4.5%, 3.6% and 1.9%. The MAFs were very low in all age groups: 0.00, 0.03, 0.04 and 0.02 for the age categories shown above. School surveys in Dar es Salaam during a prolonged dry season in 2003 showed that the prevalence of malaria parasites was low: 0.8%, 1.4%, 2.7% and 3.7% in the centre, intermediate, periphery and rural areas, respectively. *Anopheles sp*. breeding sites were fairly well distributed within the city. We found a remarkably high coverage rate of mosquito nets in the households (91.8% users) and this seemed to be protective (OR=0.60, 95% CI

0.27-0.93). An increased malaria infection rate was seen in the 11.8% of children who traveled to rural areas within last 3 month (OR=3.62, 95% CI 1.48-8.88).

Conclusion

RUMA was successfully implemented in 4 selected urban areas within a period of six to ten weeks per site. The financial cost for conducting a RUMA in these four sites ranged from 8,500-13,000 USD. All components were feasible (with the exception of breeding site mapping which clearly exceeded what can be done in such a short time period) and highly informative. The RUMA allowed to describe transmission patterns in the four cities and highlighted the enormous level of over-treatment with antimalarials. The collected information should prove of high value as a basis for further investigations and for planning effective control interventions.

ZUSAMMENFASSUNG

Hintergrund

Zurzeit leben in urbanen Zentren in sub-Sahara Afrika (SSA) 200 Millionen Menschen in endemischen Gebieten der Malaria. Im Vergleich zur Malaria in ländlichen Gebieten stellt die Epidemiologie und Kontrolle der urbanen Malaria eine Anzahl spezifischer Herausforderungen, vor allem in Bezug auf die heterogene räumliche Verteilung der Übertragung, und dem tiefen Immunstatus der Bevölkerung. Interessanterweise ist viel weniger bekannt über Malaria in urbanen als in ländlichen Gebieten. Deshalb existiert ein essentielles Bedürfnis für mehr Informationen betreffend Krankheitsbürde, Verteilung und Kontrollstrategien. In dieser Mehrländerstudie haben wir systematisch die Schlüsselfaktoren für Malaria in 4 grossen SSA Städten untersucht: Abidjan (Côte d'Ivoire), Ouagadougou (Burkina Faso), Cotonou (Benin) und Dar es Salaam (Tansania).

Zielsetzungen

Das Hauptziel dieser Serie von Fallstudien war die Erweiterung unseres Wissens über die Ubertragung und Epidemiologie von Malaria in urbanen Gebieten in SSA in Hinsicht auf die Entwicklung und Implementierung effektiver Kontrollmassnahmen.

Methoden

Das grundlegende Studiendesign in jedem Studienort beinhaltete sechs Komponenten: 1) Eine ausgedehnte Literaturrecherche und Kontakte mit nationalen Malaria-Experten, 2) Das Sammeln von Routine-Gesundheitsstatistiken, aufgeschlüsselt nach Geschlecht, Alter und Wohnort, 3) Die Kartierung der Gesundheitseinrichtungen und die Identifizierung der wichtigsten Brutplätze von *Anopheles* sp.*,* basierend auf existierenden Karten, 4) Die Untersuchung der Parasitendichte in Schulen (200 Schulkinder im Alter von 6-10 Jahren in 3-4 Schulen), 5) Die Untersuchung von Fieberfällen in Gesundheitseinrichtungen (200 Fieberfälle und 200 Nicht-Fieberfälle in 3-4

Einrichtungen), und 6) Eine systematische Beschreibung des Gesundheitsversorgungssystems. Für die Komponenten 4 und 5 kategorisierten wir jede Stadt in 3-4 Zonen (Zentrum, Zwischenzone, Peripherie und ländliche Gebiete), und wählten zufällig in jedem Gebiet eine Klinik und eine nahe Schule aus. Alle Arbeiten vor Ort wurden innerhalb von 6-10 Wochen durchgeführt.

Das Hauptaugenmerk der Studie richtete sich auf die Beschreibung der Malariabürde (Komponenten 1, 2 und 4), der Übertragungsmuster (Komponenten 1, 2, 3, 4) und der Diagnose von Malaria im urbanen Umfeld (Komponenten 5 und 6). Des Weiteren wurden Schlüsselrisikofaktoren für Infektionen mit Malaria untersucht (Komponenten 4 und 5).

Resultate

Abidjan: Die Feldarbeit wurde in August und September 2002 während der Regenzeit durchgeführt. Gemäss nationalen Statistiken meldeten Gesundheitseinrichtungen in Abidjan in 2001 ungefähr 240'000 Malariafälle (40.2% aller Konsultationen). Die höchste Inzidenz von Malaria fand sich von Juli-September. In den Gesundheitseinrichtungen der Kommune Yopougon waren die Infektionsraten mit Malaria in Patienten mit Fieber 22.1% (unter 1 Jahr alt), 42.8% (1-5 Jahre alt), 42.0% (6-15 Jahre alt) und 26.8% (über 15 Jahre alt), während die Infektionsraten in den Kontrollgruppen 13.0%, 26.7%, 21.8% und 14.6% betrugen. Die Prävalenz von Malaria in den Gesundheitseinrichtungen der verschiedenen Gebiete von Yopougon war homogen verteilt. Der Malaria zurechenbare Anteile (Malaria attributable fractions MAFs) an Fieberfällen betrugen 0.12, 0.22, 0.27 und 0.13 für die oben aufgelisteten Altersgruppen, was darauf hindeutet, dass während der Regenzeit Malaria nur eine geringe bis moderate Rolle in Fieberanfällen spielte.

Von allen Patienten benützten in der Nacht vor der Untersuchung 10.1% ein Moskitonetz (behandelt oder unbehandelt). Moskitonetze hatten einen schützenden Effekt (OR=0.52, 95% CI 0.29-0.97). Reisen in ländliche Gebiete innerhalb der letzten drei Monate waren häufig (31% aller

Befragten) und stellten ein Infektionsrisiko dar (OR=1.75, 95% CI 1.25-2.45). Die Kartierung der Gesundheitseinrichtungen und der Brutplätze, sowie die Schuluntersuchungen, konnten wegen politischen Unruhen nicht durchgeführt werden.

Ouagadougou: Die Feldarbeit wurde in November und Dezember 2002 zu Beginn der kalten Trockenzeit durchgeführt. Jahreszeitliche Schwankungen in den gemeldeten klinischen Malariafällen waren beträchtlich. Die höchsten Inzidenzraten wurden von Juli bis September gemeldet, danach ging die Inzidenzrate von Oktober bis Dezember zurück und erreichte einen Tiefpunkt während der Trockenzeit von Januar bis März. In 2001 wurden von den öffentlichen Gesundheitseinrichtungen, mit insgesamt 596'365 Konsultationen, 203'466 einfache Malariafälle (29.3-41.4% aller Konsultationen) und 19 Todesfälle gemeldet. Des Weiteren wurden 20'071 schwere Malariafälle gemeldet.

Die Infektionsraten mit Malaria in Patienten mit Fieber waren 12.1% (unter 1 Jahr alt), 25.9% (1-5 Jahre alt), 37.1% (6-15 Jahre alt) und 18.0% (über 15 Jahre alt), während die Infektionsraten in den Kontrollgruppen 14.3%, 14.4%, 34.5% und 19.8% betrugen. Für die oben aufgelisteten Altersgruppen betrugen die MAFs an Fieberfällen 0.00, 0.13, 0.04 und 0.00, was darauf hindeutet, dass Malaria nur eine geringe Rolle in Fieberanfällen spielte. In den Schulen war die Parasitenprävalenz eher hoch (Gesamt: 48.3%), wobei eine Heterogenität zwischen den 3 untersuchten Schulen bestand (31.6%, 37.6%, 73.1%). Die Kartierung der Brutplätze von *Anopheles sp*. korrelierte mit diesem Gradient der Endemizität zwischen dem urbanen Zentrum und der Peripherie von Ouagadougou. Wir fanden eine Verbindung zwischen Malariainfektionen, urbanen landwirtschaftlichen Aktivitäten und dem Vorhandensein einer Wasserversorgung. Von allen Patienten benützten 42.0% ein Moskitonetz in der Nacht vor der Untersuchung. Moskitonetze hatten einen schützenden Effekt (OR=0.74, 95% CI 0.54-1.00). Reisen in ländliche Gebiete (8.7% aller Befragten) erhöhten nicht das Infektionsrisiko (OR=1.14, 95% CI 0.70-1.90).

Cotonou: Die Feldarbeit wurde in Februar und März 2003 durchgeführt. In 2002 wurden von den öffentlichen Gesundheitseinrichtungen in Cotonou von insgesamt 289'342 Konsultationen 100'257 als einfache Malariafälle und 12'195 als komplizierte Malariafälle gemeldet. Zwischen 1996 und 2002 wurden im Durchschnitt 34% aller Konsultationen einer einfachen Malaria und 1-4.2% einer komplizierten Malaria zugeschrieben. Es trat keine klare saisonale Verteilung auf.

Die Infektionsraten mit Malaria in Patienten mit Fieber waren 0% (unter 1 Jahr alt), 6.8% (1-5 Jahre alt), 0% (6-15 Jahre alt) und 0.9% (über 15 Jahre alt), während die Infektionsraten in den Kontrollgruppen 1.4%, 2.8%, 1.3% und 2.0% betrugen. Die MAFs an Fieberfällen betrugen 0.04 in der Gruppe der 1-5 Jährigen und 0 in der Gruppe der über 15 Jahre alten Patienten. Die MAFs für die anderen 2 Altersgruppen konnten nicht berechnet werden. Daraus lässt sich schliessen, dass gegen Ende der Regenzeit Malaria eine geringe Rolle in Fieberepisoden spielte. In den Untersuchungen an den Schulen wurde eine Malaria Infektion in 5.2% aller Proben nachgewiesen. Die Parasitenprävalenz im Zentrum, der Zwischenzone und der Peripherie der Stadt betrug 2.6%, 9.0%, respektive 2.5%. Von allen Patienten benützten 69.2% ein Moskitonetz in der Nacht vor der Untersuchung (OR=0.61, nicht signifikant). Reisen in ländliche Gebiete (5.8% aller Befragten) erhöhten nicht das Infektionsrisiko, da keine der gereisten Personen Parasiten aufwies. Eine Kartierung der Gesundheitseinrichtungen und der Brutplätze konnte nicht durchgeführt werden.

Dar es Salaam: Die Feldarbeit wurde von Juni bis August 2003 durchgeführt. In 2000 wurden von den total 2.2 Millionen ambulanten Patienten in den Gesundheitseinrichtungen geschätzte 1.1 Millionen als Malariafälle gemeldet (49% aller Konsultationen). Eine klare saisonale Verteilung von Fällen klinischer Malaria wurde beobachtet, mit den höchsten Raten von März bis Juni und den tiefsten Raten in Juli-August.

Die Infektionsraten mit Malaria in Patienten mit Fieber waren 2.0% (unter 1 Jahr alt), 7.0% (1-5

Jahre alt), 7.2% (6-15 Jahre alt) und 4.2% (über 15 Jahre alt), während die Infektionsraten in den Kontrollgruppen 3.4%, 4.5%, 3.6% und 1.9% betrugen. Die MAFs waren in allen Altersgruppen gering: 0.00, 0.03, 0.04 und 0.02 für die oben aufgelisteten Altersgruppen. Untersuchungen an Schulen in Dar es Salaam während einer ausgedehnten Trockenzeit in 2003 zeigten eine tiefe Prävalenz von Malaria: 0.8%, 1.4%, 2.7% und 3.7% im Zentrum, in der Zwischenzone, in der Peripherie respektive in den ländlichen Gebieten. *Anopheles sp*. Brutplätze waren relativ gleichmässig über die Stadt verteilt. Wir fanden eine bemerkenswert hohen Deckungsgrad mit Moskitonetzen in den Haushalten (91.8% Benützer), welche einen beschützenden Effekt hatten (OR=0.60, 95% CI 0.27-0.93). Eine erhöhte Infektionsrate mit Malaria wurde in den 11.8% der Kinder festgestellt, die während den letzten 3 Monaten in ländliche Gebiete gereist waren (OR=3.62, 95% CI 1.48-8.88).

Schlussfolgerungen

Die RUMA Methode (Rapid Urban Malaria Appraisal) wurde erfolgreich in 4 ausgewählten urbanen Gebieten innerhalb einer 6-10 wöchigen Periode pro Ort angewendet. Die finanziellen Aufwendungen für die Durchführung einer RUMA in diesen 4 Orten lagen zwischen 8'500 USD und 13'000 USD. Alle Komponenten waren machbar (mit Ausnahme der Kartierung von Brutplätzen, welche klar die Möglichkeiten, was in einer so kurzen Zeitspanne getan werden kann, überstieg) und sehr informativ. Die RUMA ermöglichte die Beschreibung von Übertragungsmustern in den 4 Städten und zeigte den enormen Anteil von Überbehandlungen mit Antimalariamitteln auf. Die gesammelten Informationen werden einen hohen Wert als Grundlage für weitere Untersuchungen und für die Planung von effektiven Kontrollmassnahmen aufweisen.

RESUME

Cadre de l'étude

Environ 200 millions de personnes en Afrique sub-Saharienne (ASS) vivent actuellement en milieux urbains d'endémie palustre. L'épidémiologie et la lutte contre le paludisme en milieu urbain pose un certain nombre de défis spécifiques par rapport aux zones rurales, notamment l'hétérogénéité de la distribution spatiale de la transmission, et le faible état immunitaire de la population. Le paludisme urbain est actuellement beaucoup moins connu que le paludisime rural. Par conséquent il y a un besoin crucial de plus d'information sur le poids de la maladie, sa distribution et les stratégies de lutte appropriées. Dans cette étude nous entreprenons d'étudier systématiquement les principaux paramètres paludologiques dans quatre grandes villes de l'ASS: Abidjan (Côte d'Ivoire), Ouagadougou (Burkina Faso), Cotonou (Bénin) et Dar es Salaam (Tanzanie).

Objectifs

L'objectif général de cette série d'études était d'accroître nos connaissances sur la transmission et l'épidémiologie du paludisme en milieu urbain en ASS, en vue de développer et de mettre en œuvre des mesures de lutte efficaces.

Méthodologie

La conception de base de l'étude dans chaque site comprenait six composantes : 1) une revue extensive de la littérature et des prises de contacts avec les experts nationaux, 2) la collecte des statistiques de routine de santé par sexe, âge et résidence, 3) la cartographie des centres de santé et l'identification et localisation des gîtes larvaires sur la base des cartes existantes, 4) mener des enquêtes de prévalence parasitaire dans les école (200 écoliers âgés de 6-10 ans dans 3-4 écoles), 5) mener des études de cas de fièvre dans les centres de santé (200 cas de fièvre et 200 cas sans fièvre dans 3-4 centres de santé), et 6) la description systématique des systèmes de soins. Pour les composantes 4 et 5 nous avons divisé chaque ville en 3-4 zones (centre, intermédiaire, périphérie et rural), et avons aléatoirement choisi par zone une clinique et une école voisine dans chaque zone. Tous les travaux ont été effectués sur place dans un délai de 6-10 semaines.

L'accent a été mis sur la description du poids de la malaria (composantes 1, 2, 4), son mode de transmission (composantes 1, 2, 3, 4) le diagnostic en milieu urbain (composantes 5, 6). Finalement, des facteurs clés de risque pour l'infection ont été explorés (composantes 4 et 5).

Résultats

***Abidjan**:* Les travaux de terrain ont été menés d'août à septembre 2002, pendant la saison des pluies. Selon les statistiques nationales, environ 240,000 cas de paludisme ont été rapportés par les centres de santé à Abidjan en 2001 (40% des consultations totales). Le pic de l'incidence palustre avait lieu en juillet - septembre. Dans les centres de santé de la commune de Yopougon, les taux d'infection du paludisme chez les enfants présentant de la fièvre étaient de 22.1% (chez les moins de 1 an), 42.8% (1-5 ans), 42.0% (6-15 ans) et 26.8% (plus de 15 ans), alors qu'ils étaient de 13.0%, 26.7%, 21.8% et 14.6% dans le groupe témoin. La prévalence du paludisme dans les centres de santé était homogène dans les différents zones de Yopougon. Les fractions attribuables au paludisme (FAPs) parmi les cas de fièvre étaient de 0.12, 0.22, 0.27 et 0.13 respectivement pour les catégories d'âge énumérées ci-dessus, suggérant que le paludisme n'a joué qu'un rôle faible à modéré dans les épisodes de fièvre pendant la saison des pluies.

Parmi tous les patients, 10.1% ont utilisé des moustiquaires (imprégnées ou non) la veille de l'enquête, et ceci était protecteur (OR=0.52, IC à 95% = 0.29-0.97). Un séjour en secteur rural dans les trois derniers mois était fréquent (31% de tous les répondants) et associé à une infection de paludisme (OR=1.75, CI à 95% = 1.25-2.45). La cartographie des centres de santé et des gîtes larvaires, aussi bien que l'étude dans les écoles n'ont pu avoir lieu à cause des troubles politiques qui ont éclaté dans le pays.

Ouagadougou : Les travaux de terrain ont été menés de novembre à décembre 2002, au début de la saison sèche et froide. Des variations saisonnières très marquées des cas cliniques de paludisme ont été observées. Les taux d'incidence les plus élevés ont été observé de juillet à septembre et ont ensuite baissés d'octobre à décembre pour atteindre leur niveau le plus bas de janvier à mars, pendant la saison sèche. En 2001, il y avait 203.466 cas de paludisme simples (29.3-41.4% des consultations) et 19 cas de décès ont été rapportés parmi les 596.365 consultations effectuées dans tous les centres de santé publique. Plus de 20.071 cas graves de paludisme ont été rapportés.

Les taux d'infection dans le groupe d'enfants présentant de la fièvre étaient de 12.1% (chez les moins de 1 an), 25.9% (1-5 ans), 37.1% (6-15 ans) et 18.0% (plus de 15 ans), alors que ceux dans le groupe de témoin étaient de 14.3%, 14.4%, 34.5% et 19.8%. Les FAPs parmi les cas de fièvre étaient de 0.00, 0.13, 0.04 et 0.00 pour les catégories d'âge ci-dessus, suggérant que le paludisme n'a joué qu'un petit rôle dans la survenue des épisodes de fièvre en début de la saison sèche et froide. La prévalence parasitaire dans les écoles était plutôt élevée (taux global = 48.3%) et il y avait une hétérogénéité entre les 3 zones (31.6%, 37.6%, 73.1%). La cartographie des gîtes d'*Anophèles* sp. était corrélée avec le gradient endémique entre le centre ville et la périphérie de Ouagadougou.

Cotonou : Les travaux de terrain ont été menés de février à mars 2003. En 2002, il y avait 100.257 cas de paludisme simples et 12.195 cas de paludisme graves ont été rapportés pour 289.342 consultations dans tous les centres de santé publique de Cotonou. Entre 1996 et 2002, en moyenne 34% des consultations totales ont été attribuées au paludisme simple et 1-4.2% de cas compliqués. Il n'y avait pas un mode de variation saisonnière précis.

Les taux d'infection dans le groupe présentant de la fièvre étaient de 0% (chez les moins de 1 an), 6.8% (1-5 ans), 0% (6-15 ans) et 0.9% (plus de 15 ans), alors que ceux dans le groupe de témoin étaient de 1.4%, 2.8%, 1.3% et 2.0%. Les FAPs parmi le groupe présentant de la fièvre étaient de 0.04 dans la catégorie d'âge de 1-5 ans et de 0 dans celui des plus de 15 ans. Les FAPs n'ont pas pu être calculés pour les deux autres catégories d'âge. Par conséquent, le paludisme n'a joué qu'un petit rôle dans la survenue des épisodes de fièvre à la fin de la saison des pluies. Un taux parasitaire global de 5.2 % a été observé lors des enquêtes effectuées dans les écoles. Les prévalences parasitaires dans les secteurs centre, intermédiaire et périphérie étaient de 2.6%, 9.0% et 2.5%, respectivement. Au total 69.2% des patients avaient utilisé une moustiquaire la veille de l'enquête (OR=0.61, non significatif). Le séjour en zone rurale (5.8% de tous les répondants) n'a pas augmenté le risque d'infection puisque personne de ceux qui avaient voyagé n'avait des parasites. La cartographie des gîtes larvaires et des centres de santé n'a pu être effectuée.

Dar es Salaam : Les travaux de terrain ont été menés de juin à août 2003. Environ 1.1 million de cas annuels de paludisme ont été rapportés en 2000 sur un total de 2.200.000 patients qui se sont rendus dans les centres de santé (49% de toutes les consultations). Une saisonnalité très claire du paludisme clinique a été observée, avec des taux élevés de mars à juin et faibles de juillet à août. Les taux d'infection parasitaires du groupe de cas présentant de la fièvre étaient de 2.0 % (chez les moins de 1 an), 7.0% (1-5 ans), 7.2 (6-15 ans) et 4.2 (plus de 15 années), alors que ceux du groupe de témoin étaient de 3.4%, 4.5%, 3.6% et 1.9%. Les FAPs étaient très faibles dans toutes les catégories d'âge : 0.00. 0.03, 0.04 et 0.02. Les enquêtes dans les écoles de Dar es Salaam pendant une saison sèche prolongée en 2003 ont montré que les prévalences parasitaires étaient faibles : 0.8%, 1.4%, 2.7% et 3.7% respectivement dans le centre ville, la zone intermédiaire, péri-urbaine et rurale. Les gîtes d'*Anophèles* étaient assez bien distribués dans la ville. Nous avons observé un taux de couverture des ménages en moustiquaires remarquablement élevé (91.8% d'utilisateurs) et ceci a semblé être protecteur (OR=0.60, IC à 95%: 0.27-0.93). Une augmentation du taux d'infection chez les 11.8% d'enfants qui ont séjourné en milieu rural dans les 3 derniers mois (OR=3.62, IC à 95% 1.48-8.88) a été observée.

Conclusion

L'Evaluation Rapide de la Malaria Urbaine (ERMU) a été mise en œuvre avec succès dans 4 centres urbains dans une période de 6-10 semaines par site. Le coût financier pour conduire un ERMU dans ces quatre sites allait de 8.500-13.000 USD. Toutes les composantes étaient faisables (excepté la cartographie des gîtes larvaires qui a clairement excédé ce qui peut être fait dans une période de temps si courte) et très instructives. L'ERMU a permis de décrire les modes de transmission dans les quatre villes et a mis en relief l'énorme niveau du sur-traitement avec les antipaludiques. Les informations ainsi rassemblées sont d'une très grande importance pour d'autres investigations et pour la planification des interventions efficaces de lutte.

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Chapter 1

General Introduction

1. CHAPTER: GENERAL INTRODUCTION

1.1 Malaria and the urbanization process

Malaria is one of the most devastating diseases in sub-Saharan Africa (SSA) and Roll Back Malaria (RBM) policies and recommendations largely reflect the knowledge and strategies developed for rural areas. Over the last two decades, the impact of the urbanization process on demography, economics, life styles, ecosystems and disease transmission patterns has not been well addressed in SSA (Mott et al., 1990; Trape et al., 2002) . There are significant gaps in our knowledge of the urban malaria epidemiology, although the effects of urbanization on transmission dynamics and disease outcome have been recently hypothesized (Donnelly et al., 2005; Hay et al., 2005; Keiser et al., 2004; Omumbo et al., 2005b; Robert et al., 2003) . Urban malaria is a real issue in SSA and it is likely to get bigger due to rapid urbanization.

1.2 Defining the urban area

Defining the urban versus rural environments is difficult. The concept of an "urban area" has a broad meaning in a number of circumstances and there is no universally accepted definition of the term. There are at least three approaches to defining an urban area. Either it is defined in terms of the *built-up area,* i.e. the constructions and settlement patterns. It can also be defined in terms of the areas for which a town administration provides services and facilities - the *functional area* (Scottish Department of the Environment (DOE), 1975); the *functional area* may comprise both a densely built-up area and free-standing settlements at the outskirts, together with the surrounding countryside if the population there depends on the urban centre for access to basic services and employment. A third approach is to use the *density* of population or buildings as an indicator of the degree of urbanization. In any case, drawing boundaries involves subjective judgments with regard to any of the above parameters, because towns tend to merge physically and functionally with neighboring towns and their satellite villages.

One can also define an urban area using the following criteria: population size, type of administration, the dominant type of economic activity (industrial vs. agricultural). It is rather confusing to use only population size as defining criteria since the minimum size varies by country. It may consist of units of 2,500 or more persons (i.e. USA) or of 10,000 and more persons (i.e. Benin). An easy way to define an urban area is to use its administrative boundary - that is, the area administered by a city or town council. The disadvantage of this approach is that often the urban census excludes populations living at the urban fringe (Harpham and Tanner, 1995). Another common approach is to take into consideration of the distance from the city centre. One researcher (Benyoussef et al., 1976) classified zones up to 5 km from the centre as urban, 5 to 10 km as periphery and further than 10 km as a rural area. This approach might be particularly useful for some African towns which are shaped as a circle, with all the main paths leading to the central area (i.e. a market place), but is not suitable for many other African urban areas with scattered city centres (i.e. Addis Ababa) or the ones developed along key trade routes or a lakeshore (i.e. Ouagadougou). In practice, many African cities remain essentially agrarian (i.e. Dar es Salaam).

1.3 Rapid urbanization in SSA

SSA is rapidly urbanizing as the result of its urban population growth and rural-urban migration. An estimated 38.7 % of the population in sub-Saharan Africa lived in urban or peri-urban areas in 2003 (United Nations, 2003). In 1960, there was only one city with more than 1 million inhabitants in SSA (Johannesburg). In 1970, there were four (Cape Town, Johannesburg, Kinshasa and Lagos). By the late 1980s, Abidjan, Accra, Addis Ababa, Dakar, Dar es Salaam, Durban, East Rand, Harare, Ibadan, Khartoum, Luanda and Nairobi had also reached 1 million people. By 2010, projections predict at least 33 cities of more than 1 million inhabitants, with 2 exceeding 5 millions and one (Lagos) having more than 13 millions inhabitants. Many SSA cities experienced persistent annual growth rates of 5-6% over the last decades and their population doubled every 20 years.

1.4 Evolution of urban health problems

The current urban planning in SSA cannot catch up with the rapid growth and movements of the population. In 2001, 166 million people (72%) of Africa's urban residents were living in slums (United Nations, 2003). The cities of SSA are usually not in a position to modernize existing public infrastructure and meeting expanding education and health care needs, as well as sustaining environmental and sanitation management activities. The changes in physical and social environments of urban areas consequently affect the population's health. Currently, the urban population and the health sector face a double burden of diseases. On one hand, they suffer from a high rate of malnutrition, high infant and child mortality rate, increasing prevalence of HIV or other infectious diseases. They also have to cope with the emerging problems of non-communicable diseases, smoking, alcoholism and violence. Although a large proportion of the national health budgets in SSA countries has always been allocated to urban health care, resources were never adequate.

1.5 Urban malaria epidemiology

The epidemiological and demographic structures in SSA urban areas pose new challenges to local health care systems. So far, malaria has been predominantly considered as a rural problem in SSA, mainly because of the belief that favorable *Anopheles* sp. breeding sites could not be created easily in highly populated urban areas. While the global malaria incidence was 300–500 million cases annually in 1996, the estimate for the urban settings of Africa was only 3 to 9 million malaria cases (WHO, 2001). Recently, it was estimated that 6–28% of the overall malaria cases (25–100 million per year) occurred in urban areas and about 200 million urban dwellers were exposed to the risk of malaria, on a surface area of less than 500,000 km^2 (Keiser et al., 2004).

Malaria endemicity and mortality are thought to be low in urban areas. The annual incidence of pernicious attacks in children in Brazzaville was 1.15/1000 between 0 and 4 years, 0.25/1000 between 5 and 9 years and 0.05/1000 between 10 and 14 years (Trape et al., 1987). The annual mortality due to malaria was estimated at 0.43/1000 between 0 and 4 years and 0.08/1000 between 5 and 9 years. These rates were about 10-30 times lower than the results of previous studies on malaria in inter-tropical Africa. Urban populations in Africa receive on average 10 times fewer new infections from vectors compared to rural areas (Hay et al., 2005; Robert et al., 2003) . Since naturally-acquired protective immunity depends largely on repeated responses against highly variable parasite antigens, immunity is developed in gradually in children. In rural areas where transmission is high, people are continuously infected from an early age. With increasing transmission intensity, older children and adults suffer less from severe disease and most severe cases occur in infants or younger children. Because of lower malaria transmission in urban areas, the first contact with parasites occurs late in childhood and older people at a higher risk of severe malaria (Lindsay et al., 1990; Modiano et al., 1998; Modiano et al., 1999; Watts et al., 1990). Hence, it is important to study the age-specific pattern in malaria morbidity and mortality.

Heterogeneities in malariometric indices and vector distribution within small distances were detected in large cities and many medium-sized towns (Robert et al., 2003; Sattler et al., 2005; Trape et al., 1992; Trape and Zoulani, 1987). Newcomers from rural areas can keep the endemicity of malaria high in the periphery areas of cities (Martens and Hall, 2000; Prothero, 1977; Prothero, 1987; Trape, 1987; Trape et al., 1992). Important factors contributing to heterogeneity of malaria risk are the diversity of socio-economic status (poverty, housing materials, land use patterns and access to health care and education), vector distribution and the implementation of malaria control measures. The heterogeneity of malaria transmission is also related to the degree of urbanization of particular subdivisions and their proximity to possible vectors breeding sites.

1.6 Vector adaptation and environmental risks

Although *Anopheles* vector life cycles and behavior have been intensively studied for the past century, little is known about the mosquito's adaptation and population dynamic in urban settings. In addition, nuisance mosquito densities (mainly *Culex* sp.) can often be high. Malaria vector distribution is subject to site-specific factors such as urban agriculture activities or construction. Water pollution in urban areas often limit vector breeding activity, but vectors such as *Anopheles arabiensis* in the forest belt of West Africa may adapt to breeding in polluted waters (Molineaux, 1988). In Accra and Dar es Salaam *Anopheles* sp. was also found to adapt to new breeding sites created by urbanization (Afrane et al., 2004; Akogbeto et al., 1992a; Chinery, 1984; Chinery, 1995; Rossi et al., 1986) and its ecology and behavior seemed to differ from rural areas. *Anopheles* sp. may breed in a variety of habitats in urban areas, including: pools, borrow pits, trees holes, wells, puddles formed alongside lakes, footprints, vehicle ruts, gardens, drains and marshy areas. The heterogeneity of vector density, sporozoite rates and entomological inoculation rates (EIR) are influenced by a complex interplay of biological, physical, socio-economic and environmental factors. This can lead to a non-random distribution of breeding sites and vectors in the city. In addition, the spatial and temporal patterns of malaria are continually changing in response to urban development and environmental change. For example, Akogbeto *et al.* (Akogbeto, 1995) discovered that in 1992 population density and distribution of two *Anopheles* species were highly dependent on the level of urbanization and the salinity of a lagoon to the north of Cotonou. *Anopheles melas* was tolerant to higher salinity while *Anopheles gambiae s.s.* only occurred in water with up to 30% sea water. The level of transmission was markedly lower in communities built around the lagoon than in the city centre.

The differing composition of the vector fauna and the vector's adaptation to urban settings imply potentially different approaches for environmental management in urban areas (Knudsen and Slooff, 1992; Lindsay et al., 1990). This requires a comprehensive understanding of the vector's distribution and environmental risk factors in each city. In Dar es Salaam, insecticide was wasted in major water bodies in which there were no mosquitoes breeding, while the actual breeding sites were few and ignored (Yamagata, 1996). Identification of vector species, regular larval inspection and larvicide activity should be implemented in the framework of urban malaria control programmes (Caldas de Castro et al., 2004; Yamagata, 1996). Mapping geographic information system (GIS) or remote sensing can help to discriminate between high and low risk areas for malaria (Hay et al., 2000; Srivastava et al., 2003).

A higher risk of malaria might be associated with urban agriculture activities and poor irrigation systems (Afrane et al., 2004; Knudsen and Slooff, 1992). There are normally two systems for vegetable production in SSA urban settings: the "open space" system and the "home garden" system. Home gardening or backyard farming is the most important urban production system in many SSA cities and is practiced by all income groups. Urban poors or newcomers from villages often sustain rural economic activities within city boundaries. For instance, one in five people of working age in Dar es Salaam was involved in some urban agriculture activities in the early 1990s (Smit et al., 1996). Traditional patterns of water storage also create potentially favourable environments for vector breeding. A study in Dakar showed that the urban area had more than 5,000 garden wells that provided permanent sites for larvae of the main malaria vector *An. arabiesis* (Robert et al., 1998). Given the nature of urban environments, most urban larval habitat could be identified (Caldas de Castro et al., 2004; Yamagata, 1996) and productive larval habitats could be managed by water management, drainage and canalization. Larval control with standard insecticides and biological agents is also likely to be feasible in SSA urban areas.

1.7 Insecticide treated net (ITN)

ITNs coverage is generally higher in urban areas and in wealthier households. Bednet and ITN ownership and usage by children < 5 years are 2-3 folds lower in rural areas than in urban areas

(WHO/RBM, 2005). Cash availability and awareness of malaria prevention in the urban areas provide many opportunities for malaria control. Bednet and ITNs ownership and usage are 2-8 times lower in the poorest households compared to the least poor households (WHO/RBM, 2005). Cost and distribution are the major barriers to protect target groups or communities and social marketing can effectively reduce the inequity to access the ITNs (Nathan et al., 2004).

1.8 Case management and public/private partnership

Malaria is diagnosed through clinical symptoms and sometimes with microscopic examination of the blood. Although fever is the most characteristic sign of clinical malaria in rural areas, a number of studies demonstrated that many fevers episodes were not due to malaria (Amexo et al., 2004). There is, therefore, an urgent need to further determine the proportion of fever episodes due to malaria parasites and hence improve case management practices. Treatment providers need to take into account the fact that severe malaria in urban areas may occur in all age groups because of inadequate development of immunity and the malaria symptom presentation may vary according to local endemicity. It is also important to investigate risk factors for severe malaria in different urban settings and why many cases are delayed in reaching health facilities. Several studies in Nigeria explored the management of cases by doctors and demonstrated that health facilities in urban settings were not able to detect malaria properly (Brieger et al., 2001; Ibeh et al., 2004; Oguonu et al., 2005; Rougemont et al., 1991).

A great diversity of health care providers determines the overall quality of case management. Both public and private health facilities in SSA are diverse in nature and offer a widely varying quality of care. The urban public health sector no longer maintains a dominant role in service provision in many settings. In some SSA cities, private practitioners, pharmacies and drug outlets have taken over a large share of the health care in the community. Yet, these private health providers are often excluded from public health program planning and regular monitoring. In Kenya shop-bought medicines were used first in 69% of urban fevers (Snow et al., 1992). Home treatment and traditional healers are popular choices for malaria management in some urban areas (Agyepong and Manderson, 1994; Gessler et al., 1995). The patients then attend health facilities when self-treatment fails and even then they do not always receive a correct diagnosis and treatment.

In Dar es Salaam, about 45% of drug sellers, 35% of medical aids and 30% of patients did not know the correct dose of chloroquine (CQ) for malaria cases in 1995 (Massele et al., 1993). This highlights the need for community-based promotion. The effect of malaria misdiagnosis and mistreatment falls heavily on the poor and vulnerable. They bear the cost of prolonged illness resulting in more clinical visits and additional economic burden (Amexo et al., 2004; Breman et al., 2004; Knudsen and Slooff, 1992).

The urban prenatal and perinatal care providers should play an active role in the promotion of intermittent preventive treatment for pregnant women (Massele et al., 1997). Poor quality malaria case management will result in more clinic attendances, heavier working load for health professionals and a bad reputation for the health sector (Amexo et al., 2004). Over-treatment of malaria may increase selection pressure for resistance to antimalarials and over-reporting of cases may lead to a misallocation of the national health budget.

1.9 Drug resistance to antimalarials

The increasing accessibility of antimalarial drugs in unauthorised drug outlets, their misuse and the interruption of medication challenge the quality of case management. A study in Cotonou in 1980-89 explained the geographical distribution of drug resistance, which was restricted to the urban area, as being associated with inappropriate CQ distribution (Chippaux et al., 1990).

Drug policy and regulations involve not only the health care sector but also commerce, foreign pharmaceutical companies and local markets. The drug sensitivity issue is particularly important given the diversity of treatment outlets in urban areas. Many pharmacists and shopkeepers of drug outlets operate without authorization from municipal drug departments and have an alternative channel of drug supply in which the quality of antimalarials is poorly controlled.

1.10 Urban malaria control interventions-case study in Dar es Salaam

Malaria control in Dar es Salaam dates back to the German colonial period in the 1890s. Quinine administration and environmental management including drainage, soil modification and bednets distribution were introduced and these control efforts had reduced the mosquito population by 90% by World War I. The British government took over Tanzania from Germany after World War I and therefore the larviciding and environment management interventions were carried out by the Royal Army Medical Corps during 1918-1961. After the independence of Tanzania in 1960 the vector control approaches and community health education were adapted, In the 1970s, chemotherapy was the only control measure remaining in Dar es Salaam due to the deterioration of the preventive health care system. As a consequence, the *Anopheles* sp. population re-emerged. In the 1980s, the government reduced further the size of the central malaria control unit and malaria surged in the city. The Urban Malaria Control Project (UMCP) was launched in 1988 and completed in October 1996, as a collaboration between the government of the Republic of Tanzania and the Japanese International Cooperation Agency (JICA)(Yamagata, 1996). UMCP concluded that rapid diagnosis and treatment in the health facilities, health education and active participation of the community were essential components. Caldas de Castro *et al.* (Caldas de Castro et al., 2004) also mentioned that the mapping of potential *Anopheles* sp. breeding sites by remote sensing and emphasis on the maintenance and cleaning of drains were of prime importance.

The Ministry of Health (MOH) of Tanzania with its partners confirmed their commitment to health sector reforms in a gradual manner since March 1998. Malaria control was included in the health sector reform of the regional/city office of health of Dar es Salaam (CMOH). Progress in implementation of the Malaria Annual Plan was examined annually along with other MOH priorities during the government annual review of the health sector. Since 2002, integrated urban malaria control is being introduced to Dar es Salaam in collaboration with the Swiss Tropical Institute (STI). Environmental management is the central focus, with several interventions/surveillance methods acting simultaneously.

List of abbreviations

CMOH	Regional/city office of health of Dar es Salaam
CQ	Chloroquine
DOE	Scottish Department of the Environment
EIR	Entomological inoculation rates
GIS	Geographic Information System
ITNs	Insecticide-Treated Nets
JICA	Japanese International Cooperation Agency
MOH	Ministry of Health
RBM	Roll Back Malaria
RUMA	Rapid Urban Malaria Appraisal
SSA	Sub-Saharan Africa
STI	Swiss Tropical Institute
UMCP	Urban Malaria Control Project

Chapter 2

Objectives

2. CHAPTER: OBJECTIVES

2.1 Objectives

The general objective of this series of case studies is to further our understanding of malaria transmission and epidemiology in the urban environment on the basis of a Rapid Urban Malaria Appraisal (RUMA); the studies also aim to determine key issues for an effective intervention or in-depth assessment in urban settings, in view of facilitating a multi-sectoral integration of malaria control activities.

2.2 Specific objectives

- To formulate and validate a generic rapid assessment procedure for urban malaria.
- To describe urban malaria patterns in sub-Saharan Africa (SSA).
- To estimate key risk determinants of malaria infection in SSA urban environments.
- To estimate the accuracy of clinical diagnosis of malaria and understand the malaria burden in the health facilities.
- To provide basic evidence for the planning of integrated malaria control activities.

2.3 Rationale for an urban malaria assessment

There is an urgent need to describe further the urban malaria endemicity and measure its burden, as well as address the urban/rural differences for key risk factors, risk behaviours, risk groups and risk areas. We have aimed to achieve this through a generic methodology of rapid assessment which is cost-effective and feasible in a period of six to ten weeks. Our work is the first multi-site assessment for urban malaria and it has been funded by the Roll Back Malaria (RBM) partnership.

List of abbreviations

RBM	Roll Back Malaria
RUMA	Rapid Urban Malaria Appraisal
SSA	Sub-Saharan Africa

Chapter 3

Methods and Materials

3. CHAPTER: METHODS

In July 2002, a generic RUMA protocol was developed based on existing urban malaria research protocols (Warren et al., 1999; WHO, 2001). In this series of rapid assessments we aimed at comparing different methodological approaches with regard to their feasibility and efficiency. The first step in starting a rapid assessment is to thoroughly collect available data and literature in order to give a comprehensive overview of the situation. The relevant institutions in each setting were contacted and city-specific proposals were then produced. Parts of health facilities mapping, school and health facility-based survey activities were integrated into the routine surveillance and health system evaluation at the municipal level. All the fieldwork was completed in August 2003. Final reports were completed in June, 2004. The methodology employed should be flexible and relevant. The RUMA study design proposes six complementary methodologies covering the key issues in a rapid assessment of six to ten weeks.

3.1 Methodology 1: literature review

A search of the PUBMED bibliographic database was conducted for the time period from 1945 to April 2004, using the terms “malaria”, “urban” and “sub-Saharan Africa”. The search was limited to the articles published in English, Chinese, French and Spanish. The reference list of all identified papers was screened.

Thesis abstracts filed in the medical libraries of universities and national hospitals were collected at each site and local researchers were also contacted. In each setting, local institutions had previously completed various studies, in particular on parasitaemia prevalence, morbidity and mortality rates. Potential environmental risks and information on vector species may also have been documented. Retrospective data related to drug resistance, the effectiveness of ITN and preferences for malaria fever treatment may also be available in publications.

3.2 Methodology 2: collection of heath statistics

The lack of reliable routine data is a major deficiency of surveillance systems in SSA. If available and of good quality, health statistics can provide a good overview of malaria epidemiology and burden, patterns and gradients in town and document the numbers and categories of treatment providers.

Census data involving population structure and human density was collected from the national census bureau and urban planning. Local experts in ministries of health (MOH) (disease surveillance systems, municipal health departments and national malaria control programmes) were contacted to collect health system information and statistics, including routine malaria morbidity and mortality reports.

We obtained weekly infectious disease reports and routine malaria case reports from each health facility for the last three years. The following clinical information was extracted from the routine reports to estimate the malaria burden at the project site.

- Age-specific morbidity and mortality rate: does the incidence vary by age group?
- Severity: what are age-specific rates of severe malaria?
- Seasonal patterns: is malaria reporting consistent all year round or does it vary by season?
- Distribution in town: are there substantial differences in rates reported across the city?

3.3 Methodology 3: mapping

It is essential to take a transect walk across the town for a visual orientation when arriving in the field. By marking the major drainage and water bodies, channels, urban agriculture areas, pits, construction sites, and wetlands on the map, one can generate an overall impression of the project site. Due to security issues and technical problems, the mapping of breeding sites and health facilities could not be performed in Yopougon municipality (Abidjan) and Cotonou.

3.3.1 Mapping of *Anopheles* breeding sites

A malaria risk map showed the geographical variation of malaria transmission and identified the malaria clusters in the urban areas. In order to identify *Anopheles* breeding sites, simple larvae sampling was performed with the assistance of entomological technicians in Dar es Salaam and Ouagadougou. The duration of these tasks varied by site: 12 weeks during the rainy season in Dar es Salaam and around three weeks during the dry season in Ouagadougou.

Steps:

The entire city was searched systematically for major open water bodies to locate areas of potential breeding sites. The search was lead by local entomologists with a good knowledge of the area. A dipper was used to glide over the water surface to collect larvae. All larvae were identified on the spot and were transferred to water containers. The containers were also filled with the water taken from the breeding sites and were labeled with their locations. These were delivered to the entomological laboratory for hatching so that the adults could be identified morphologically by light microscopy.

The work was done by the same entomologists to maintain consistency. The special features and general impressions of breeding sites were described. Geographic coordinates were recorded for all confirmed breeding sites of *Anopheles* by Global Positioning System (GPS) (Garmin® eTrex 12 canal GPS). A vector layer of a digital map with the locations of all health facilities and schools was prepared by the local partners.

3.3.2 Mapping of health facilities

Three or four trained workers carried out the health facility mapping under the guidance of local health personnel. We visited all the public and private health facilities and mapped their location by marking the geographical coordinates using an available physical map and applying GPS and GIS. A list of private health facilities was updated with information regarding the owner and location and all of them were marked on a digital map.

3.4 Methodology 4: school parasitaemia surveys

School surveys were aimed at determining the local endemicity and risk gradient of malaria. In each city, the surveys were conducted at three elementary schools located in subdivisions with different transmission levels (high, medium and low). It is a rapid assessment with limited budget; therefore, in each area only one health facility and school were selected for the surveys. The schools were selected near the selected clinics. 200 school children aged 6-10 years were recruited in each school. Additional information on children was collected using a questionnaire.

Steps

About four-six classes of younger children were selected for the survey. A questionnaire and a consent form were delivered to the head of household or the guardian of each child three days before the survey. After obtaining the informed consent and the filled questionnaires from the parents, the social workers recorded the age of children, and doubled-checked the questionnaires with each child concerning their family situation and travel histories. The social workers asked the children whether any febrile syndrome has occurred in the previous one to two weeks or if a malaria treatment was received. Mosquito net usage in the previous night was double-checked as well. The laboratory technicians then took the axillary temperature measurement and blood sample from each child. Both thin and thick blood films were prepared on the same slide stained by Giemsa. The details of blood sample examination are documented in chapter 3 section 5.4. The parasite density was defined as the number of parasites per 200 white blood cells.

Electronic thermometers were used to measure the armpit temperature. A “normal” body temperature is referred to as an oral temperature of 37 °C. An armpit temperature reading is usually 0.3°C to 0.6°C lower than an oral temperature reading. Therefore we added 0.5 °C to the temperature displayed on the digital readout. We paid for the prescription of antimalarial drugs if a child showed signs of fever or had parasitaemia.

3.5 Methodology 5: health facility-based fever surveys

The facility-based fever surveys focused on the age-specific fraction of malaria-attributable fevers (Smith et al., 1994). This methodology is also aimed at identifying the potential risk factors. Each city was categorized into three to four areas (centre, intermediate, periphery and rural areas) and one clinic from each area was chosen. Health facilities with a high enough volume of outpatients per day were considered for the survey.

3.5.1 Sample size: 600

In urban areas it was estimated that 5% to 50% of fever cases among children under 15 years old were due to malaria. In order to generate a parasite prevalence estimate for the urban community, sample sizes of approximately 600 patients with fever and 600 controls without fever are required. This sample size was divided equally among three selected health facilities located in risk areas (200 fever cases and 200 controls recruited from each health facility). A sample size of 200 in each facility gave an estimate of the proportion of cases with parasites with the following approximate lower 95% confidence limits (Table 3-1).

Since malaria occurs more frequently in childhood, in each facility the survey staff started to recruit 100 consecutive controls and 100 outpatients aged <5 years old, then assessed another 100 controls and 100 outpatient cases of age group ≥ 5 years old.

Table 3-1 Calculation of sample size

Expected frequency %	Lower 95% confidence limits	Sample size
50	43	196
25	19	200
5	2.0	203

Steps:

- Selection of survey sites: Based on the preliminary malaria risk map, we stratified the risk into high, medium and low levels.
- Sampling: Take a list of all health facilities in each area and then select three-four health facilities that should serve patients exposed to the three presumed transmission risk areas.
- Identify the suitable place for study: The ideal health facility included a high volume (at least 200 outpatients' visits per day) of suspected malaria cases. If the selected health facilities have a low volume of daily visit, an additional health facility nearby was taken for the survey to increase the sample size.
- Visit the selected health facilities: It is important to check the environment of the selected site and to contact key personnel. Permission to conduct a fever survey was also requested from the health facility.

3.5.2 Definition of “cases” and “controls”

The “cases” are the outpatients with a history of fever (past 36 hours) or a measured temperature $\geq$ 37.5°C for all age groups.

The “controls” are from another department of the same clinic without current or past fever, matched with the cases by age and ideally by residency (the smallest administrative unit).

3.5.3 Inclusion and exclusion criteria

Inclusion:

- Patients of all age and both sexes
- Permanent residence in urban and suburban areas (more than six months)
- Patients who are not permanent residents in town for more than six months per year but frequently stay in town as seasonal workers
- Meeting the definition of case or control
- Patients or caretakers who have given informed consent

Exclusion:

- Patients with signs and symptoms of severe disease
- Infants with congenital abnormalities
- Patients returning to the health facility for follow-up visits or who have been treated as fever cases and referred from other hospitals or clinics.

3.5.4 Blood sample collection

After being recruited and giving informed consent, each patient, including fever cases and controls, had an axillary temperature measurement. A thin and thick blood film was taken on the same slide and stained by Giemsa stain. The thin film was used to identify the parasite species and the thick films were checked for parasite density. Using 100X magnification to read the thick smears, all malaria trophozoites and gametocytes were counted separately. Parasite density was calculated according to parasites per 200 white blood cells (WBC) in a thick film (assuming 8000 white blood cells per ml of blood). If 200 WBC were counted and less than 9 malarial parasites found, the counting continued until 500 WBC were identified. We converted the parasite count per WBC identified into parasite concentration per ml with one of the following formulas:

If 200 WBC were counted: Number of parasites counted x 40 = parasites per ml.

If 500 leukocytes were counted: Number of parasites counted x 16 = parasites per ml.

3.5.5 Interview

Each subject included in the survey outpatient (or a caretaker of a young patient) was interviewed before being examined and treated by the clinical staff on duty at the health facility (Annex 1). This interview covered the following context: personal information, socio-economic situation of the family (including the type of the house and resources of water supply), urban agriculture activities, ITN usage, the history and duration of travels outside the urban area in the previous three months and previous malaria infections and reasons for seeking care.

3.6 Methodology 6: brief description of the health care system

This study aims to assess the institutional capacity of the urban health care system. The design allows an appraisal of how the public/private partnership performs on provision of malaria diagnosis and treatment. It focused on i) the municipal malaria control and prevention efforts, ii) the levels and coverage of service delivery, iii) disease surveillance systems, iv) malaria case management and v) trends of parasite resistance to antimalarials.

3.6.1 Draw an organogram of the administrative structure at each level

We described the structure of health administration, including city council and decentralized district authority. A list of recently government-owned health facilities (clinics or hospitals) was obtained and categorized by administrative districts.

3.6.2 Describe the distribution of coverage of health services

We identified the health facilities with clinically-trained health professionals according to the following categories: public and private sector or non-profit sector like Non-Governmental Organization (NGO) and religious health care services. The coverage area and served population of each health facility was calculated and compared with national data. We collected the numbers of qualified medical staff and estimated the workload. The distribution and quantity of pharmacies and drug outlets was obtained too. We also reviewed the literature concerning the role of shopkeepers, vendors, and traditional healers in malaria and fever management. The health information was updated but the quality of health care delivery was not assessed because of restricted scope and time.

Whether to implement the optional study was decided together with the local malaria experts and investigators; it depended on the following variables:

- the size and complexity of the city
- the availability of human resources and budget
- time frame

3.6.3 Review the existing urban malaria control intervention - optional

Most of malaria control interventions are currently conducted in rural areas. Although the use of ITNs and insecticide residual spraying are widely accepted mosquito prevention tools in the urban areas, the urban poor living in city fringes cannot afford such services. Therefore, we checked whether the following malaria control activities existed in the urban areas:

- ITN promotion campaign
- routine larval breeding inspections and larvicide activities
- environmental management intervention, i.e. drainage or water sanitation projects

3.6.4 Review of literature on antimalarial resistance rate - optional

Antimalarial drug resistance has emerged as the biggest challenge to the health care system in

Africa. The first or second-line treatment for malaria was well documented in the national malaria control policy or prescription guidelines. Concerning the over-treatment of malaria, we therefore reviewed the drug resistance to antimalarials in urban areas if the publications are available.

3.7 Study areas

The following urban areas and institutions were identified as good locations to apply RUMA because of their implementation experiences and available documentation on urban malaria. Three study sites were located in francophone countries (Abidjan/Côte d'Ivoire, Cotonou/Benin and Ouagadougou/Burkina Faso) and one was in an anglophone country (Dar es Salaam/Tanzania).

3.7.1 Ouagadougou

Ouagadougou is the capital of Burkina Faso, one of the least urbanized countries in SSA with just 18% of total population living in urban areas. Ouagadougou is expanding because the government tries to transform informal settlements at the periphery into formal ones. The total surface area is estimated to be around 570-655 sq. km (Institut National de la Statistique et de la Démographie (INSD), 2000). Ouagadougou is on the Sahelian border and has an annual precipitation of 750 to 900 mm per year. The average temperature is approximately 19°C in January, and 40°C from April to May.

The original name of Ouagadougou was *Kombemtinga*, "the field of warriors", which was established during the 11^{th} century by Yonyonsé. The city became the capital of the Mossi Empire in 1441 and until 1681 it was the permanent residence of the emperor. The districts around the imperial palace were developed quickly and they have preserved their names to this date. Ouagadougou is a city with a long history of urban development. There were three periods of development after independence (World Bank, 2002b).

During the first period, 1960-1983, the development of Ouagadougou was marked by a continuation of the urban policies initiated during French colonial times. During this period, two urban zones were created, the first zone for traditional dwellings of the local low-income population. The other was intended as the residential area for Europeans and African civil servants. The basic difference between these two areas was the level of infrastructure. The second period, from 1983 to 1990, began with the revolution in 1983. A new urban policy was applied that broke with former institutional arrangements, traditional social structures, and urban regulations. The implementation of the Land Tenure Reform Act (Réorganisation Agraire et Foncière) created a national public domain in 1996. Land was nationalized and a strong centralized urban and housing policy was implemented through the Directorate of Urban Planning. Burkina Faso's third period of urban development since 1991 has featured the improvement of housing and urban functions.

Ouagadougou consists of 5 administrative districts, which are divided into 30 urban sectors and 17 periphery villages. The infrastructure and quality of services in the city centre are much better than in the periphery zones. 20 sectors of the periphery areas are considered under-equipped which some of these sectors have been upgraded quickly due to industrial development (World Bank, 2002b).

The sanitary administrative structure is not identical with the administrative structure. The highest level is the Ouagadougou region sanitaire; it is divided into the provinces of Kadiogo, Kouweogo, Bazega, Oubritenga and Ganzourgou. The Kadiogo province is further divided into 4 sanitary districts. The four districts are Pissy (sectors 1-12 and 16-19) Kossodo (sectors 13, 23-27), Paul VI (sectors 20-22) and Secteur 30 (sectors 14, 15 and 28-30).

Collaborations in Ouagadougou

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Mr. Mathieu Kientga, Ecole Inter-Etats d'Ingénieurs de l'Equipement Rural (EIER), Burkina Faso.

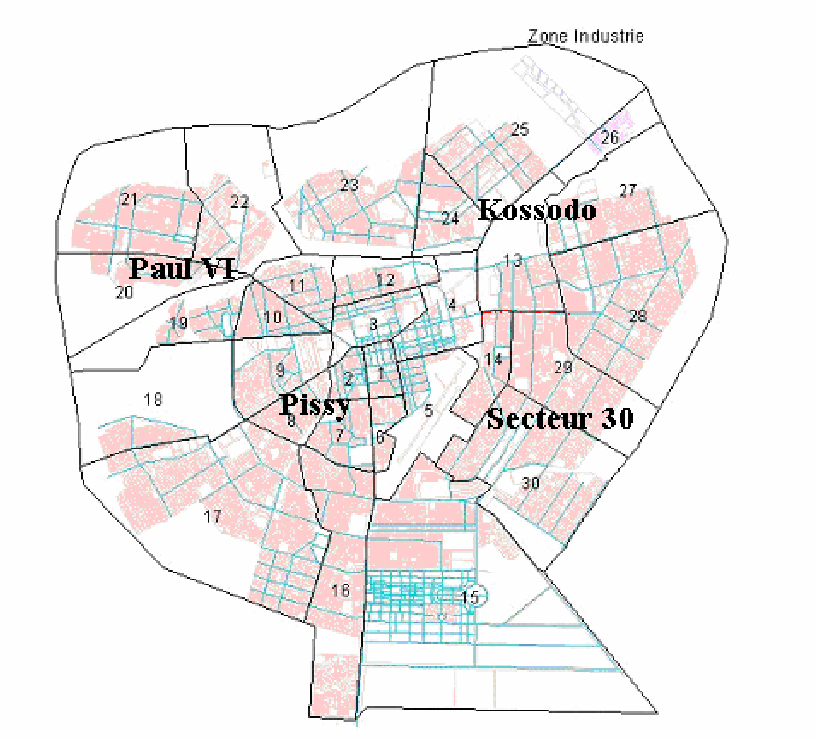

Figure 3-1 Map of Ouagadougou with 4 sanitary sectors.
Source: EIER Ouagadougou.

3.7.2 Dar es Salaam

Dar es Salaam is the most prosperous harbor in Tanzania. The total surface area is 1,393 sq. km (approximately 200 sq. km for the inner city). There were 357,000 inhabitants (with a density of 256 per sq. km) in 1967, which then increased to 844,000 people (605 per sq. km) in 1978. The population has since nearly tripled reaching 1,361,000 (with a density of 977 per sq. km) in 1988, then 2,497,940 (with a density of 1,793 per sq. km) in 2002 (Damas K. Mbogoro, 2002).

It was a fishing village until Sultan Seyyid Majid of Zanzibar turned it into a safe port and trading centre in 1862. The city developed rapidly since it became the location of the German colonial headquarters in 1891. Later, the British colonial administration introduced the three zones model into the city. According to a historical document of the Ministry of Agriculture and Co-operatives (Jacobi et al., 2000), Zone 1, the northeast of the harbor, was reserved for Europeans. Zone 2, the surroundings of the harbor, was set up as a business centre later dominated by the Indian community. Today, it is the most dynamic business district with the highest population density. Zone 3 was reserved for the native quarters, which was planned in order to avoid squatting.

The urban development of Dar es Salaam followed this model after the independence from Britain. At present there are three districts in Dar es Salaam, Kinondoni, Ilala and Temeke.

Dar es Salaam is governed by a political structure consisting of three levels: region, district and division. The highest political level is headed by the regional commissioner who is appointed by, and accountable to, the president of the country. The three districts (Kinondoni, Temeke and Ilala) are headed by district commissioners. The third level, the division, is headed by a divisional secretary. Four divisions are found in Kinondoni District, three in Temeke and three in Ilala.

Alongside the political structure are the administrative and executive structures. The administrative structure of Dar es Salaam has four basic levels: city, municipality, ward (kata) and subward (Mtaa). The highest level is the Dar es Salaam City Council. Below the City Director are three municipal directors. The ward and subward leaders are below the municipal directors. In some areas, there are also villages (*vijiji*) and hamlets (*vitongoji*)(Mtasiwa et al., 2003).

For administrative purposes the Ilala Municipality is divided into 3 divisions (Ilala, Ukonga and Kariakoo), 22 wards, 65 subwards and 9 villages. Kinondoni Municipality is divided into 4 divisions, 27 wards, 13 subwards and 14 villages. Temeke Municipality is divided into 3 divisions, 24 wards, 97 subwards and 15 villages.

Ilala Municipality covers an area of 210 sq. km with an estimated population of 638,000. The Municipality has the Indian Ocean to the East and the Coast Region to the West. The Msimbazi Valley passes through the northern part of the district. The land is almost flat and the highest altitude is 900 ft above sea level.

Kinondoni Municipality is located at the north of Dar es Salaam and is bordered by Bagamoyo District to the north. The Msasani peninsula extends into the Indian Ocean to the east. There are many recently planned settlements in this district. The population is 1,089,000. In general, the living standards in Kinondoni are higher than in the other two districts.

Temeke Municipality is the largest district located in the south of Dar es Salaam, with a population of 772,000. The district is divided by the creek. The south of the district and the right bank of the creek remain rural; most of the settlements there are new.

Collaborations in Tanzania

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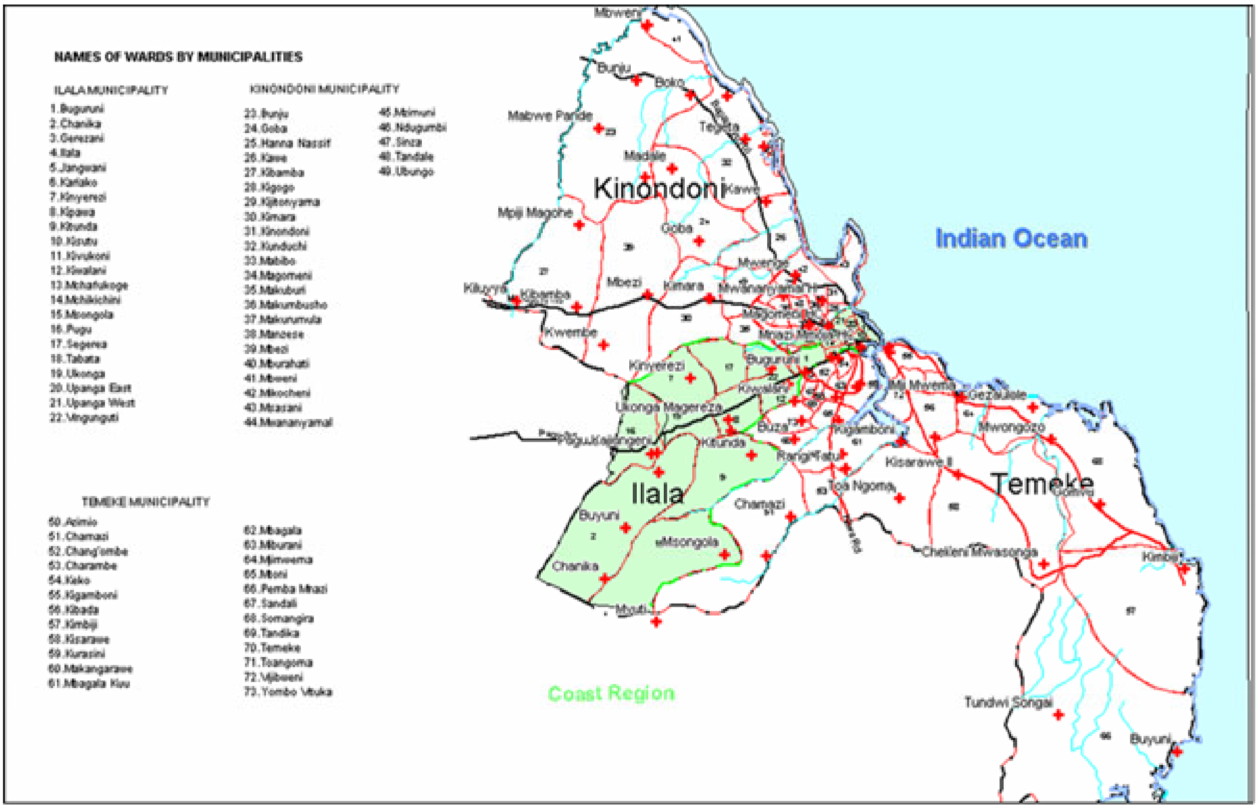

Figure 3-2 Map of Dar es Salaam with information of public health facilities.

3.7.3 Abidjan

The total surface area is 261 sq. km. In 1891, Abidjan was a little lagoon village chosen as a hub of the Niger-Ivory railway. The population in Abidjan has multiplied nearly 10 times every 25 years; from 5,000 habitants in 1920, 46,000 in 1946, to 500,000 in 1970. There were 1 million habitants in 1993 and it was estimated at 3,238,000 people in 2001(Institut National et de la Statistique (INS), 1998).

Around one fifth of the total population of Côte d'Ivoire lives in Abidjan. The city is characterized by high social stratification: its settlement style and household size reflect these social classes (World Bank, 2002a). The extended families occupy mainly the residential areas and inexpensive modern buildings, while the nuclear families occupy both yard and makeshift settlements. An estimated 50% of the total population in Côte d'Ivoire lives in poverty. According to a survey in 1990, 15-17% of the population lived in informal settlements and among them, 60% lived in slums with poor road and sanitation infrastructure. The remaining 40% lived in the surrounding neighborhoods in under-serviced areas of Abidjan.

Abidjan, situated beside a lagoon, is divided into 10 communes: Abidjan North: Abobo; Abidjan Central: Adjamé, Attécoubé and Plateau; Abidjan East: Cocody; Abidjan South: Koumassi, Marcory, Port-Bouét, Treichville; Abidjan West: Yopougon. The population density in Abidjan varies from the centre to the periphery. Koumassi in the centre had the highest density (27,900 per sq. km) while Plateau and Cocody have lower population density (2,600 and 3,300 per sq. km).

Collaborations in Abidjan

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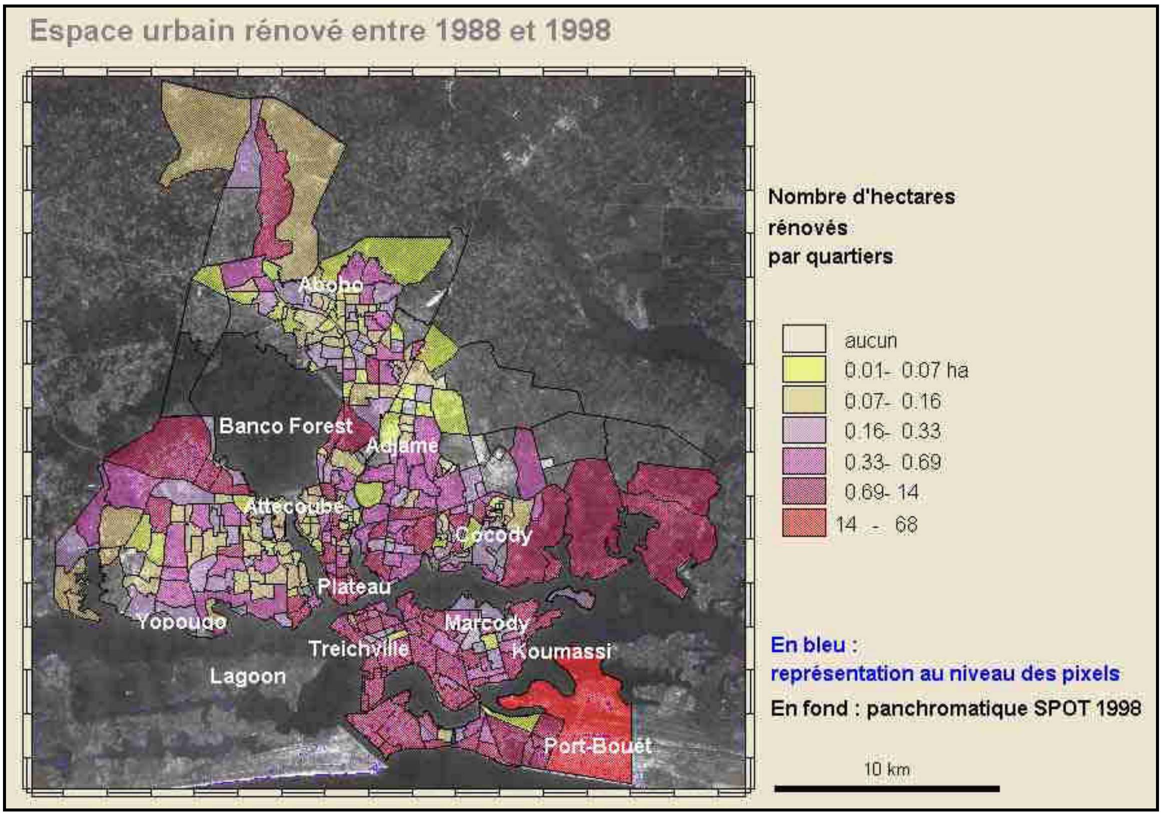

Figure 3-3 Map of Abidjan and urban renovation.
Source: Centre de Cartographie et de Télédétection, Abidjan.

3.7.4 Cotonou

The total area of greater Cotonou is estimated to be around 73.8 sq. km (Institut National de la Statistique et de l'Analyse Economique Bénin (INSAE), 2003). Its population has multiplied rapidly: from 3,300 habitants in 1921, 20,000 in 1951, to 383,000 in 1981. The population of Cotonou was estimated at 781,000 inhabitants in 2002.

The original name of Cotonou was Ku-tonu, “river mouth of the dead”, which was established during the 1830s by King Ghezo. In 1851, the French established with his help a trading post in Cotonou. It is entirely located on a land strip, which is about 5 km wide along the Gulf of Guinea. It is divided by an inlet channel connecting the Lake Nokoué and the Atlantic Ocean.

There are two rainy seasons and two dry seasons in Cotonou. The average temperature is approximately 30°C in April and 25°C in August. The average rainfall is 1,200-1,313 mm and the rainy period lasts from 80 to 120 days. One of the most serious environmental problems in Cotonou is the abundance of water, especially during the rainy seasons. Frequent flooding constrains both development and long-term investments. Every year Cotonou suffers from flooding for several months.

Cotonou is situated in the smallest departments of Benin, Littoral, which was split from the Atlantique department after the decentralisation in 1999. Cotonou as a whole counts as one commune (urban district), consisting of 6 administrative zones and 138 areas. According to the decentralisation policy, the Littoral department was further divided into 4 health zones (Cotonou health zones 1, 2, 5 and 6). The administrative zone 4 was joined with the Cotonou health zone 1 while the administrative zone 3 was joined with the Cotonou health zone 2. The development levels of the zones are different; in general, the coastal areas are better planned than the lakeside ones. The income inequality was serious in urban areas. In Cotonou, the income of the wealthiest 20% divided by the poorest 20% was more than 6.3. Around 70% of the unemployed lived in urban areas in 1996; and 60% of the urban unemployed live in Cotonou.

Collaborations in Benin

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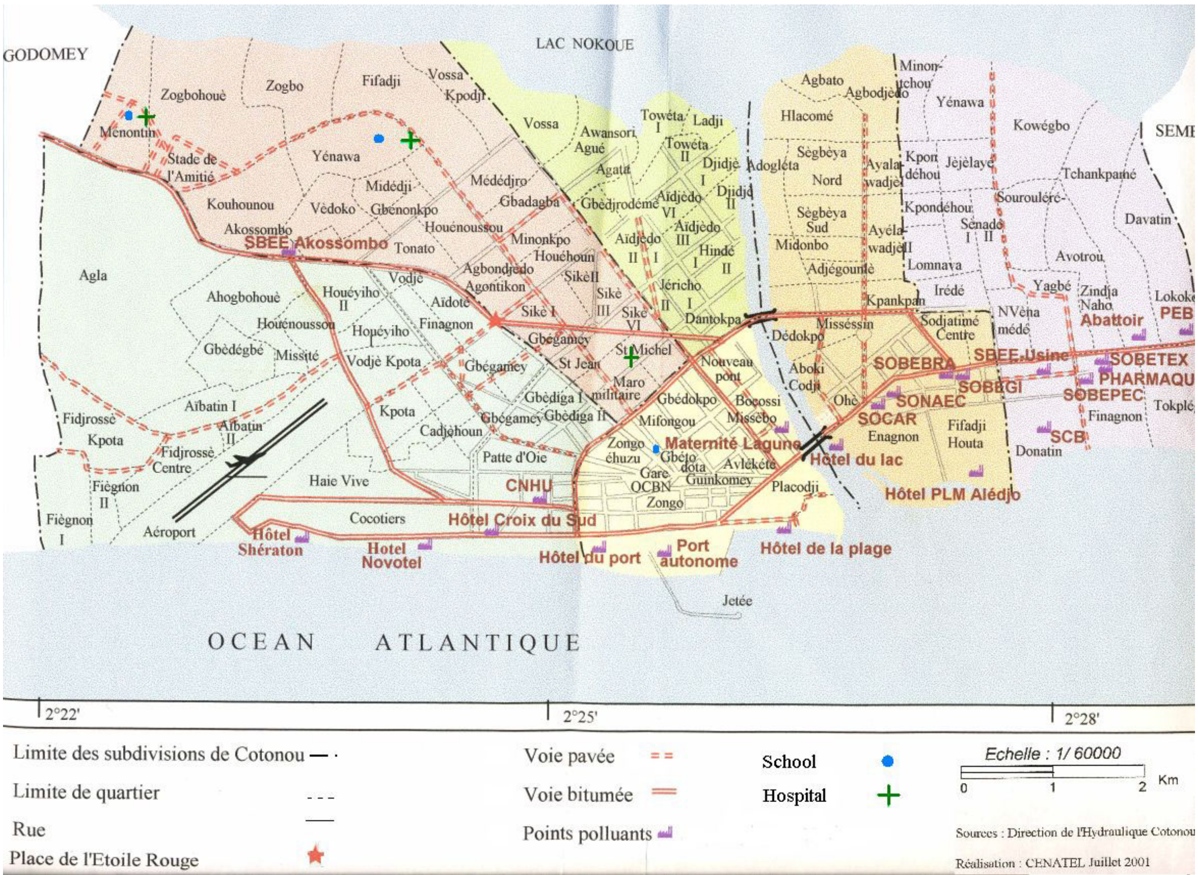

Figure 3-4 Map of Cotonou and its divisions.

3.8 Data collection and analysis

The data were double-entered and validated in EpiInfo 6.04 (CDC Atlanta, USA, 2001). Data analysis was carried out in Stata 8 (Stata Corp. Texas, USA, 2003). Explanatory variables were age group, sex, residence, education level, axillary temperature, fever duration, bednet usage, urban agricultural activity, water resources and previous malaria infection within one month, as well as whether the patients had visited a rural area. The X^2 test was applied to assess associations between categorical variables. Logistic regression was performed to assess the association between binary outcomes and explanatory variables, adjusted for the confounding effects of age groups.

List of abbreviations

CNRFP	Centre National de Recherche et de Formation sur la Paludism, Burkina Faso
CMOH	Regional/city office of health of Dar es Salaam
CREC	Centre de Recherche Entomologique de Cotonou
EIER	Ecole Inter-Etats d'Ingénieurs de l'Equipement Rural, Burkina Faso
GIS	Geographic Information System
GPS	Global Positioning System
INS	Institut National et de la Statistique, Côte d'Ivoire
INSAE	Institut National de la Statistique et de l'Analyse Economique-Bénin
INSD	Institut National de la Statistique et de la Démographie-Burkina Faso
ITNs	Insecticide-Treated Nets
MOH	Ministry of Health
MUCHS	Muhimbili University College of Health Sciences and Medical Centre
NGO	Non-Governmental Organization
RUMA	Rapid Urban Malaria Appraisal
WBC	White Blood Cells

Chapter 4

RUMA Review

4. CHAPTER: RUMA REVIEW

Rapid urban malaria appraisal (RUMA) in sub-Saharan Africa I

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4.1 Abstract `

Background: The rapid urban malaria appraisal (RUMA) methodology aims to provide a cost-effective tool to conduct rapid assessments of the malaria situation in urban sub-Saharan Africa and to improve the understanding of urban malaria epidemiology.

Methods: This work was done in Yopougon municipality (Abidjan), Cotonou, Dar es Salaam and Ouagadougou. The study design consists of six components: 1) a literature review, 2) the collection of available health statistics, 3) a risk mapping, 4) school parasitaemia surveys, 5) health facility-based surveys and 6) a brief description of the health care system. These formed the basis of a multi-country evaluation of RUMA's feasibility, consistency and usefulness.

Results: A substantial amount of literature (including unpublished theses and statistics) was found at each site, providing a good overview of the malaria situation. School and health facility-based surveys provided an overview of local endemicity and the overall malaria burden in different city areas. This helped to identify important problems for in-depth assessment, especially the extent to which malaria is over-diagnosed in health facilities. Mapping health facilities and breeding sites allowed the visualization of the complex interplay between population characteristics, health services and malaria risk. However, the latter task was very time-consuming and required special expertise. RUMA is inexpensive, costing around 8,500-13,000 USD for a six to ten-week period.

Conclusion: RUMA was successfully implemented in four urban areas with different endemicity and proved to be a cost-effective first approach to study the features of urban malaria and provide an evidence basis for planning control measures.

4.2 Background

Urbanization has a significant impact on the economy, lifestyles, ecosystems and disease patterns, including malaria (Hay et al., 2005; Omumbo et al., 2005a). An estimated 39% of the population in sub-Saharan Africa (SSA) lived in urban areas in 2003 (United Nations, 2003), 198 million Africans lived in urban malaria-endemic areas and 24-103 million clinical attacks occur annually in those areas (Keiser et al., 2004). An important message addressed in the Pretoria Statement on urban malaria was that the malaria control strategies used in rural areas cannot be directly transferred to the urban context (Donnelly et al., 2005). The epidemiology of urban malaria poses a number of specific challenges: i) the first malaria infection occurs often late in childhood and the acquisition of semi-immunity is delayed (Trape, 1987); ii) the intensity of the malaria risk is often heterogeneous over small distances, being subjected to the degree of urbanization of particular subdivisions (Robert et al., 2003; Trape and Zoulani, 1987) and their proximity to possible vector breeding sites (Staedke et al., 2003; Trape et al., 1992); iii) rural-urban migration is likely to increase the endemicity of malaria (Benyoussef et al., 1976); iv) agricultural and animal husbandry are important economic activities which create a favourable environment for *Anopheles* breeding (Afrane et al., 2004; Robert et al., 1998); v) marginalized populations usually lack access to health care, which hampers the effectiveness of case management and the promotion of intermittent antimalarials during pregnancy (Donnelly et al., 2005; Massele et al., 1997; Noor et al., 2003; Sanon, 1999). There is now substantial private sector activity in health care provision in many cities. The private services providers are often untrained or unlicensed, but are seen as a source of inexpensive care by patients. There is not much information about the impact of the private sector on case management.

Around 235 papers related to malaria epidemiology in SSA urban settings were published from 1974 to 2004. Entomological profiles and clinical patterns are known to vary between urban, suburban and rural environments (Modiano et al., 1999). A review of other studies in SSA urban centres showed that transmission patterns vary greatly by city, season and age group. The overall prevalence of parasitaemia was 4.0% in schoolchildren in Brazzaville (Trape et al., 1987), 2.4-10.3 % in Lusaka (Watts et al., 1990), 2.0% in a Gambian urban area (Lindsay et al., 1990) and 3.6-7.5% in Dakar (Trape et al., 1993). It was also reported that malaria prevalence in school children varied from 3.0% to 26.4% in different areas of Ouagadougou (Sabatinelli et al., 1986a) and varied from 14% in a central urban area to 65% in peri-urban areas in Kinshasa (Kazadi et al., 2004).

Evidence showed that the rate of clinical malaria attacks detected in urban health facilities was high and season-dependent. For example, Hendrickse *et al.* found that 36.8% of outpatients were parasitaemic in a hospital in Ibadan (Hendrickse, 1976). In Niamey, the parasite prevalence was 61.9% during the rainy season but only 5.4% in the dry season in 1989 (Olivar et al., 1991). In Kinshasa, malaria admissions comprised 29.5% of consultations in 1983, then 38.2% in 1985-86 (Greenberg et al., 1989). In Dakar, malaria fever represented 19.7% of consultations and 34.3% of fever cases were caused by malaria in 1988 (Gaye et al., 1989); the same authors found that 5.3% (dry season) and 58.8% (rainy season) of febrile outpatients were parasitaemic in 1994 (Gaye et al., 1997). In Ouagadougou, malaria prevalence accounted for 33% of all outpatients(Coulibaly et al., 1991), while Dabire reported 22% malaria parasitaemia among children aged 0-14 years in the paediatric ward (Dabire, 1990).

Transmission and severity of malaria are influenced by the geographic characteristics of a town and by the socio-economic environment. The heterogeneity and seasonal variation of the entomological inoculation rate, depending on both vector densities and sporozoite rates, have been documented (Akogbeto et al., 1992a; Sabatinelli et al., 1986b). Lindsay *et al.* (1990) showed a difference in the composition of vector species and the vector's adaptation in different subdivisions Banjul (Lindsay et al., 1990). To improve interventions, the determinants of the diversity of transmission levels within subdivisions of a city should be understood. Concerns were raised about the association between urban agricultural activities or local irrigation systems and the creation of breeding sites for *Anopheles* sp. (Afrane et al., 2004; Brock, 1999; Gerstl, 2001). Peri-urban areas often lack infrastructure, including poor water supply and sanitation, which provides an ideal environment for vector breeding (Knudsen and Slooff, 1992). For example, urban Dakar has >5,000 market-garden wells which provide permanent sites for mosquito larvae (Robert et al., 1998). An identification of vector species, regular larval inspection and larviciding activities should be implemented in the framework of urban malaria control programmes (Caldas de Castro et al., 2004).

This article presents the experience of developing a rapid urban malaria appraisal (RUMA) in SSA, carried out with the support of the Roll Back Malaria Partnership. The aims were i) to develop a rapid assessment package that is explicitly evidence-based and can be carried out within a six to ten weeks timeframe; and ii) to assess how rapid malaria appraisal efforts could be best integrated into the municipal health department supervision and to inform control programmes.

4.3 Methods

4.3.1 Study sites

The fieldwork took place in Yopougon municipality/Abidjan (Côte d'Ivoire), Ouagadougou (Burkina Faso), Cotonou (Benin) and Dar es Salaam (United Republic of Tanzania) (Figure 4-1). Abidjan is the economic capital of Côte d'Ivoire. It is located between latitude 3.7° N-4.0° N and longitude 5.7° E-6.0° E, with a surface area of 454 sq. km. The study was carried out in the large commune of Yopougon (population: 775,000 in 1998) located in the west of Abidjan (Daigl, 2002). The fieldwork in Yopougon municipality (Abidjan) took place from August to September 2002.

Ouagadougou, the capital of Burkina Faso, is situated on the Sahelian border between latitude 12.0° N-13.0° N and longitude 1.15° E-1.40° E. The total surface area was estimated to be around 570-655 sq. km in the year 2000(Institut National de la Statistique et de la Démographie (INSD), 2000). The population of Ouagadougou was around 1,100,000 inhabitants in 2002. The fieldwork in Ouagadougou took place from November to December 2002.

Cotonou is the economic capital of Benin. It is located on a strip of land between Lake Nokoué and the Gulf of Guinea (between latitude 6.2° N-6.3° N and longitude 2.2° E-2.3° E). The total population was estimated at 780,000 inhabitants on a territory of 73.8 sq. km in 2002 (Institut National de la Statistique et de l'Analyse Economique Bénin (INSAE), 2003). The fieldwork in Cotonou took place from February to March, 2003.

Dar es Salaam is situated between latitude 6.0° S-7.5° S and longitude 39.0° E-39.6° E on the East African coast. There are 2,500,000 inhabitants on a total surface area of 1,393 sq. km (Damas K. Mbogoro, 2002). The fieldwork in Dar es Salaam took place from June to August, 2003.

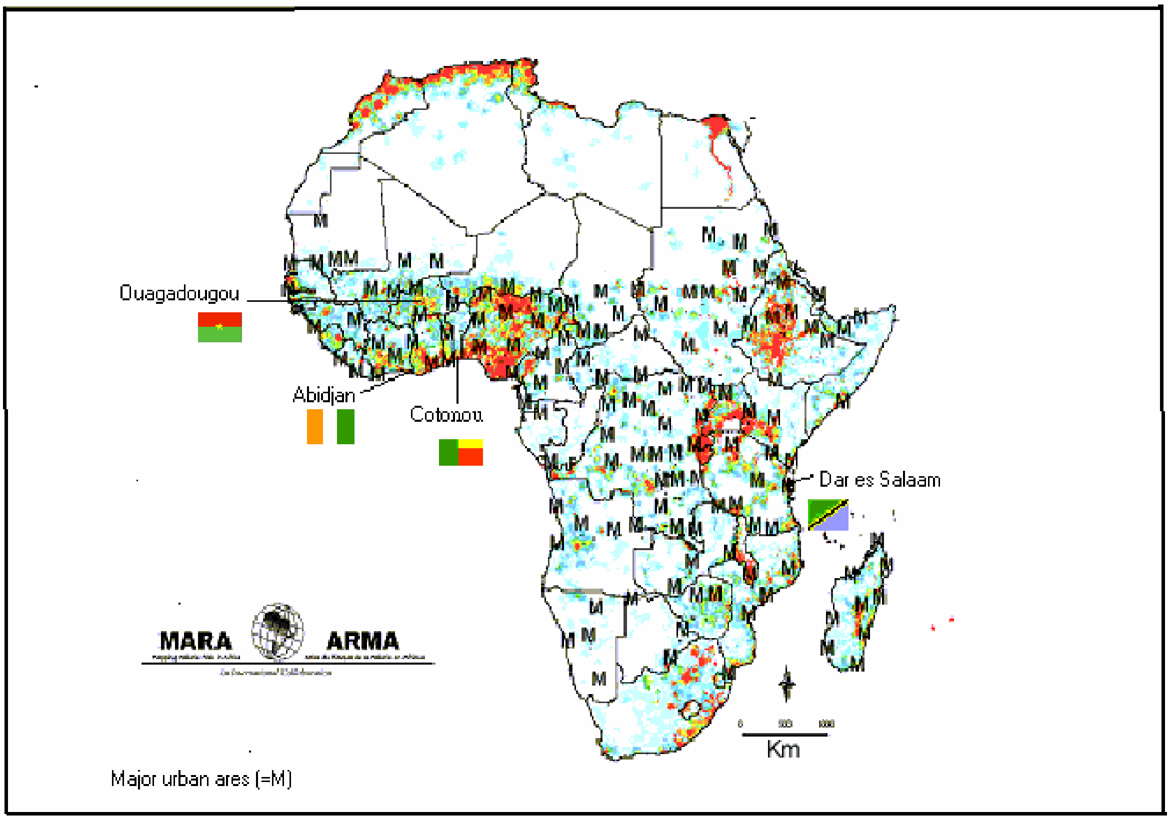

Figure 4-1 Map of major urban areas in sub-Sahara Africa and the four selected project sites. Major cities (=M) and population density (red >=200, green >100 and blue=40 population per square kilometres. Copyright: MARA/ARMA.

4.3.2 Study design

In July 2002, a generic RUMA protocol was developed based on existing urban malaria research protocols (Warren et al., 1999; WHO, 2001). The relevant institutions in each setting were contacted and city-specific proposals were then produced. Parts of health facilities mapping, school and health facility-based survey activities were integrated into the routine surveillance and health system evaluation at the municipal level. All the fieldwork was completed in August 2003. Final reports were completed in June, 2004. The six key components of the RUMA were the following (see also Table 4-1):

Table 4-1 Study design and methodology of RUMA.

Key measures	**Epidemiological measures**			**Spatial relationships**			**Individual variations**			**Institutional factors**		
Methodology	Age-specific morbidity and mortality rates	Fraction of malaria-attributable fevers	Overall endemicity	Gradient of malaria risk	Environmental risks	Travelling history	Socio-economic factors	Bednet usage	Treatment strategy	Public/private partnership	Coverage of treatment providers	Degree of drug resistance
1. Literature review	x		x	x	x		x	x	x			x
2. Collection of health statistics			x					x	x			x
3. Risk mapping				x	x						x	
4. School parasitaemia survey			x	x	x	x	x	x	x			
5. Health facility-based fever survey	x	x		x	x	x	x	x	x			
6. Brief description of the health care system										x	x	x

Literature review

A search of the PUBMED bibliographic database was conducted for the time period from 1945 to April 2004, using the terms “malaria”, “urban” and “sub-Saharan Africa”. The search was limited to the articles published in English, Chinese, French and Spanish. The reference list of all identified papers was screened. Thesis abstracts filed in the medical libraries of universities and national hospitals were collected at each site and local researchers were also contacted.

Collection of routine health statistics

Local experts in ministries of health (MOH) (disease surveillance systems, municipal health departments and national malaria control programmes) and national census and statistics bureaus were contacted to collect demographic data, health system information and statistics, including routine malaria morbidity and mortality reports.

Mapping of health care facilities and major Anopheles breeding sites

Three or four trained workers carried out the health facility mapping under the guidance of local health personnel. In order to identify *Anopheles* breeding sites, simple larvae sampling was performed with the assistance of entomological technicians in Dar es Salaam and Ouagadougou. The duration of these tasks varied by site: 12 weeks during the rainy season in Dar es Salaam and around three weeks during the dry season in Ouagadougou. Due to security issues and technical problems, the mapping of breeding sites and health facilities could not be performed in Yopougon municipality (Abidjan) and Cotonou.

School parasitaemia surveys

School surveys were aimed at determining the local endemicity and risk gradient of malaria. In each city, three to four schools with different malaria endemicity (centre/low, intermediate/medium and periphery/high) were investigated. It is a rapid assessment with limited budget; therefore, in each area only one health facility and school were selected for the surveys. The schools were selected near the selected clinics. 200 school children aged 5-10 years were recruited in each school. Additional information on children was collected using a questionnaire with the assistance of teachers (Annex 1).

Health facility-based surveys (Annex 2)

The facility-based fever surveys focused on the age-specific fraction of malaria-attributable fevers (Smith et al., 1994). Each city was categorised into three to four areas (centre, intermediate, periphery and rural areas) and one clinic from each area was chosen. Health facilities with a high enough volume of outpatients per day were considered for the survey. In urban areas, an estimated 5 % to 50% of fever cases among children under 15 years old were due to malaria. A sample size of 200 in each facility gave an estimate of the proportion of cases with parasites with the following approximate lower 95% confidence limits (at 5%, lower 95% CI: 2; at 50%, lower 95% CI: 6). In each clinic, 200 fever cases and 200 non-fever controls were recruited, with half of them being aged <5 years. Outpatients with a history of fever (past 36 hours) or a measured temperature ≥ 37.5°C were defined as cases. Controls were recruited from another department of the same clinic without current or recent past fever, matched by age and residency.

Electronic thermometers were used to measure the armpit temperature. A "normal" body temperature is referred to as an oral temperature of 37 °C. An armpit temperature reading is usually 0.3°C to 0.6°C lower than an oral temperature reading. Therefore 0.5 °C was added to the temperature displayed on the digital readout. Thick and thin blood films were taken to identify malaria infections. Using 100X magnification to read the thick smears, all malaria trophozoites and gametocytes were counted separately. Parasite density was calculated according to parasites per 200 white blood cells in a thick film (assuming 8000 white blood cells per ml of blood). If 200 white blood cells were counted and less than 9 malarial parasites found, the counting continued until 500 white blood cells were identified.

Brief description of the health care system

It focused on i) the municipal malaria control and prevention efforts, ii) the levels and coverage of service delivery, iii) disease surveillance systems, iv) malaria case management and v) trends of parasite resistance to antimalarials.

4.3.3 Quality assurance for blood slides

The diagnostic performance and the quality of blood sample readings were checked twice: first in the field and then at the reference laboratory of the Swiss Tropical Institute (STI) in Basel, Switzerland. The results in Yopougon municipality (Abidjan), Dar es Salaam and Ouagadougou were: sensitivity 87.9%, 83.5% and 98.7%; specificity 89.2%, 99.0% and 98.2%; accuracy rate of slide readings 88.8%, 98.5% and 98.6%. The quality control process was not implemented in Cotonou due to operational problems.

4.3.4 Costing

The financial cost of the resources required for a RUMA were calculated for each site based on local market prices and salary standards, except for the laboratory material that was purchased in Switzerland. All expenses fell into seven categories: salaries, transportation, communications, stationery, laboratory materials, other cost and administrative fees (Table 4-2). A project team was assembled within the existing structure of partner institutions and then the accountants in each site used a setting-specific cost model to identify the cost factors and determine their local value. The preparation and training cost, programme and administrative costs with the partner institution were estimated and an allowance was added for unforeseen circumstances in the finalized budget. The cost for resources like microscopes and drugs for treatment, vehicles and computers were calculated according to the cost structure of the host institution.

Table 4-2 Budget categories.

Type of cost	Categories	Valuation	Information source
Human resources	Project staff Health sector staff	Gross salary Per diem	Salary slips or personnel records from the project office
Transportation	Project vehicles, petrol and maintenance Taxi, motorbike and Shipping and packaging	Petrol and maintenance of vehicles based on vehicle logbook Actual expenditure Freight cost	Bills and receipts Tickets and receipts Invoices
Communication	Postage and telephone bills		Bills or contract documents
Stationery	Office maintenance cost Survey materials Photocopies Lap top and printer use	Actual expenditure for items	Agreement with site Agreement and receipts Standard local cost Agreement with site
Laboratory materials & drugs for treatment		International trade good price	Invoices
Other items			Bills and receipts
Administration	Rent of project office, computer and vehicles		Agreement with site

4.4 Results

One of the principal aims of the present work was to review the feasibility, perceived usefulness and consistency of the collected information. Because RUMA was a cross-sectional assessment the external validity of the findings could not be assessed. However, the internal consistency of the results was assessed.

Below, the strengths and weaknesses of each methodology are presented, bearing in mind the constraints imposed by a rapid assessment. Detailed results for each site will be provided in a series of forthcoming publications.

4.4.1 Literature review (Tables 1 and 3)

The systematic review of all literature in each city allowed the collection of background information in a time-efficient manner. A substantial body of information was found in each setting, although it was often incomplete in place (for example covering only a part of the city), in time (few time points, only one season) and in content (not all subject areas covered). For the period 1945 to 2004, a total of 109 papers was found (18, 23, 29 and 39 for Abidjan, coastal Benin, Dar es Salaam and Ouagadougou, respectively), relating to malaria epidemiology, socio-economic risk factors of malaria, entomology and drug resistance (Wang et al., 2002).

4.4.2 Collection of health statistics (Tables 1, 3 and 4)

The routine weekly or monthly malaria reports provided a baseline on the burden of malaria in public health facilities, as well as an assessment of the scale of malaria treatment. Overall, case detection in the antenatal clinics and public health services was poor and reporting was not systematic and consistent.

In Abidjan, data were collected from the national malaria control programme (Table 4-4a).

Age-specific monthly data were available. The statistics for 2001 from four out of 10 communes were missing. The malaria cases reported from the main hospitals (Centre Hospitalier Universitaire-CHU) in Yopougon, CHU Cocody and CHU Treichville were separated from the commune data. CHU receive many referral patients and the malaria cases may therefore be over-reported. The data from CHU Yopougon were missing for 2001.

In Ouagadougou, the number of malaria-specific cases and the total number of consultations were collected (Table 4-4b). The raw data were available by season for 1999-2001, but not for 2002. All the data were missing for Paul VI sanitary district from October to December 2001. The reporting of clinical malaria was also inconsistent in Paul VI.

In Dar es Salaam, the weekly malaria reports were collected from the Ilala, Kinondoni and Temeke district health departments (Table 4-4c). The data were available for 2000-mid 2003, two months before the survey. A discrepancy in records in Kinondoni District was found, as not all health facilities sent their weekly reports to the district municipal office. Moreover, the sums of reported malaria cases in the raw dataset and in the final district reports were not identical. The Kinondoni district health department had lost all of its 2001 weekly reports.

Only Cotonou had complete data sets for 1996-2002, but the raw datasets were unavailable. Hence, it was impossible to review the consistency and accuracy of the data (Table 4-4d).

Overall, considerable gaps were found in the routine surveillance systems, particularly for remote health services. Often, the data were collected and presented in different formats, making a generalization impossible and this limited their usefulness. Furthermore, the municipal health departments simply summed up the total numbers of reported cases as they lacked the capacity to analyse these data and to extract useful information for management purposes.

Table 4-3 RUMA methodology strengths and weaknesses.

RUMA Methodology	Strengths	Weaknesses
Literature review	● Time-saving, can be done before and afterwards ● Can identify qualified local expertise ● Comparison of the malaria patterns and trends	● Incomplete information in time and space
Collection of health statistics	● Good description of malaria burden over a longer time period	● Completeness and quality of data
Cross-sectional mapping of healthcare facilities & major *Anopheles* breeding sites	● Visualization of information for policy makers ● Helps to plan urban health programmes and upgrade community infrastructure	● Time consuming and only limited scale possible ● Breeding sites may be transient /seasonal
School parasitaemia surveys	● Good estimates of local endemicity and local risk factors ● Good description of fever prevalence in school ● Malaria risk gradient	● Limited representativeness if only small number of schools were sampled
Health facility-based fever surveys	● Estimates malaria-attributable fevers and prevalence of clinical malaria ● Description of fever management	● Limited representativeness due to attendance bias
Brief description of the health care system	● Understanding of the structure of city health department and of current malaria control activities ● Limited cost ● Review of the efficacy of case management	● Only focuses on the available information ● Depends on the efficiency of information dissemination within municipal departments

Table 4-4 Reported simple malaria cases among total consultations in 4 African cities, all ages. CHU=Centre Hospitalier Universitaire.

a) Abidjan 2001

Communes	Adjamé & Attécoubé	Cocody	Yopougon	Abobo	Plateau	Treichville & Marcory	Port-Bouét & Koumassi	Total	% of total consultations†
Health centers	35,714	55,500	-	71,437	-	-	62,607	225,258	
CHU	No CHU	2,525	-	No CHU	No CHU	12,375	No CHU	14,900	
Malaria cases	35,714	58,025	-	71,437	-	12,375	62,607	240,158	40.2

b) Ouagadougou 2001

Sanitary District	Kossodo	Paul VI	Pissy	Secteur 30	Total	% of total consultations
Malaria cases	16,007	24,527	95,868	67,064	203,466	29.3-41.4

c) Dar es Salaam 2000

District hospitals‡	Ilala	Kinondoni	Temeke	Total	% of total consultations
Malaria cases	178,016	498,991	395,566	1,072,573	45.4-53.7‡

d) Cotonou 2002

Sanitary District	I	II	III	IV	V	VI	Total	% of total consultations
Malaria cases	6,759	9,678	17,339	7,108	29,890	29,483	100,257	32.1-35.9

† Reported number of malaria cases divided by the total number of consultations.

‡ Both Ilala and Temeke district hospitals have malaria reported weekly and monthly. The raw dataset of malaria reports of district hospitals in Kinondoni was missing in 2001.Total numbers of consultations were estimated.

4.4.3 Mapping activities (Tables 1 and 3)

As stated above, the mapping activities were only done in Ouagadougou and Dar es Salaam.

a) Public and private health facilities

In Dar es Salaam, the list of existing public and private health facilities was updated and their locations were recorded by a geographic positioning system (GPS). In Ouagadougou, the mapping of health facilities and schools was done in 2002 by the Ecole Inter-Etats d'Ingénieurs de l'Equipement Rural (EIER), Burkina Faso. Both digital city maps were updated and available for public use.

b) *Anopheles* breeding sites

The malaria risks in Dar es Salaam and Ouagadougou were displayed in relation to the location of health facilities and schools. The mapping of *Anopheles* breeding sites in Dar es Salaam was done on a city wide-scale in conjunction with another project (Caldas de Castro et al., 2004; Sattler et al., 2005). In Ouagadougou, in the limited time available, the focus was on permanent and semi-permanent breeding sites instead of searching for the numerous temporary breeding sites. The produced maps of breeding sites indicated mosquito productivity and distribution in the city in a given season.

The major drawback of mapping is that ground-truthing is very time-consuming and variable over time. During the rainy season, the city-wide larvae collection, larvae hatching and management of data are difficult tasks. Another disadvantage of this approach is that it tends to be very expensive, unless local Geographic Information Systems (GIS) mapping expertise and/or digital city maps are already available for public use. For future studies, it is recommended focusing on the mapping of health facilities and dropping the breeding sites work as it is difficult to assemble a team with the required expertise within such a short time period.

4.4.4 School parasitaemia surveys (Tables 1 and 3)

It was possible to determine the transmission intensity and gradients in different communities. At each site, parasitaemia and fever prevalence rates were obtained for different schools (Figures 4-2a-c) and by residential areas of children. Around 10 to 70% of children (from city centre to periphery) attended schools with elevated temperature. Malaria prevalence was always higher than the fever prevalence in Ouagadougou since there were many asymptomatic infections. Different communities in Ouagadougou may be exposed to different patterns of malaria transmission and hence the age at first infection and infection patterns may vary. Certainly, the more exposed areas of Ouagadougou experience hyperendemic (if seasonal) malaria. The association between malaria infections and various risk factors were measured and these results are reported elsewhere (Wang et al., 2004a; Wang et al., 2004b; Wang et al., 2004c; Wang et al., 2004d).

4.4.5 Health facility-based surveys (Tables 1, 3 and 5)

Both the fever and control groups (non-febrile admission) had a medium level of parasitaemia prevalence in the health facilities in Yopougon municipality (Abidjan) and Ouagadougou (Table 4-5). Some people in the control groups reported self-medication with paracetamol or traditional herbs before visiting the clinics. This could have led some malaria cases to present without fever at the clinic. The overall prevalence of malaria was surprising low in Cotonou and Dar es Salaam. This might have been due to high Insecticide Treated Nets (ITNs) coverage and/or the dry climate at the time of survey.

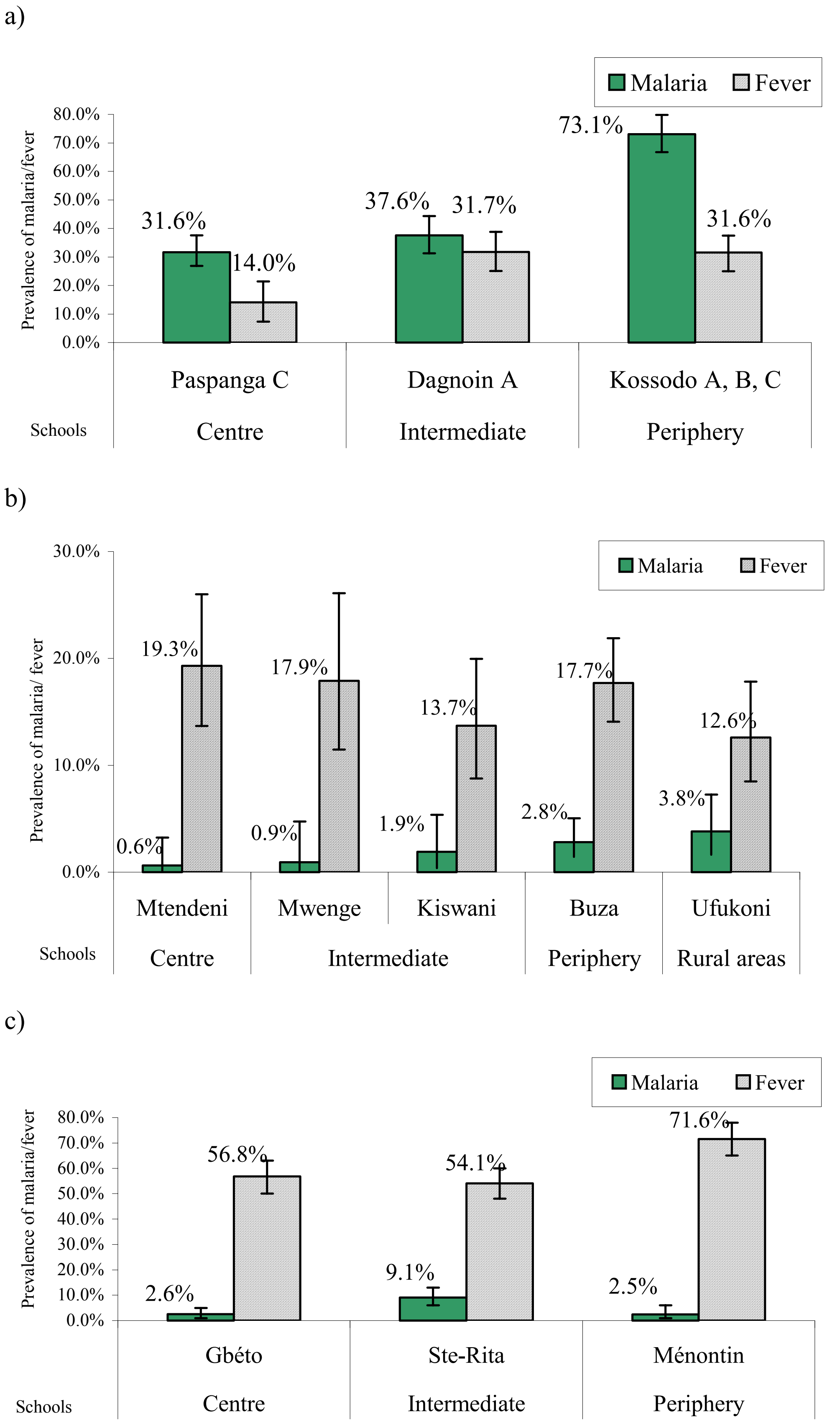

Figure 4-2 Prevalences of parasitaemia and fever detected in schools, in three sites. The vertical bars represent the 95% CI. a) Ouagadougou, b) Dar es Salaam, c) Cotonou

The detection of malaria parasites in a febrile case does not necessarily indicate clinical malaria. In an effort to improve the case definition and clinical diagnosis, the method of Smith *et al*. (Smith et al., 1994) was used to estimate the probabilities that individual episodes were really due to a malaria infection. The odds ratio (OR) is the proportion of odds of having parasitaemia in fever cases over controls. The formula for the fraction of fever episodes attributable to malaria parasites is: (1-1/Odds Ratio)*P. P is the proportion of fever episodes in which the subjects had parasitaemia. These age-specific malaria attributable fractions were very low: 0.12-0.27, 0-0.04, 0-0.02 and 0-0.13 in Yopougon municipality (Abidjan), Benin, Dar es Salaam and Ouagadougou, respectively. These results indicated substantial over-treatment at all sites (Wang et al., 2004a; Wang et al., 2004b; Wang et al., 2004c; Wang et al., 2004d).

The questionnaires (Annexes 1 and 2) administered to cases and controls were tailored for local use. They contained four sections: personal information, economic situation of the family, travelling history, clinical signs and malaria history. The information on age, sex, measured axillary temperature, length of febrile illness, types of previous treatment and the reasons for seeking care were obtained. Stay outside the urban area during the previous three months, the type of housing, urban agriculture activities and ITNs usage were also investigated. These data provided indications of disease perception, preventive measures and socio-economic background at community level.

The questionnaires administered to cases and controls in health facilities were similar to the ones used in school surveys. In all settings the two sets of data were comparable, which allowed for an internal consistency check. For example, in Dar es Salaam 43.1% and 40.2% of households reported ITN use in both the health facility surveys and the school parasitaemia surveys. In Cotonou, these figures were 36.6% and 28.4%, in Ouagadougou 7.8% and 11.1%. The similarity of both surveys also made possible a combined planning and implementation strategy. Detailed results are presented elsewhere (Wang et al., 2004a; Wang et al., 2004b; Wang et al., 2004c; Wang et al., 2004d), as well as in a series of forthcoming publications.

4.4.6 Brief description of the health care system (Tables 1 and 3)

The administrative structures of the national and municipal health departments were sketched out and the list of health facilities was updated at each site. The total numbers of registered malaria diagnosis or treatment providers were: 1060 in Abidjan, 365 in Cotonou, 1684 in Dar es Salaam and 315 in Ouagadougou. Non-governmental organizations and religious hospitals play an important role in health care delivery in Cotonou and Ouagadougou. The catchment areas of all public and private health facilities were further calculated. The city malaria control programmes and WHO offices provided information about current malaria control efforts. In order to assess treatment efficacy, the trend of the susceptibility of *P. falciparum* to different antimalarials was reviewed at each site (Wang et al., 2004a; Wang et al., 2004b; Wang et al., 2004c; Wang et al., 2004d).

This component required few resources and brought strong political commitment because it involved representatives of the Ministry of Health and the Directors of the municipal health department. The extra-budgetary resources from RUMA helped the local governments to better monitor the provision of health care services, which facilitated an effective exchange of information. The health information was updated but the quality of health care delivery was not assessed because of restricted scope and time. The disadvantage of this approach is that effective communication and dissemination of official documents depends on the attitude of senior officers.

4.4.7 Compared costing of RUMA activities

The cost for conducting a RUMA in a SSA city with a population of 0.5-3 million is around 8,500-13,000 USD for a six to ten-week period (Table 4-6). The cost of human resources in Dar es Salaam and Ouagadougou was highest, mainly because of the additional fieldwork performed there (mapping of breeding sites and health facilities). Indeed, the per diem standard was lower in these cities. The higher savings on transportation, communications and materials in Abidjan and Ouagadougou were made possible by our affiliation with local research institutions. The total expense in Abidjan was much lower because the school survey was not performed (the children did not attend school during a politically troubled time). In Cotonou, the excess of human resource and transportation cost was due to unforeseen supervisory expenses.

In general, the difference in the cost of human resources and communications was due to differences in personnel capacity and fluctuations in the amount of work. The costs of stationery and laboratory materials were less variable, because the needs were the same at each site.

4.5 Discussion and conclusions

This assessment was accomplished in four countries within a period of six to ten weeks in the field and has proven to be a helpful tool in supporting planning of urban malaria control. An ongoing urban malaria control intervention in Dar es Salaam has been initiated on the knowledge basis provided by RUMA. With the incentive of extra-budgetary resources and technical support from STI, local partners were committed to incorporate RUMA into existing activities at the municipal level. Qualified personnel and opportunities for integration, synergy and co-ordination were identified during the meetings with local partners and the collaborations were always very successful.

The RUMA methodology is a cross-sectional design and the results are likely to change over time due to seasonality, the dynamics of urbanization and the evolution of malaria transmission. In Dar es Salaam, for example, the surveys were carried out during an exceptionally dry period and results could underestimate the true transmission intensity. Many factors such as the size of the city, the fieldwork logistics, the availability of local expertise and the coordination with local senior officers can influence the schedule and planning, as well as the outcome of such surveys.

The study highlighted the need for improved Health Management Information Systems (HMIS) in SSA urban areas. Municipal health departments routinely collect health facility data but information is rarely fed back to the districts and facilities that generate the information. The data are often not available for analysis or accessible due to false registration and under-reporting from health facilities, as well as poor filing and storage of documents at the district or municipal level. In addition, the low number of true malaria cases among fever episodes treated as “malaria” raises the issue of the validity of the collected data even further. Hence, much progress needs to be made in order to estimate more accurately the urban malaria burden and plan relevant control measures.

GIS provides a platform to display health services and geographic features in relation to population settlements. In this experience policy-makers could readily use the presented information for improved planning, re-allocation of resources and for strengthening the networking between the public and private sectors. While the GIS technology has been shown to be very useful in studying health care delivery and distribution of diseases, its application in an entomological assessment was quite difficult and costly and could only be done in conjunction with other ongoing projects. Hence it should be excluded from the process of RUMA. In contrast, the mapping of health facilities with GIS was feasible and cost-effective.

While results from the school surveys gave an indication of the endemicity range and risks in the targeted community, they cannot be considered as being representative without a wider survey. The variations of malaria risk were sometimes related to political divisions or man-made boundaries, but often were due to divergent socio-environmental factors and the degree of urbanization. Because site-specific environmental conditions lead to an aggregated distribution of vectors and different malaria risks, the sampling sites were selected taking into account the population density, the natural environment and urbanization patterns. This should improve the rough categories that previous researchers applied (centre, intermediate and periphery).

Despite a potential attendance bias, the health facility surveys allowed the determination of prevalence of parasitaemia among presenting clinical cases, and the calculation of the fraction of malaria-attributable fevers. This allowed the high rate of malaria mis-diagnosis in the health facilities to be clearly documented. This information is of great importance for urban malaria control.

Overall, RUMA is a first step towards understanding malaria endemicity and designing control strategies. It has highlighted the concern for mis-diagnosis of clinical malaria in SSA cities (Amexo et al., 2004; Olivar et al., 1991). A report by the Tanzania-Japan malaria control programme in Dar es Salaam mentioned that drug administration to diagnosed children was one of the essential interventions that reduced the malaria rates between 1988 and 1996 (Caldas de Castro et al., 2004). An in-depth research is now being implemented in Dar es Salaam to assess the malaria burden with a much larger sample size. The application of RUMA methodology is possible and desirable in other SSA urban areas and it should have a special focus on improved diagnosis.

Authors' contributions

SW participated in the design of the study, conducted the field work, analyzed and interpreted data and drafted the manuscript. CL conceived the study, coordinated the field work and revised the manuscript. TS and PV assisted in the design and the statistic analysis. CG, DD, MA and DM were the key local contacts, facilitated the collaboration and supervised the data collection and laboratory works at each site. AT participated in the design of the study. MT participated in the conception of the work, facilitated the overall coordination and revised it critically at all stages.

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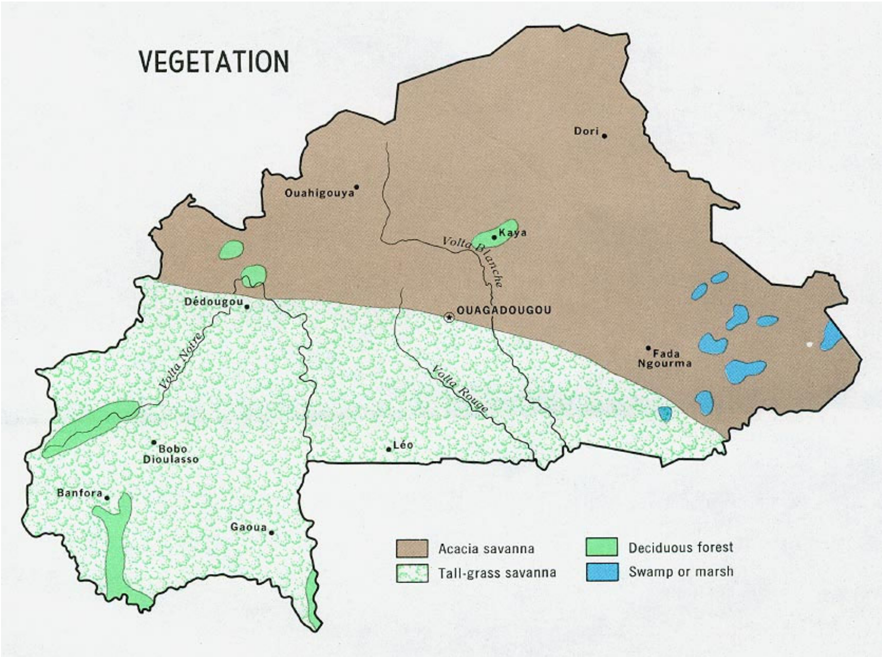
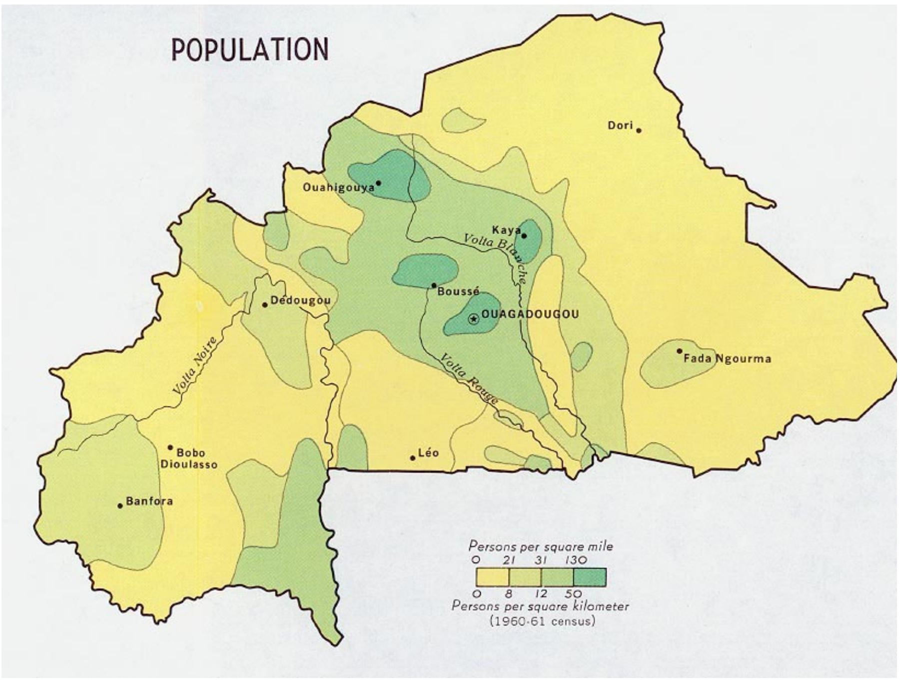
List of abbreviations

CHU	Centre Hospitalier Universitaire
CNRFP	Centre National de Recherche et de Formation sur la Paludisme, Burkina Faso
CREC	Centre de Recherche Entomologique de Cotonou
CSRS	Centre Suisse de Recherches Scientifiques, Côte d'Ivoire
EIER	Ecole Inter-Etats d'Ingénieurs et de l'Equipement Rural, Burkina Faso
GIS	Geographic Information System
HMIS	Health Management Information Systems
ITNs	Insecticide-Treated Nets
MOH	Ministry of Health
RUMA	Rapid Urban Malaria Appraisal
SSA	Sub-Saharan Africa
STI	Swiss Tropical Institute

Chapter 5

Ouagadougou





5. CHAPTER: OUAGADOUGOU

Rapid urban malaria appraisal (RUMA) I:

Epidemiology of urban malaria in Ouagadougou (Burkina Faso)

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5.1 Abstract

Background: Rapid urbanization in sub-Saharan Africa has a major impact on malaria epidemiology. While much is known about malaria in rural areas in Burkina Faso, the urban situation is less well understood.

Methods: An assessment of urban malaria was carried out in Ouagadougou in November -December, 2002 during which a rapid urban malaria appraisal (RUMA) was applied.

Results: The school parasitaemia prevalence was relatively high (48.3%) at the cold and dry season 2002. Routine malaria statistics indicated that seasonality of malaria transmission was marked. In the health facilities, the number of clinical cases diminished quickly at the start of the cold and dry season and the prevalence of parasitaemia detected in febrile and non-febrile cases was 21.1% and 22.0%, respectively. The health facilities were likely to overestimate the malaria incidence and the age-specific fractions of malaria-attributable fevers were low (0-0.13). Peak prevalence tended to occur in older children (aged 6-15 years). Mapping of *Anopheles* sp. breeding sites indicated a gradient of endemicity between the urban centre and the periphery of Ouagadougou. A remarkable link was found between urban agriculture activities, seasonal availability of water supply and the occurrence of malaria infections in this semi-arid area. The study also demonstrated that the usage of insecticide-treated nets and the education level of family caretakers played a key role in reducing malaria infection rates.

Conclusion: These findings show that determining local endemicity and the rate of clinical malaria cases are urgently required in order to target control activities and avoid over-treatment with antimalarials. The case management needs to be tailored to the level of the prevailing endemicity.

5.2 Background

An estimated 200 millions people live in urban malaria endemic areas in Africa (Keiser et al., 2004) and a high proportion of clinical admissions in these areas are treated as malaria. Urban malaria poses a major challenge for health care systems in Africa. The impact of urbanization and uncontrolled population growth on malaria endemicity needs to be established (Donnelly et al., 2005; Hay et al., 2005; Omumbo et al., 2005a; Robert et al., 2003).

Epidemiological profiles and clinical patterns are known to vary between urban, suburban and rural environments in Burkina Faso (Modiano et al., 1999). Sabatinelli *et al.* (Sabatinelli et al., 1986a) collected blood samples from 2,117 children aged 0-5 years in Ouagadougou and reported prevalence rates of 3.0%, 9.5%, 20.0%, 15.6%, 21.8% and 26.4% in sectors 1, 8, 11, 14, 22 and 23, respectively. These findings showed a gradient of malaria incidence from the centre (lowest risk) to the areas close to an artificial lake (highest prevalence). Dabire (Dabire, 1990) further categorized the residence of patients into 1) town centre, 2) the areas across the canals and 3) the shore areas of the artificial lake or dam (*barrage*), reporting prevalence rates of 13.1%, 25.3% and 31.4%, respectively.

Entomological research in Ouagadougou dates back to the colonial period. The main vectors *Anopheles gambiae s.l., Anopheles funestus* and *Anopheles nili* were already identified in Ouagadougou by Le Gac *et al*., in 1945 (Le Gac et al., 1945). Later, a longitudinal entomological survey (Bosman et al., 1988; Rossi et al., 1986) reported six species of *Anopheles* sp. mosquitoes with *An. gambiae s.l.* and *An. funestus* playing a key role during the dry season. The focality of malaria transmission was also noted. Concerns were also addressed about the breeding of *Anopheles* sp. vectors in large water reservoirs and in the water supply resources (Parent et al., 1997).

A standard study protocol Rapid Urban Malaria Appraisal (RUMA) was developed in June 2002 based on a WHO proposal and an Environmental Health Project draft protocol (Warren et al., 1999; WHO, 2001). RUMAs were commissioned by Roll Back Malaria (RBM) for three francophone countries (Côte d'Ivoire, Burkina Faso and Benin) and one anglophone country (Tanzania). Each of the four assessment reports provides the following: an overview of the urbanization history, an estimate of the fractions of malaria-attributable fevers, parasite rates for different areas, an outline of health care services and highlights of the "lessons learned" from the survey. A separate overview introduces this work in a wider framework (Wang et al., 2005).

The study aimed to compile a minimum dataset on urban malaria features in Ouagadougou within a period of six to ten weeks and to display the malaria risk in relation to population settlements, social and health care services, as well as the environment. The study aimed to provide essential information to better plan malaria control interventions.

5.3 Methods

5.3.1 Study sites and sample selection

Ouagadougou is the capital of Burkina Faso, situated between latitude 12.0° N-13.0° N and longitude 1.15° E-1.40° E, 300 meters above sea level. To the north, the vegetation thins out into sand dunes as it approaches the Sahara. The total area of Ouagadougou was around 570-655 km^2 in 2000 (Institut National de la Statistique et de la Démographie (INSD), 2000). The annual precipitation is 750 to 900 mm. The rainy season is between June and October, the cold and dry season is between November and January and the hot and dry season is between February and May. The average temperature is approximately 19°C in January and 40°C from April to May. The total population in Ouagadougou was around 1,040,000 inhabitants in 2002 (Municipale de Ouagadougou, 2004; World Bank, 2002b).

The sanitary administrative structure is not identical to the political administrative structure. There are five administrative districts, which are divided into 30 urban sectors and 17 peripheral villages (Figure 5-1a). The four sanitary districts are Pissy (sectors 1-12 and 16-19) Kossodo (sectors 13, 23-27), Paul VI (sectors 20-22) and Secteur 30 (sectors 14, 15 and 28-30). Ouagadougou were classified into three different areas (centre, intermediate and periphery), according to their population size, distance to the centre and physical characteristics. The patterns of development and settlement, i.e. commercial, industrial areas, residential areas and natural environments (lakeside, forest or dry areas), were considered. It is a rapid assessment with limited budget; therefore, in each area only one health facility and school were selected for the surveys. Health facilities with a higher volume of outpatients per day were considered for the survey.

Centre: Due to low attendance in the urban dispensary (Dispensaire Urbain) which was originally selected, two sites were added to speed-up recruitment: Centre de Santé et de Promotion Sociale

(CSPS) Paspange sector 12 and CSPS Dapoya sector 3 (Figure 5-1b). The selected dispensaries and the school, Paspanga C primary school (Figure 5-1b), are situated between the main dam and a busy commercial centre.

Intermediate areas: Dagnoin A primary school is situated in a poor residential area of sector 29, east of Ouagadougou (Figure 5-1b). An irrigation canal passes through this area. The missionary hospital St. Camille serves as a government Centre Médical avec Antenne Chirurgicale (CMA), with the highest attendance of patients in town.

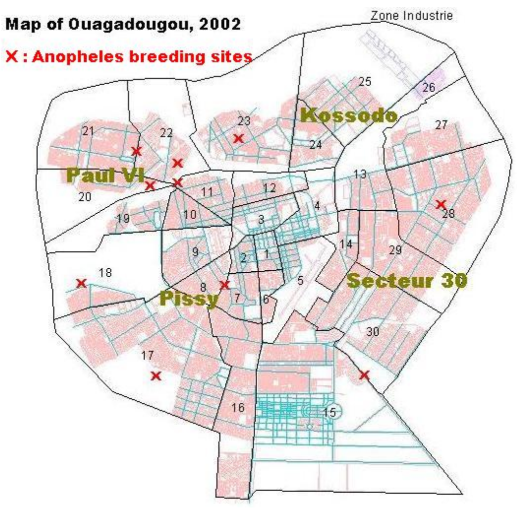
Periphery: Kossodo A, B and C primary schools are situated in sector 26 at the north-east border behind the small forest Bois de Boulogne, which is a large farming area near an industrial zone. Centre Médical (CM) Kossodo is just opposite to the schools (Figure 5-1b). It is the only CM in Kossodo and it serves the majority of the population there.

To maximise case detection, the Centre National de Recherche et de Formation sur le Paludisme, Ouagadougou (CNRFP), situated in a busy area of the sector 4, near the University of Ouagadougou and CHN-YO, was identified as an additional site for the health facility-based fever survey (Figure 5-1b). It is not a health centre or clinic, but a national laboratory known for receiving self-referred malaria patients.

5.3.2 RUMA Methodology

Review of literature and collection of health statistics

The author surveyed the articles published on urban malaria and the relevant thesis presented in the medical libraries in Ouagadougou. Demographic, health information and routine malaria reports were collected from the CNRFP, the Institut National de la Statistique et de la Démographie (INSD) and the statistics unit of the municipal health department.



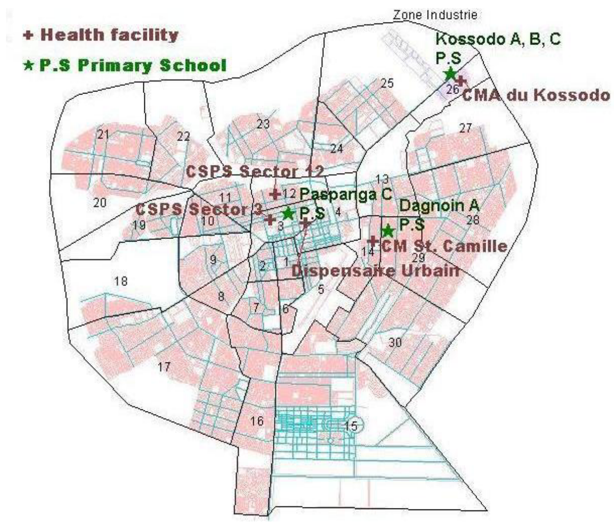


Figure 5-1a Map of sanitary districts and sectors and Anopheles breeding sites. Numbers indicated sectors.

Figure 5-1b Map of selected sites for schools and health facilities surveys.

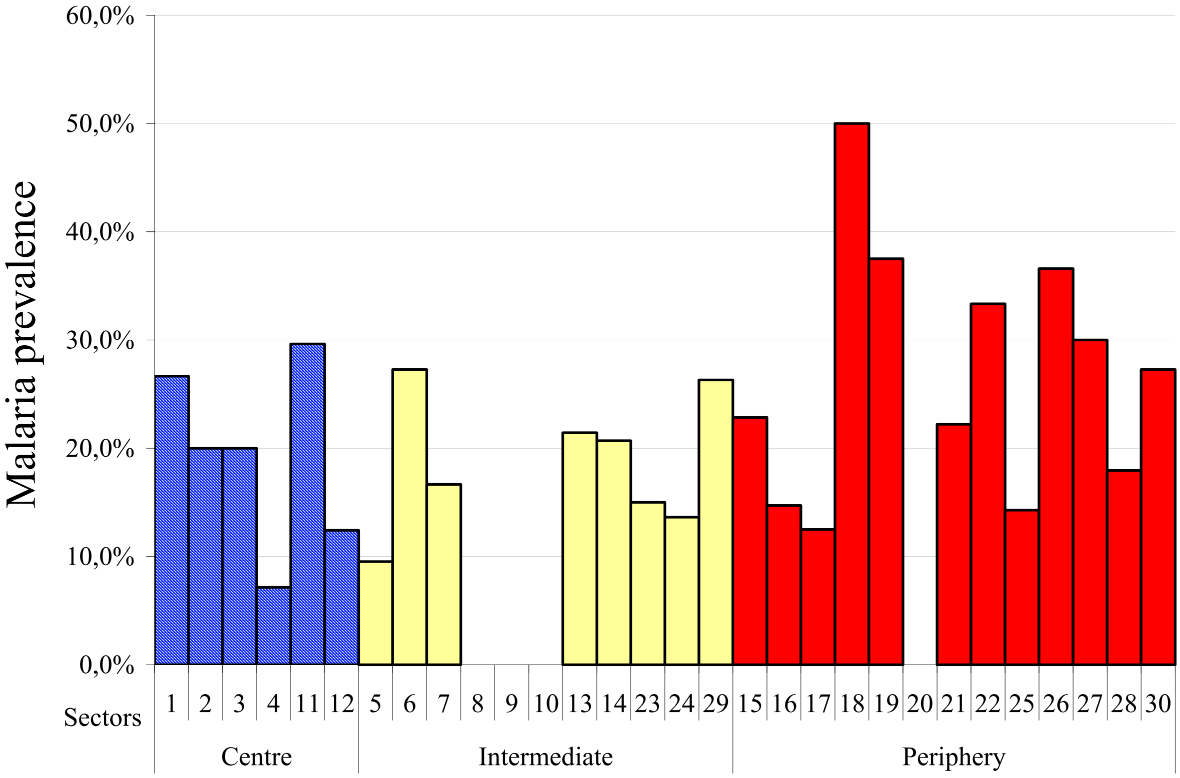


Figure 5-1c Malaria prevalence by sectors of Ouagadougou. Health facility-based surveys.

Mapping of breeding sites

A rapid entomological survey was conducted with the assistance of CNRFP entomologists and produced a map of *Anopheles* breeding sites. At the beginning of the rainy season in 2002, there had been an entomological survey in Ouagadougou conducted by CNRFP, to identify mosquito breeding sites. In December, 2002, the entomological team double-checked all water bodies which were identified earlier. Due to time limitations, additional potential breeding sites were not checked. All larvae were collected and transferred to water containers. The containers were filled with the water taken from the breeding sites and were labelled with their location. These were delivered to the entomological laboratory of the CNRFP for hatching. The mature adult mosquitoes were then identified to species level. Geographic coordinates were recorded for all confirmed breeding sites of *Anopheles* sp. by Global Positioning System (GPS) (Garmin® eTrex 12 canal GPS). A vector layer of a digital map of Ouagadougou with the locations of all health facilities and schools was provided by the GIS unit of the Ecole Inter-Etats d'Ingénieurs de l'Equipement Rural (EIER).

School parasitaemia surveys

School parasitaemia surveys were carried out to estimate endemicity in different transmission areas (high, medium and low). The school surveys were carried out from November 21 to 30, 2002, at the cold and dry season. Each school was close to the health facility chosen for the fever survey (see below) and was visited by the survey team (sociology students-interviewers, nurses, laboratory technicians and a field assistant). A series of meetings was held with teachers and schoolmasters to explain the purpose and methodology of the survey. Participation was voluntary and parents had to fill out a questionnaire and sign the consent form. Only children who returned the consent forms had a blood sample taken and axillary temperature measured. Samples were collected from 200 students aged six to ten years in each school. Children were interviewed with the assistance of schoolteachers regarding their socio-economic situation and malaria infection histories. Both thin and thick blood films were taken on the same slide and stained by Giemsa stain. Based on the assumption that 8000 white blood cells are found in one ml of blood, parasite density in thick smears was defined as the number of parasites per 200 white blood cells. If 200 white blood cells were identified and less than 9 malarial parasites found, the process was continued until 500 white blood cells were identified.

Health facilities fever surveys

This methodology aimed to assess malaria prevalence in fever cases and estimate the age-specific fractions of malaria-attributable fevers and improve the case definition and clinical diagnosis of malaria. In urban areas, an estimated 5 % to 50% of fever cases among children under 15 years old were due to malaria. A sample size of 200 in each facility gave an estimate of the proportion of cases with parasites with the following approximate lower 95% confidence limits: for 5%, lower 95% CI: 2; for 50%, lower 95% CI: 46. The survey activities lasted for 18 days from December 1st, 2002. Over this period, 200 fever cases and 200 non-fever controls in each health facility were interviewed. About 50% of the sample was aged ≤5 years. Outpatients with a history of fever (past 36 hours) or with a measured temperature of ≥ 37.5°C were defined as cases. Controls were recruited from another department of the same clinic without current or past fever, and matched by age and residency. Infants with congenital abnormalities, patients with signs of severe disease, patients returning to the health facility for follow-up visits and patients who were not permanent town residents for more than six months per year were excluded from the survey. After being recruited and giving informed consent, each patient had an axillary temperature measurement and had a blood film taken. The odds ratio (OR) is the proportion of odds of having parasitaemia in fever cases over controls. The formula for the fraction of fever episodes attributable to malaria parasites is: (1-1/Odds Ratio)*P with P being the proportion of fever episodes in which the subjects also had malaria parasites present.

For quality control, 200 slides were re-examined by a senior technician of the CNRFP and then a second time at the Swiss Tropical Institute (STI). The sensitivity, specificity and accuracy rates of readings were 98.7%, 98.2% and 98.6%, which was considered excellent.

Brief description of the health care system

The diversity of malaria fever management has a critical impact on the early diagnosis and treatment of malaria. Planning malaria control in urban areas cannot be achieved without an overview of the distribution, coordination and practices of existing treatment providers. This evaluation involved a meeting with representatives of the CNRFP, EIER and the municipal health department. The senior officers facilitated the exchange of information, in particular through lists and maps of public and private health care providers.

5.3.3 Statistical methods

The data were double-entered and validated in EpiInfo 6.04 (CDC Atlanta, USA, 2001). Data analysis was carried out in Stata 8 (Stata Corp. Texas, USA, 2003). Explanatory variables were age group, sex, residence, education level, axillary temperature, fever duration, bednet usage, urban agricultural activity, water resources and previous malaria infection within one month, as well as whether the patients had visited a rural area. The X^2 test was applied to assess associations between categorical variables. Logistic regression was performed to assess the association between binary outcomes and explanatory variables, adjusted for the confounding effects of age groups.

5.3.4 Ethics

The Ethics Committee of the Ministry of Health of Burkina Faso and the research commission of the STI gave approval for the protocol. All the patients gave informed consent. In school surveys, the consent forms and questionnaires were delivered to the parents there days before the survey. Chloroquine (CQ) or amodiaquine (AQ) were paid if the patients presented fever signs.

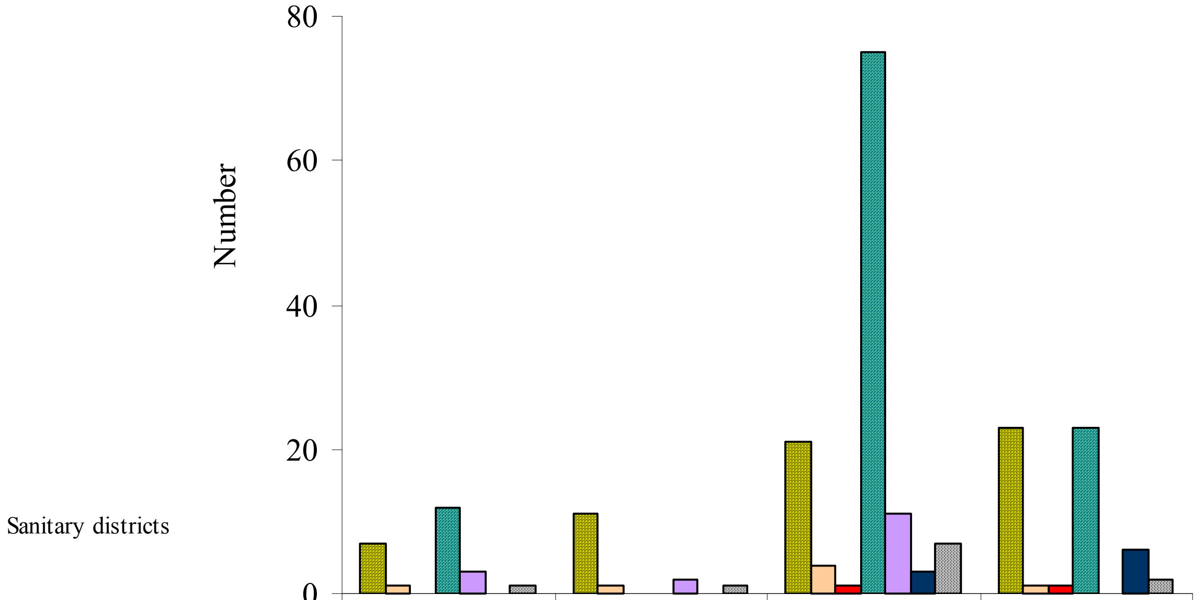
5.4 Results

From 1945 to 2002, 39 papers regarding urban malaria epidemiology in Ouagadougou were published in international journals. The documentation of urban malaria research in Burkina Faso is well organised; most research work was published in thesis of resident doctors reporting and analyzing data from their clinical practices. Previous studies showed that the malaria peak prevalence occurred in September and October (30%), while 80-95% of malaria cases are reported during the rainy season (July to mid-October) and up to six weeks afterwards. The reports of clinical malaria dropped from December onwards to reach the lowest point (3%) in June (Coulibaly, 1989; Dabire, 1990). The overall parasite index was 16% in Ouagadougou in August and September, 1984 (Sabatinelli et al., 1986a). From January to December, 1988, 6,109 outpatients in three health facilities were examined and found that malaria infections were the main reason for fever episodes with a prevalence rate of 33% (Coulibaly et al., 1991).

5.4.1 Brief description of the health care system

The health care system in Burkina Faso is structured in five hierarchical levels (health post, health centre and district, regional and national hospitals). The public, private and voluntary services in Ouagadougou were heterogeneously distributed by district (Figure 5-2a). There were 80 public health facilities, 110 private health services (formations sanitaires privées) and 16 religious health facilities (formations confessionnelles). A total of 69 prescription pharmacies (officines pharmaceutiques) and 29 non-prescription drug outlets (Dépôts MEG) for essential medicines were registered in Ouagadougou in 2002 (Figure 5-2b). Over 60% of the prescription pharmacies were located in Pissy district (centre and south of city). Very few pharmacies were open in the intermediate and periphery areas. There was one dispensary (Centre de Santé et de Promotion Sociale) serving 23,800 inhabitants in Kossodo, 9,100 in Paul VI, 23,100 in Pissy and 12,400 in Secteur 30, respectively. There was no private health facility in Paul VI. This shows that the workload of public health services was heavy. Most of the inhabitants (76.0%, 83.4%, 72.4% and 64.2% in Kossodo, Paul VI, Pissy and Secteur 30, respectively) lived within 0-4 km of a public health facility, which means that the accessibility of services was good.

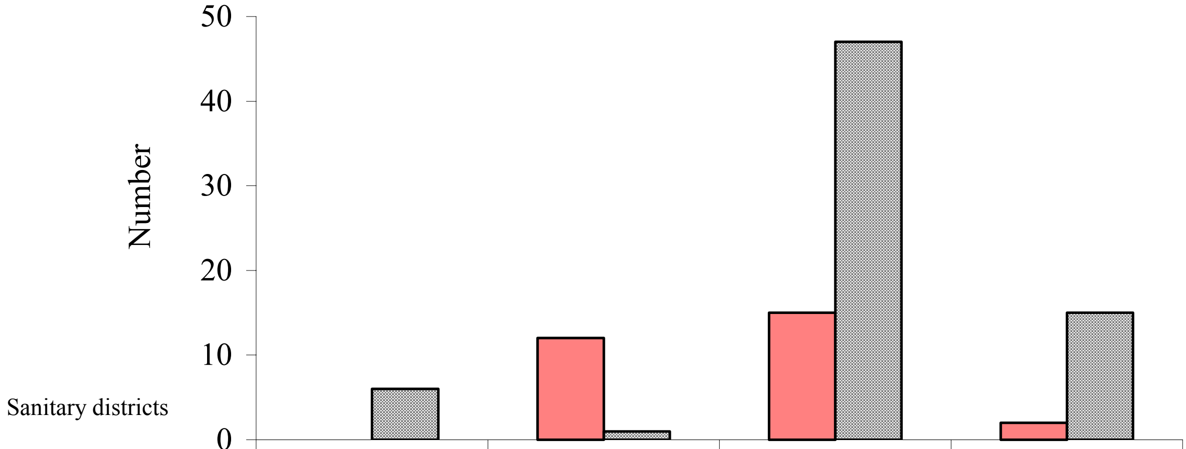
Although the policy of privatisation of health care services was launched more than 15 years ago, the private sector in Ouagadougou has not developed as much as in other SSA cities. However, many private paramedical practices and drug outlets are not authorized and registered and, therefore, the number of private health facilities was certainly underestimated. Over a third of all health facilities were owned by the government in 2002.



	Kossodo	Paul VI	Pissy	Secteur 30
CSPS	7	11	21	23
CM/CMA	1	1	4	1
CHR/CHN	0	0	1	1
Formations sanitaires privées	12	0	75	23
Formations confessionnelles	3	2	11	0
Formations sanitaires para publiques	0	0	3	6
Formations sanitaires de l'armée	1	1	7	2

Figure 5-2a Categories and distribution of health services in Ouagadougou in 2002.
Centre Hospitalier National (CHN)-National hospital. Centre Hospitalier Régional (CHR) -Regional hospital. Centre Médical (CM)-Health centre. Centre Médical avec Antenne

Chirurgicale (CMA)-Health centre with an operating theatre. Centre de Santé et de Promotion Sociale (CSPS)-Dispensary and reproductive health unit.



	Kossodo	Paul VI	Pissy	Secteur 30
Dépôts MEG	0	12	15	2
Officines pharmaceutiques	6	1	47	15

Figure 5-2b Distribution of pharmacies in Ouagadougou 2002.
Dépôts MEG: Drug outlets. Officines pharmaceutiques: Pescription pharmacies.

Results of malaria routine reports

Malaria morbidity and mortality data are reported from each health facility on a seasonal basis. The seasonal reports were available for 1999-2001, but not for 2002. The datasets were missing for the sanitary district Paul VI from October to December, 2001. The annual and seasonal patterns of mild and severe clinical malaria were marked (Figures 5-3 and 4). The highest incidence rates were reported from July to September and incidence rates went down from October to December. The lowest point was during the cold and dry season, from January to March. There was no big year-to year variation of reporting for simple malaria cases, while there was a sharp increase in reported complicated malaria during the rainy season in 2001. There was also a marked increase in reported cases in Pissy during the 1999 rainy season, for which no clear explanation could be found (Figure 5-4b).

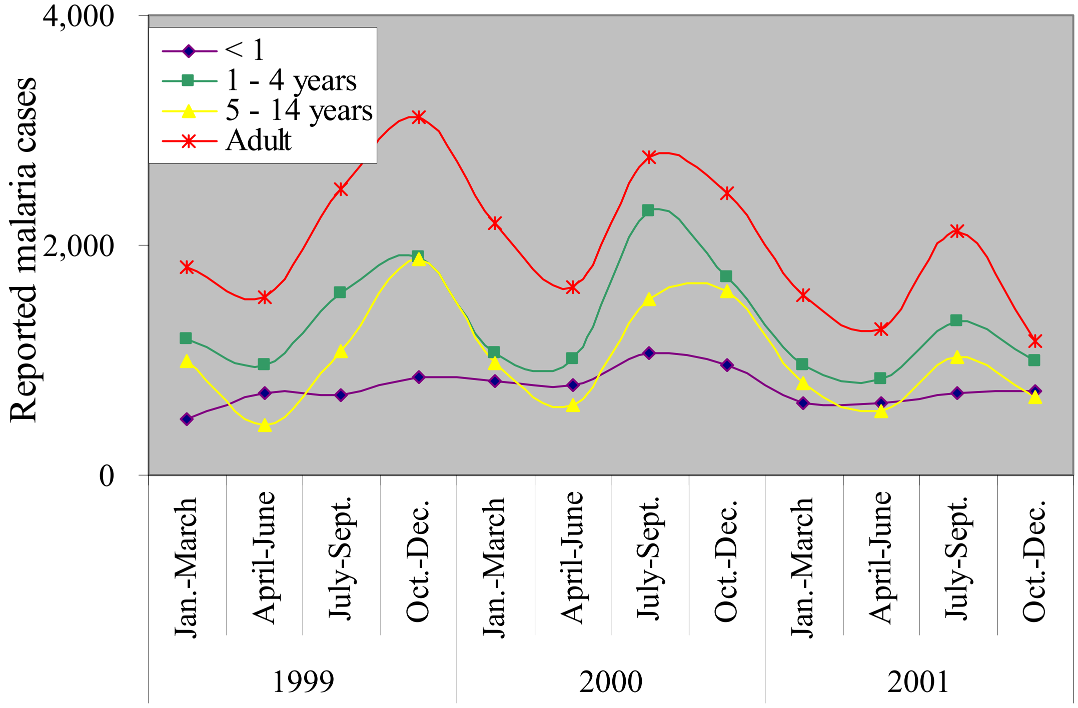
In 2001, there were 203,466 mild malaria cases (30-40% of all consultations) reported among 596,365 consultations in the public health facilities of Ouagadougou (Table 5-1). There were 20,071 complicated malaria cases reported, which accounted for 1.9-4.9% of total consultations in the different age groups and 10% of all malaria cases. The original seasonal malaria reports were classified by age and gender using the following categories: one year old, one to four years old, five to 15 years old, male and female from 15 years-old. For infants and children under five years, one third of clinical consultations were due to malaria and one third was due to diarrhoea and lower respiratory tract infections. For children aged 5-14 years, malaria (41.4%), skin problems and wounds (14.2%), as well as lower respiratory tract infections (9.9%) were the major causes of consultations.

Table 5-1 Reported malaria cases and top 3 major causes for clinical consultations in Ouagadougou 2001.

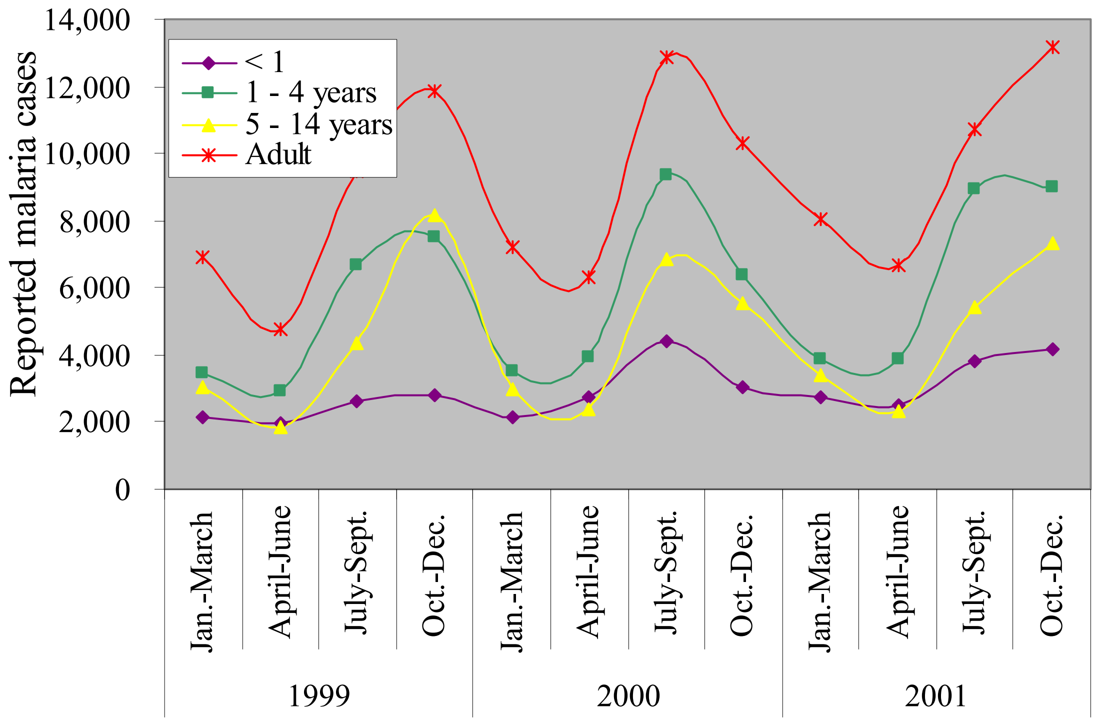
Age category	Simple malaria	Severe malaria	LRTI¥	Skin/ wounds	Diarrhoea	Total consultations
Infants	31,430	3,478	15,348	7,765	16,306	97,001
<1 year	(32.4%)	(3.6%)	(15.8%)	(8.0%)	(16.8%)	
Children	58,070	7,542	20,592	12,410	20,338	154,196
1-4 years	(37.7%)	(4.9%)	(13.4%)	(8.0%)	(13.2%)	
Children	38,283	3,765	9,120	13,167	3,424	92,436
5-14 years	(41.4%)	(4.1%)	(9.9%)	(14.2%)	(3.7%)	
Adults	75,683	5,286	20,862	30,095	10,884	252,732
≥15 years	(29.9%)	(2.1%)	(8.3%)	(11.9%)	(4.3%)	
Total	**203,466**	**20,071**	**65,922**	**63,437**	**50,952**	**596,365**
	(34.1%)	**(3.4%)**	**(11.1%)**	**(10.6%)**	**(8.5%**	

¥LTRI: Low Tract Respiratory Infection

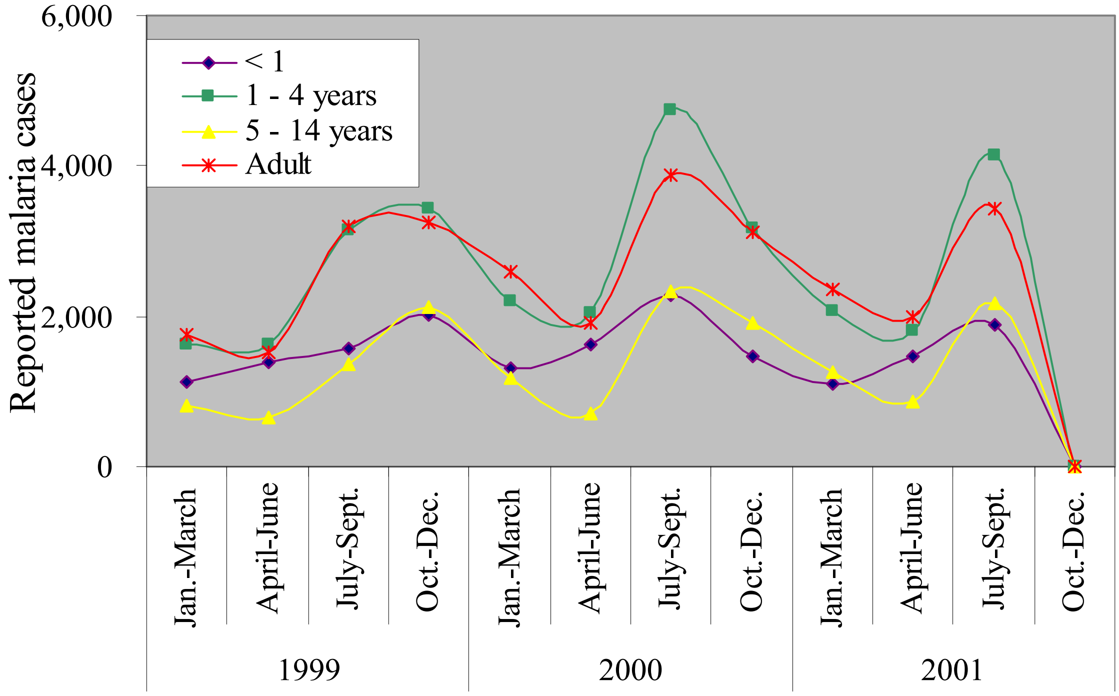
a)Kossodo



b) Pissy



c) Pual VI



d) Secteur 30

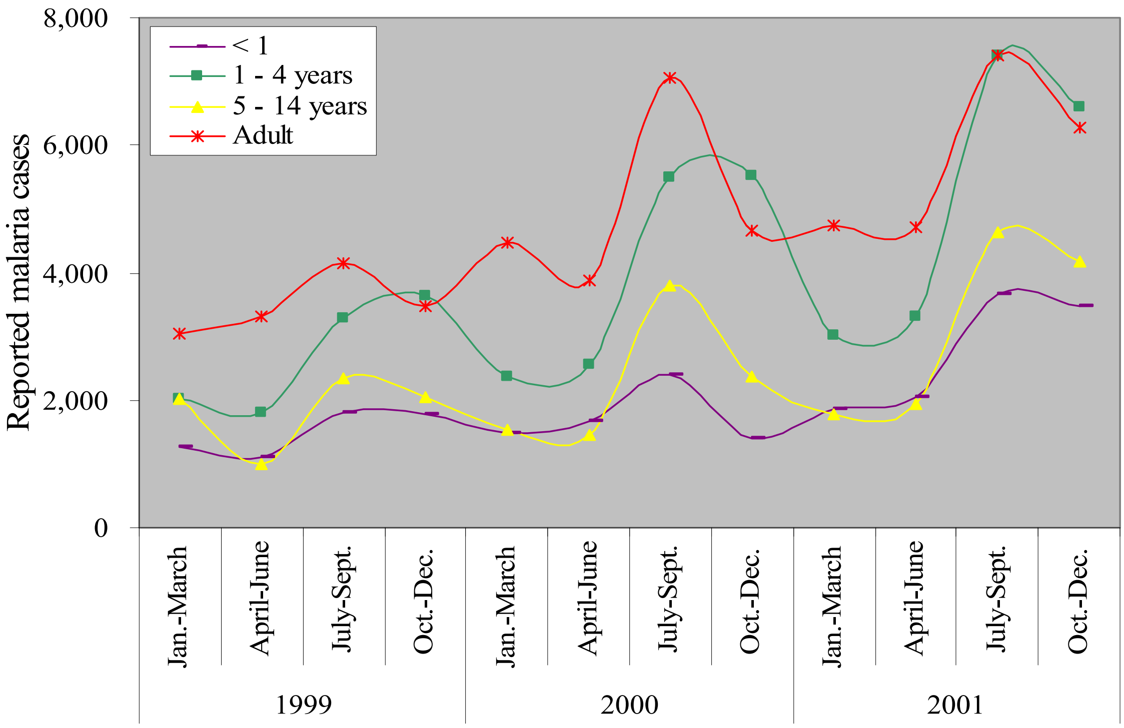
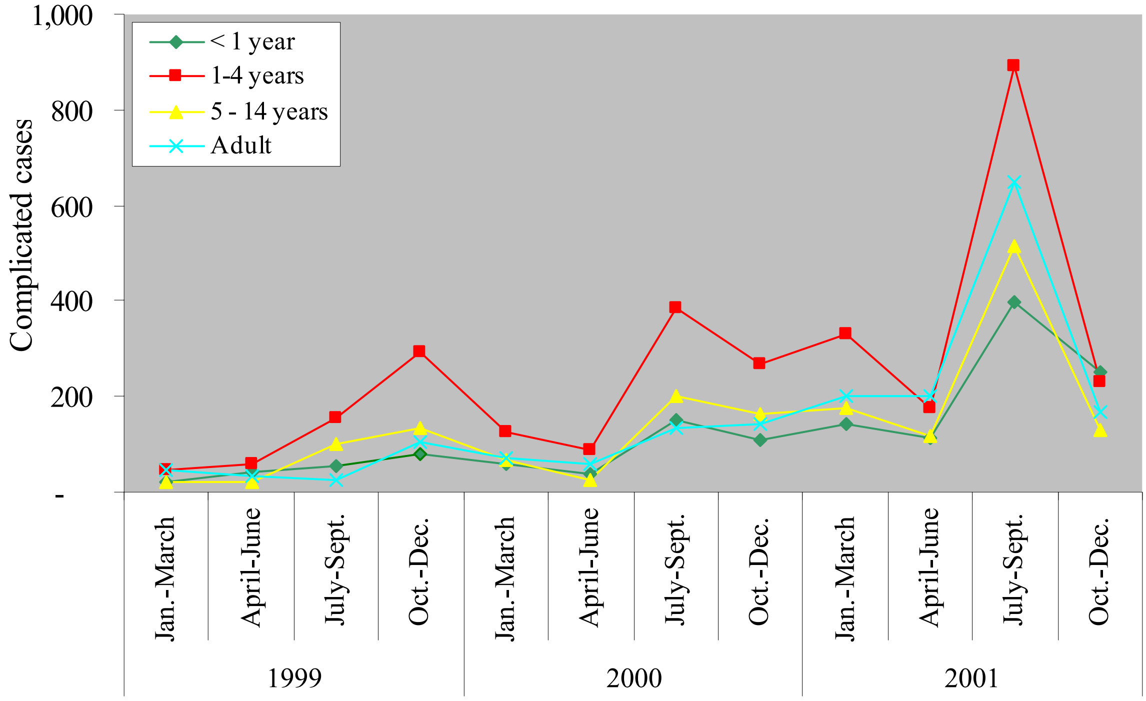


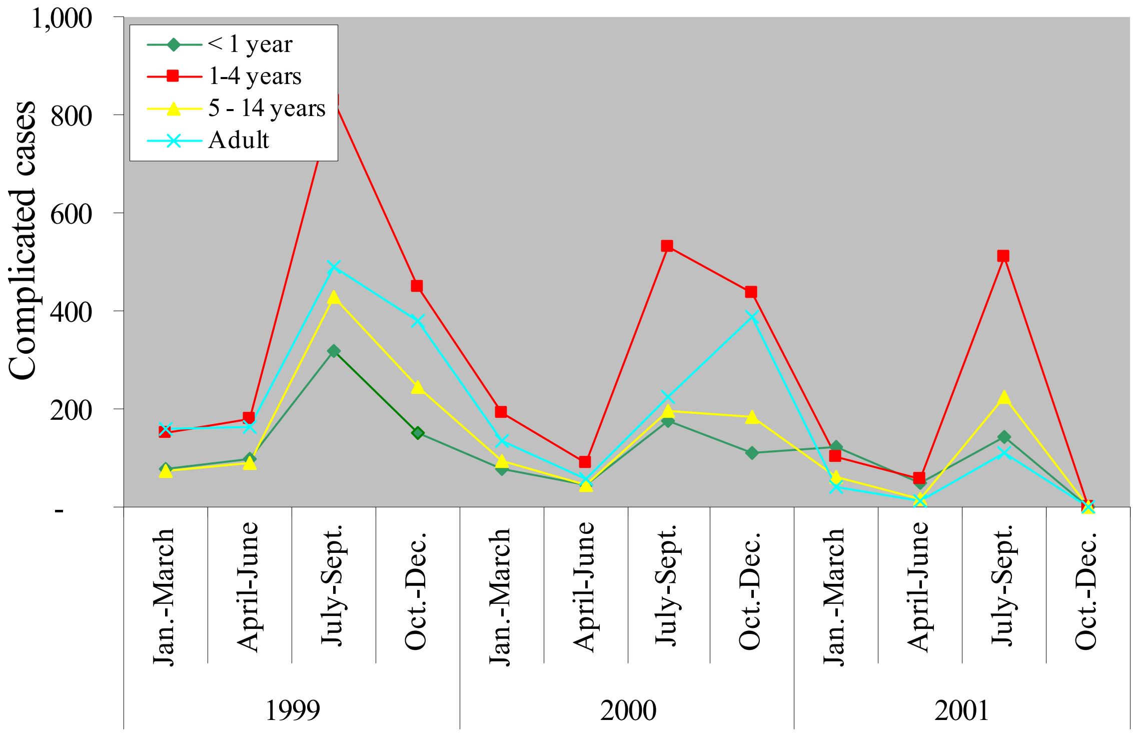
Figure 5-3 Reported simple malaria cases in Ouagadougou.

By sanitary district, 1999-2002. Adult:≥15 years. a)Kossod, b)Pissy, c)PaulVI, d)Secteur 30.

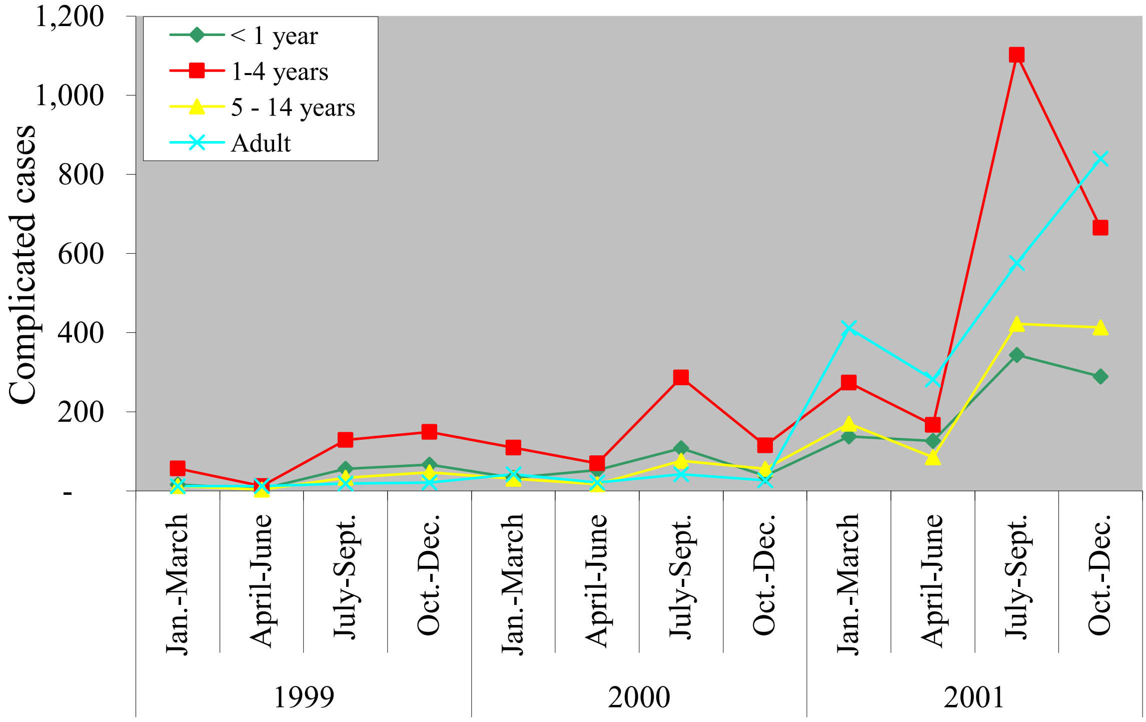
4a) Kossodo



4b) Pissy



4c) Paul VI



4d) Secteur 30

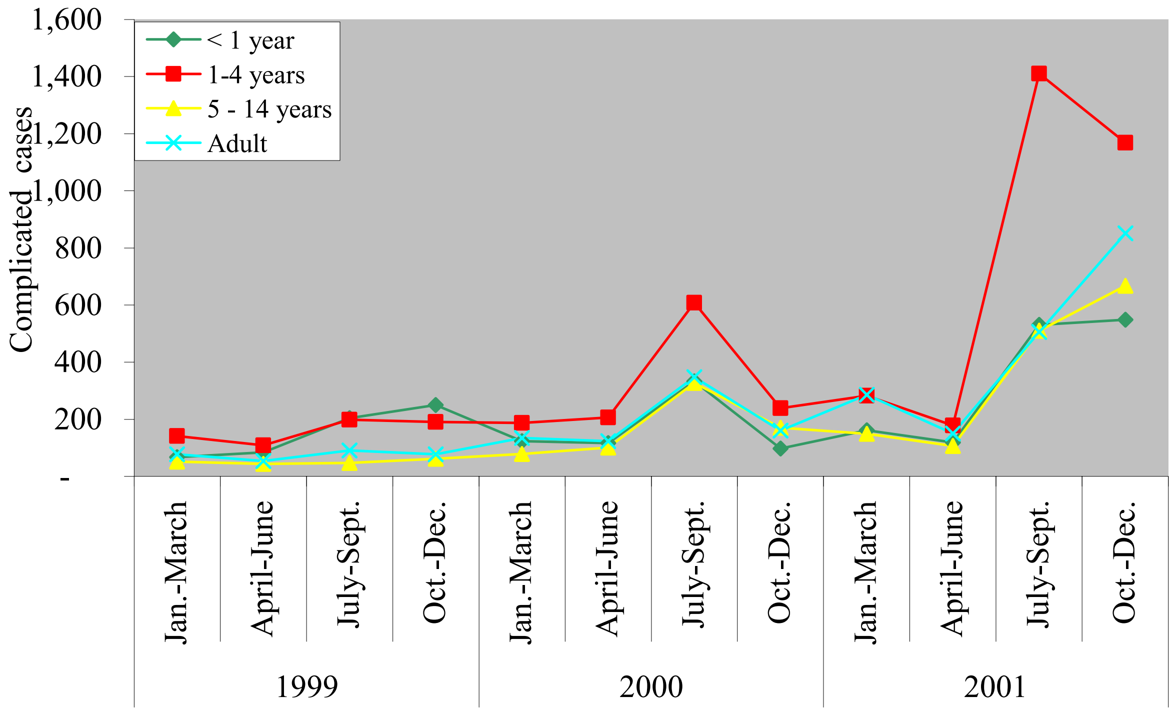


Figure 5-4 Reported complicated malaria cases in Ouagadougou.

By sanitary district, 1999-2002. Adult:≥15 years. a)Kossod, b)Pissy, c)PaulVI, d)Secteur 30.

5.4.2 School parasitaemia surveys

Plasmodium falciparum and *Plasmodium malariae* were detected. The presence of a malaria infection was found in 285 out of 590 valid samples (48.3 %, 95% CI: 44.2-52.4). The prevalence of parasitaemia was 31.6%, 37.6% and 73.1% in Paspanga C, Dognoin A and Kossodo A, B, C primary schools, respectively. Each school had its own catchments area, although the children attending the same school lived in different districts of Ouagadougou. The children's residence was further classified; the prevalence rates were 24.1%, 38.6% and 68.7% in the centre, intermediate and periphery areas, respectively (Figure 5-5).

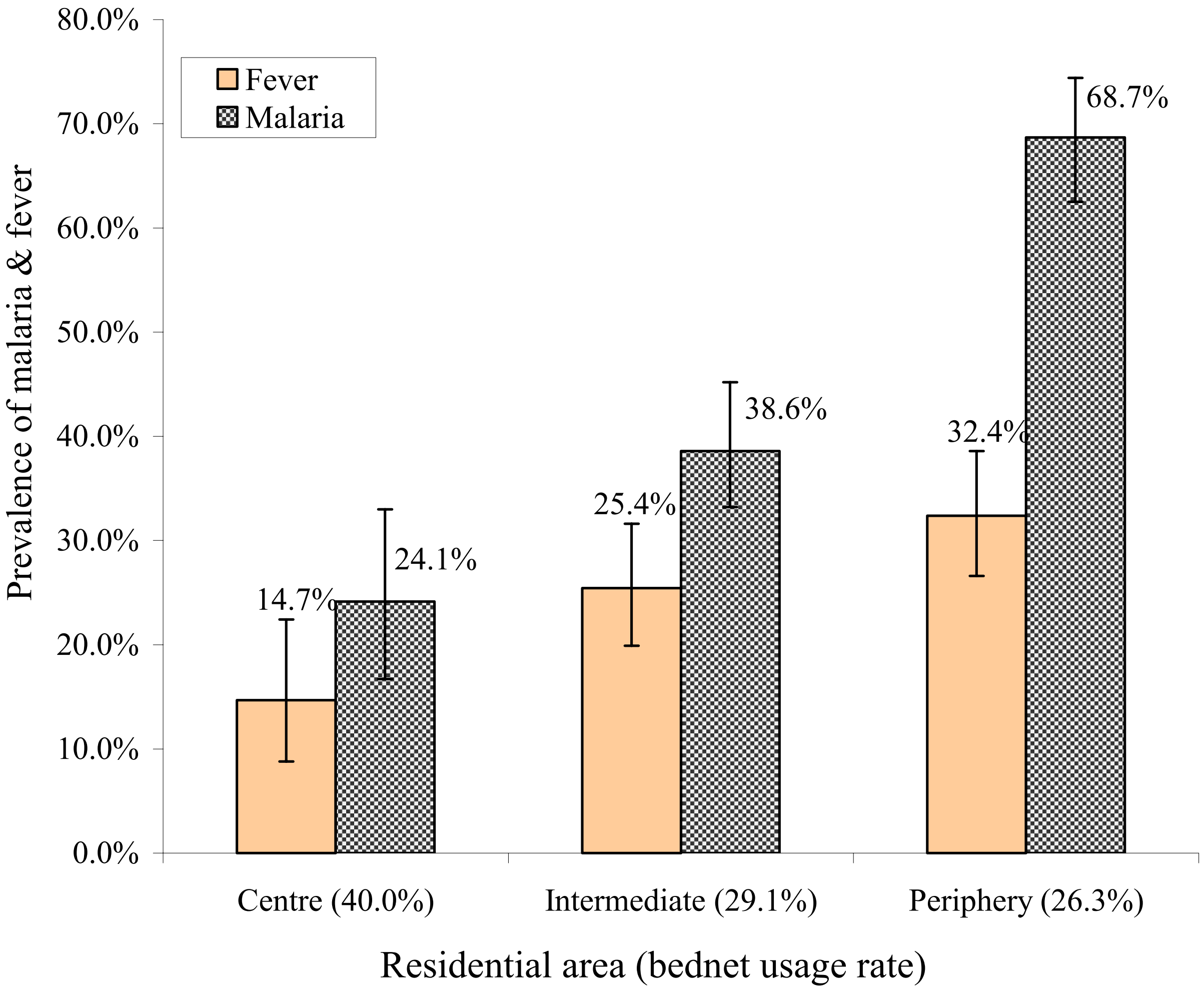


Figure 5-5 Malaria and fever prevalence in school children by area of residency. School parasitaemia survey. Vertical bars represent 95%CI.

5.4.3 Health facility-based surveys

Overall, 123/437 fever cases (22.0%) and 110/436 (20.1%) of controls were positive. The majority of infections were due to *P. falciparum*; very few cases of *P. malariae* and *Plasmodium vivax* were identified. The difference in parasitaemia rates between facility-based surveys and school surveys was likely to be due to the different age distribution of the sample populations: the mean age was 7.7 years in the school parasitaemia surveys and 19.9 years in the facility-based fever surveys.

Table 5-2 Odds ratio (OR) of having parasitaemia by age groups and fever/control groups. Health facility-based surveys.

Malaria prevalence	Fever	Controls	Fever			Controls		
Age groups			OR	95% CI	P value	OR	95% CI	P value
Infants 0-1 year	7/58 (12.1%)	3/21 (14.3%)	1	-	-	1	-	-
Children 1-5 years	45/174 (25.9%)	15/104 (14.4%)	2.54	1.08-6.00	<0.05	1.01	0.27-3.86	0.987
Children 6-15 years	23/62 (37.1%)	20/58 (34.5%)	4.30	1.67-11.03	<0.005	3.16	0.83-12.02	0.092
Adults >15 years	48/266 (18.0%)	72/363 (19.8%)	1.60	0.69-3.75	0.276	1.48	0.43-5.18	0.535

In all four cities where RUMA was used, the age groups were classified using following categories: one year old, one to five years old, six to 15 years old and adults from 15 years-old. Table 5-2 shows that in the above age groups the parasites rates in febrile episodes were 12.1%, 25.9%, 37.1% and 18.0%, respectively, while 14.3%. 14.4%, 34.5% and 19.8 % of controls were parasitaemic. The six to 15 year old group of children was at the highest risk of malaria infection compared to infants and adults. Age-specific differences were only significant in the fever group (Table 5-2). The OR of having malaria in fever cases varied from 0.82 to 2.07 for different age groups. The estimated fractions of malaria-attributable fevers were low: -0.03, 0.13, 0.04 and -0.02 in the above age groups, respectively. A separate paper will give an overview of the fraction of fever attributed to malaria.

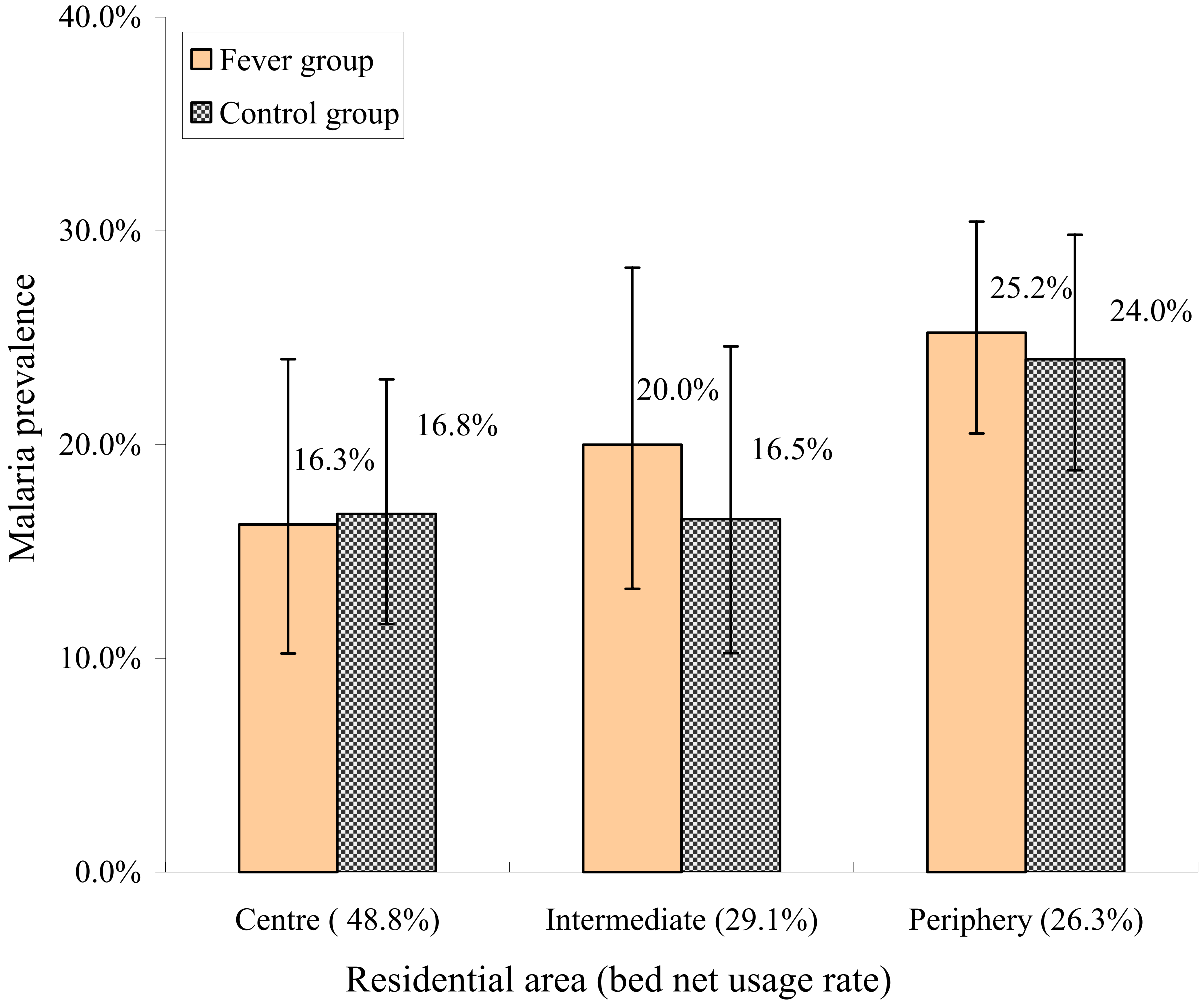


Figure 5-6 Malaria prevalence in fever cases and control groups by residential areas of patients. Health facility-based surveys. Vertical bars represent 95% CI.

Gradients of malaria prevalence and breeding site mapping

The study population was categorized by their residence rather than the location of health facilities. Malaria infections were nearly equally found in both febrile episodes and afebrile controls in the study (Figure 5-6). Overall, the centre and intermediate areas of Ouagadougou were at a lower risk of malaria (prevalence: 14.1% and 20.7%) compared to the periphery of Ouagadougou (25.9%). Higher malaria infections were found among the residents from the periphery sectors 18 and 26 (Figure 5-1c). There was no malaria infection among the residents of sectors 8-10, where the government and business centres are located. The parasite rates in peripheral sectors such as 15-17 and 20 were surprisingly low, but this could be due to a small sample population.

In total, eight sites at the periphery and two sites in the centre were identified where *Anopheles* sp. larvae production was ongoing (Figure 5-1a). In the city centre, one *Anopheles* sp. breeding site was found in sector 8 where the canal passes and one in puddles/pools around artificial lake No. 2 in sector 11. In the periphery, the major open water bodies with productive *Anopheles* breeding were found in sectors 18, 19, 20, 21, 23, 28 and 30 (Figure 5-1c). The small temporary breeding sites in household compounds were not checked.

Socio-economic factors

The socio-economic status of study population was heterogeneous: over 70% of those in the city centre and around 50% of those in the intermediate and peripheral areas had at least a primary school level education. The proportion of households with tap water supply in the centre was higher (47.0%) than in the periphery (31.9%). Over 50% of the population relied on public fountains for water supply. There was no big difference in housing materials in the different areas (53.0-63.6% of houses were built with concrete and bricks and 3-5% were built with mud). An average of 42.2% of study population used a bednet the night before survey. The residents of the centre (48.8%) were more likely to sleep under a bednet than those in the intermediate (36.2%) and periphery areas (38.6%). This difference was significant (intermediate areas: OR=0.59, 95% CI=0.42-0.84, P<0.001, periphery: OR=0.66, 95% CI=0.50-0.87, P<0.001). More ITNs were present in households in the city centre (10.4%) than in the intermediate (7.5%) and the periphery areas (7.1%).

A logistic regression model was performed to estimate the association between socio-economic factors and malaria infection, adjusted for the effects of residential areas and age groups (Table 5-3). The risk of malaria was significantly reduced for people sleeping under a bednet (OR=0.74, 95%

CI=0.54-1.00, P<0.05). Neither education levels of the caretakers nor housing material were identified as significant risk factors. Having an urban agricultural land/garden near living compounds was positively associated with a malaria infection (OR=1.39, 95% CI=1.01-1.92, P<0.05). Increased risk of malaria was associated with exposure to open water bodies, like fountains (OR=1.66, 95% CI=1.19-2.31, P<0.005) or streams (OR=2.80, 95% CI=1.30-6.04, P<0.005). Travelling to rural areas within 90 days was not correlated with the presence of parasitaemia. 518 (47.5%) patients were treated for malaria within one month prior to the survey: 62.0% were treated at health centres and hospitals, while 35.0 % were self-treated at home or underwent no treatment. Very few people reported purchasing drugs in a pharmacy (2.2%) or using traditional medicine (0.8%).

5.4.4 Monitoring of parasite resistance to anti-malarial drugs

The evolution of drug resistance of malaria in Burkina Faso has been described in two urban areas, Ouagadougou and Bobo-Dioulasso and is summarized in Table 5-4 (Aouba, 1992).

Table 5-3 Socio-economic factors and the risk of malaria infection by logistic regression model. Health facility-based surveys.

Socio-economic factors	%	OR	95% CI	P value
Adjusted for the effects of residential areas and age groups				
Education				
Primary	23.2%	1	-	-
Secondary	33.4%	0.97	0.62-1.49	0.873
Superior	5.2%	0.96	0.44-2.09	0.911
No education	35.5%	1.3	0.85-1.98	0.222
Religious	2.6%	0.74	0.24-2.27	0.594
Housing material				
Concrete/brick	58.1%	1	-	-
Leaf/mud	4.6%	1.61	0.82-3.19	0.17
Leaf	0.8%	2.13	0.50-9.00	0.304
Others	36.5%	**1.45**	**1.06-1.98**	**<0.05**
Water supply resource				
Tap water	38.1%	1	-	-
Well	0.6%	1.58	0.18-13.90	0.68
Fountain	58.1%	**1.66**	**1.19-2.31**	**<0.005**
Others	3.2%	**2.8**	**1.30-6.04**	**<0.005**
Living near a garden or agriculture land				
No	71.0%	1	-	-
Yes	29.0%	**1.39**	**1.01-1.92**	**<0.05**
Adjusted for the effects of different residential areas				
Bednet usage				
No use	58.0%	1	-	-
Used	42.0%	**0.74**	**0.54-1.00**	**<0.05**
Without adjusting for residential areas and age groups				
Rural exposure within 90 days				
No	91.3%	1	-	-
Yes	8.7%	1.14	0.70-1.90	0.6
Previous malaria treatment within 30 days with the presence of parasitaemia				
No	52.5%	1	-	-
Yes	47.5%	1.1	0.82-1.48	0.5

Table 5-4 Susceptibility of P. falciparum to antimalarials in Burkina Faso.

Year	Drugs tested	Study sites	Urban/ Rural	Authors	Failure rate *In vivo*
1982- 1986	CQ (*in vitro & in vivo*)	Koudougou	Urban	(Baudon et al., 1984)	First case found
1988-1989	CQ	Koudougou Zaghtouli Dori Banfora Fada N'Gourma	Urban Rural Urban Rural Rural	(Pietra et al., 1992)	25%
1988	CQ	Zaghtouli	Rural	(Kabore, 1991)	18.7%
1989	CQ	Dapelgo	Rural	(Kabore, 1991)	20.2%
1982- 1991	CQ, SP, quinine, MP (*in vitro*)	Ouagadougou Bobo-Dioulasso	Urban	(Guiguemde et al., 1994)	6-15.8 %
1990-1992	CQ, SP (*in vitro*), quinine, halofantrine hydrochloride MP,	Ouagadougou and its neighbouring villages	Urban Rural	(Del Nero et al., 1993a; Del Nero et al., 1994a; Del Nero et al., 1993b; Del Nero et al., 1994b)	CQ & SP: 8.1-24.4% Others: 0%
1993	CQ	Ouagadougou	Urban	(Nabalma, 1994)	25%
1995-1996	CQ, quinine, MP (*in vitro*)	Bobo-Dioulasso	Urban	(Ouedraogo, 1998)	CQ: 19-20% M:2-9.6%
1992-1998	CQ, AQ, quinine, halofantrine MP	Ouagadougou	Urban	(Djire, 1999)	AQ:4.3% & 2.2 % in 1997 CQ:8.5% in 1992, CQ:20% in 1994 H: 7.9% in 1997 (*in vitro*) MP: 0% in 1997 (*in vitro*) Q: 0.9% in 1995 MP+H:7.6% in 1997
1999-2002	CQ & SP	Bobo-Dioulasso	Urban	(Tinto et al., 2002)	CQ:18% SP: <1%

AQ: Amodiaquine CQ: Chloroquine MP: Mefloquine SP: Sulfadoxine/pyrimethamine

5.5 Discussion and conclusions

RUMA methodology

The RUMA methodology is a cross-sectional study and the results may be different at another time of the year, or even vary between years.

Valuable information was extracted from the existing scientific literature and from health statistics. However, the research highlighted the need to enhance the capacity of municipal health department in collecting, processing, disseminating and using information. Some information needed for the evaluation of the health care system, such as the map with public/private health service providers and the schools had been prepared earlier by the GIS unit of EIER. A malaria map of breeding sites was produced during the cold and dry season mainly due to the help of CNRFP. They conducted an entomological survey in Ouagadougou at the beginning of the rainy season in 2002. Without such help, mapping breeding sites would not be possible in the frame of a RUMA.

Mis-diagnosis of malaria

One-third of all clinical consultations were diagnosed as malaria cases and many of them are likely to be mis-diagnosed. Fever is no longer an indicative sign for the diagnosis of malaria As a result, a review of clinical guideline for the management of fever episodes is necessary in order to reduce over-treatment.

A heterogeneity of clinical signs of severe malaria was observed between the paediatric wards of the main hospital, the Centre Hospitalier National Yalgado Ouédraogo (CHN-YO) and a rural district hospital near Ouagadougou during the rainy season (Modiano et al., 1999). In town, the age distribution and the clinical spectrum of severe malaria were related to the place of residence of the patients. While Sanou (Sanou et al., 1997) demonstrated that malaria remained a major cause of childhood morbidity and mortality in the main hospital in Ouagadougou during the rainy season 1993-94, the mis-diagnosis of malaria was reported to be close to 34.7% (Coulibaly, 1993). Dabire in 1990 showed that 63.4% of malaria cases in CHN-YO defined on clinical criteria alone were not parasitaemic (Dabire, 1990). The severity and diversity of malaria symptoms reflect the diversity of local malaria endemicity, leading to difficulties for malaria diagnosis. Presumptive treatment of malaria based uniquely on the fever sign leads to high rates of over-diagnosis and over-treatment. Hence, it is important to introduce diagnosis tests, among which rapid tests are very promising. If physicians then exclude malaria they should check for other causes of fever and initiate an appropriate therapy. All the cases confirmed by the rapid diagnosis test should be treated as malaria since the transmission level is not high.

Parasitaemia results

In the school surveys, the parasitaemia rates were always higher than the febrile episodes since many children have asymptomatic infection. It was also observed that the community prevalence remained high at the beginning of the cold and dry season, while clinical malaria cases diminished quickly in health facilities. The control group had an even higher prevalence of parasitaemia than the fever group. The difference between parasitaemia rates in active and passive case detection was expected. The health facilities received patients from various communities, while school children mostly came from the same areas. This indicated that malaria infections were clustered in certain areas and that there were different levels of malaria transmission in Ouagadougou. Another explanation could be that some feverish patients may have taken paracetamol or another anti-pyretic and hence might not necessarily have presented with fever when visiting the dispensary.

Urban agriculture and *Anopheles* vector breeding sites

The risk of a malaria infection in Ouagadougou might be associated with seasonal agricultural activities. A Ouagadougou home gardening map produced by Cissé and Gerstl showed that a majority of home gardens were situated at the city's outskirts and along the shores of artificial lakes and canals (Cissé, 1997; Cissé et al., 2002; Gerstl, 2001). The irrigated plots along the dam and the water channels create rural enclaves within the city. A study conducted near Ouagadougou described a positive association between irrigated farming, the malariometric and malaria morbidity among children below five years of age (Zamane, 2000). In the health facility-based surveys, it was found that the water supply types (fountains or streams) and the proximity to home gardening fields were associated with malaria infection. This association was noted as well in Uganda (Staedke et al., 2003) and Dar es Salaam (Caldas de Castro et al., 2004).

Malaria clusters in Ouagadougou.

The parasitaemia prevalence rates in schools varied widely from the city centre to the periphery. The heterogeneity of endemicity within a small distance between the urban centre and the periphery of Ouagadougou was confirmed. Different levels of malaria transmission were previously found to be related to the spatial and temporal distribution of *An. gambiae* larval breeding sites in Ouagadougou (Petrarca et al., 1986; Rossi et al., 1986). Rossi *et al.* and Petrarca *et al.* concluded that higher prevalence rates of malaria occurred in areas where larvae breeding sites were semi-permanent. The most significant semi-permanent breeding sites are along the artificial lake, particularly in sectors 19-23. This was consistent with the observations mentioned above: higher prevalence rates were found along artificial lakes and canals, which are associated with urban agricultural activities.

Awareness and practices of malaria prevention

ITNs coverage was not high, possibly due to economic constraints and availability problems. Annual household expenses for malaria treatment were estimated at 38,398 CFA (Coulibaly, 1993). The average cost of malaria treatments was 4,929 CFA per person in 1992 (Dajoari, 1992). The average hospitalisation costs for complicated malaria have risen up to 21,160 CFA in the paediatric ward of CHN-YO (Sanon, 1999). Because of such high cost, the patients reported taking self-medication before visiting health facilities (35%) or increasingly invested in preventing mosquito bites (42.2%). These results agreed with the findings of local researchers who found 28-36% (Sabatinelli et al., 1986a), 30.2% (Traore, 1994) and 50% (Coulibaly, 1989) self-medication.

Some suggestions can be made concerning in-depth research and interventions. Firstly, emphasis urgently needs to be put on the proper diagnosis of “malaria cases”, including the use of rapid tests. Secondly, Ouagadougou has a huge artificial lake for its water supply and irrigation. It would be important to explore the malaria impact of current hydro-agriculture systems and urban agriculture activities during the cold and dry season and to find ways to mitigate their malaria potential. Thirdly, the cost for malaria treatment is relatively high in Burkina Faso, which leads to a high proportion of self-medication. The pricing policy in public health facilities should be revised as it should be considered an obstacle to case management and malaria control goals.

Authors’ contributions

SW participated in the design of the study, conducted the field work, analysed and interpreted data, drafted and revised the manuscript. CL conceived the study, coordinated the field work and revised the manuscript. TS and PV participated in the design and statistical analysis. DD, XP and ES managed and supervised the data collection and laboratory work in the field. MK supervised the production of the breeding site map and the cleaning of this dataset. MT participated in the conception of the work, revised it critically at different stages and gave final approval of the version to be published.

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List of abbreviations

AQ	Amodiaquine
CHN	Centres Hospitalier National
CHN-YO	Centre Hospitalier National Yalgado Ouédraogo (CHN-YO)
CHR	Centre Hospitalier Régional
CM	Centre Médical
CMA	Centre Médical avec Antenne Chirurgicale
CNRFP	Centre National de Recherche et de Formation sur la Paludisme, Burkina Faso
CSPS	Centre de Santé et de Promotion Sociale
CQ	Chloroquine
INSD	Institut National de la Statistique et de la Démographie
EIER	Ecole Inter-Etats d'Ingénieurs et de l'Equipement Rural, Burkina Faso
GPS	Global Positioning System
GIS	Geographic Information System
ITNs	Insecticide-Treated Nets
MP	Mefloquine
OR	Odds Ratio
RUMA	Rapid Urban Malaria Appraisal
SP	Sulfadoxine/pyrimethamine
STI	Swiss Tropical Institute

Chapter 6

Dar es Salaam

6. CHAPTER: DAR ES SALAAM

Rapid urban malaria appraisal (RUMA) II: Epidemiology of urban malaria in Dar es Salaam (Tanzania)

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6.1 Abstract

Background: The thinking behind malaria research and control strategies stems largely from experience gained in rural areas and needs to be adapted to the urban environment.

Methods: A rapid assessment of urban malaria was conducted in Dar es Salaam in June-August, 2003 using a standard Rapid Urban Malaria Appraisal (RUMA) methodology. This study was part of a multi-site study in sub-Saharan Africa supported by the Roll Back Malaria Partnership.

Results: Overall, around one million cases of malaria are reported every year by health facilities. However, school surveys in Dar es Salaam during a dry spell in 2003 showed that the prevalence of malaria parasites was low: 0.8%, 1.4%, 2.7% and 3.7% in the centre, intermediate, periphery and surrounding rural areas, respectively. Health facilities surveys showed that only 37/717 (5.2%) of presenting fever cases and 22/781 (2.8%) of non-fever cases were positive by blood slide. As a result, malaria-attributable fractions for fever episodes were low in all age groups and there was an important over-reporting of malaria cases. Increased malarial infection rates were seen in persons who traveled to rural areas within the past three months. A remarkably high coverage of insecticide-treated nets and a corresponding reduction in malarial infection risk were found.

Conclusions: The number of clinical malaria cases was much lower than routine reporting suggested. Improved malaria diagnosis and re-defined clinical guidelines are urgently required to avoid over-treatment with antimalarials.

6.2 Background

Rapid urbanization brings about major changes in ecology, social structure and disease patterns in sub-Saharan Africa. It was estimated that 300 million people currently live in urban areas in Africa and two-third of them are at risk of malaria (Keiser et al., 2004). There is a lack of understanding of the complex interactions between human social structure, the environment and malaria infections (Donnelly et al., 2005; Hay et al., 2005; Omumbo et al., 2005a)

Malaria research and control efforts in Tanzania began in the late 1890s, both in urban and in rural areas (Clyde, 1961; Schneppen, 2000). In the 1970s the malaria problem emerged again on a large scale in Dar es Salaam, mainly because of the deterioration of the health care system. In 2000, 33% of the population in Tanzania lived in urban areas (Damas K. Mbogoro, 2002) and urban poverty was widespread and increasing. More attention is now being devoted again to urban malaria, as uncontrolled urban population growth calls for upscaled and adapted strategies (Caldas de Castro et al., 2004; Yamagata, 1996)

There are only few papers concerning malaria epidemiology in Dar es Salaam. Okeahialam *et al.* (Okeahialam et al., 1972) examined 218 hospital inpatients and 422 outpatients throughout 1971 and found that 20% of fever cases had malaria parasitaemia. Mkawagile (Mkawagile and Kihamia, 1986) reported that during the heavy rainy season in 1981, about 47.6% of adult outpatients attending Mwananyamala hospital with typical malaria symptoms had parasitaemia; among all outpatients the parasitaemia prevalence was only 27%. Makani (Makani et al., 2003) noted that 87% of patients who received antimalarial treatment in Muhimbili National Hospital for presumed severe malaria did not have detectable parasitaemia. In that situation, over-diagnosis of cerebral malaria in patients with neurological dysfunction resulted in over-treatment for malaria and a neglect of other potentially life-threatening conditions. Yamagata (Yamagata, 1996) reported that the malaria prevalence among schoolchildren in the centre, intermediate and periphery of Dar es

Salaam in 1988 were roughly 6%, 28-41% and 68-74%. Following the implementation of the first Urban Malaria Control Project (UMCP) during the period 1988-1994 these rates decreased to 3-10%, 10-25% and 21-46%.

A standard study protocol for Rapid Urban Malaria Appraisal (RUMA) was developed in June 2002 based on a WHO proposal and an Environmental Health Project draft protocol (Warren et al., 1999; WHO, 2001). RUMAs were commissioned by the Roll Back Malaria Partnership for three Francophone countries (Côte d'Ivoire, Burkina Faso and Benin) and one Anglophone country (Tanzania). Each of the four assessments provided the following information: an overview of the urbanization history, an estimate of the fraction of fevers attributable to malaria, parasite rates for different city areas, an outline of health care services, and highlights of the "lessons learned"(Wang et al., 2004c). The aim of the present study was to compile a minimum dataset to identify key malaria issues affecting Dar es Salaam within a 6-10 weeks timeframe. In addition, malaria vulnerability in relation to urban agriculture, socio-economic factors and rural exposure were also assessed.

6.3 Methods

6.3.1 Study sites and sample selection

Dar es Salaam is situated between latitude 6.0°-7.5° S and longitude 39.0°-39.6° E. It had 2,500,000 inhabitants in 2002 (a density of 1,800 per sq. km)(Damas K. Mbogoro, 2002). The municipality is divided into three districts: Ilala, Kinondoni and Temeke. To study the heterogeneity of malaria risk, Dar es Salaam was divided into 4 zones: centre, intermediate, periphery and surrounding rural areas. The zones were defined on the basis of city characteristics and the potential malaria risk indicated by two existing *Anopheles* breeding site maps (Figure 6-1) (Sattler et al., 2005; Yamagata, 1996). Due to the time constraints of a RUMA, only one-two representative health facilities and one-two representative schools in each zone could be selected (two units were selected when the target sample size could not be reached in a single unit).

Centre: Mtendeni primary school and Mnazi Mmoja Health Centre are located in Ilala District facing the harbour and Mbagala Creek (Figure 6-1). It is a trader-dominated commercial centre of the inner city. They are approximately located 1-2 km from Msimbazi Valley where *Anopheles* sp. breeding sites are numerous (Sattler et al., 2005).

Intermediate zone: Mwenge primary school, Kijitonyama Kisiwani primary school, Mwenge dispensary and Kijitonyama dispensary are located in Kijitonyama Ward in Kinondoni District in a middle class suburb (Figure 6-1). There are only few breeding sites in this area apart from one with high productivity near Kijitonyama Kisiwani primary school (1 km away). Mwenge primary school is far from the identified breeding sites.

Periphery: in Temeke District, Ufukoni primary schools and Kigamboni Health Centre in Kigamboni Ward were chosen (Figure 6-1). Kigamboni Ward is a new peri-urban low-income suburb associated with a medium level of mosquito breeding sites, south of Dar es Salaam.

Rural zone: Buza primary school, Buza dispensary and Makangarawe dispensary are located at the emerging urban-rural interface on the hill beside Buza Forest in Temeke District (Figure 6-1). Most children were from Makangarawe Ward and Yombo Vituka. The surroundings of Yombo Vituka consist of several large open vegetation fields and there is a high risk of malaria transmission according to the available *Anopheles* sp. breeding site map. The area is favourable to newcomers (Sliuzas, 1999) and there is a high proportion of low-income households.

6.3.2 RUMA Methodology

Details for the RUMA methods are given in an overview publication (Wang et al., 2005). Briefly, the following components were included.

Review of literature and collection of health statistics

Published information on malaria epidemiology was reviewed systematically through a literature search in the main bibliographic databases (PUBMED and EMBASE), through scanning reference lists and through contacting relevant experts, nationally and internationally. Unpublished data were obtained from the Dar es Salaam City Medical Office of Health (CMOH) and DUMP. Demographic data and malaria reports were collected from the three urban District Medical Offices (DMO) of Iala, Kinondoni and Temeke, the CMOH, from the Ministry of Health (MOH) and from the Population and Housing Census Bureau of Tanzania.

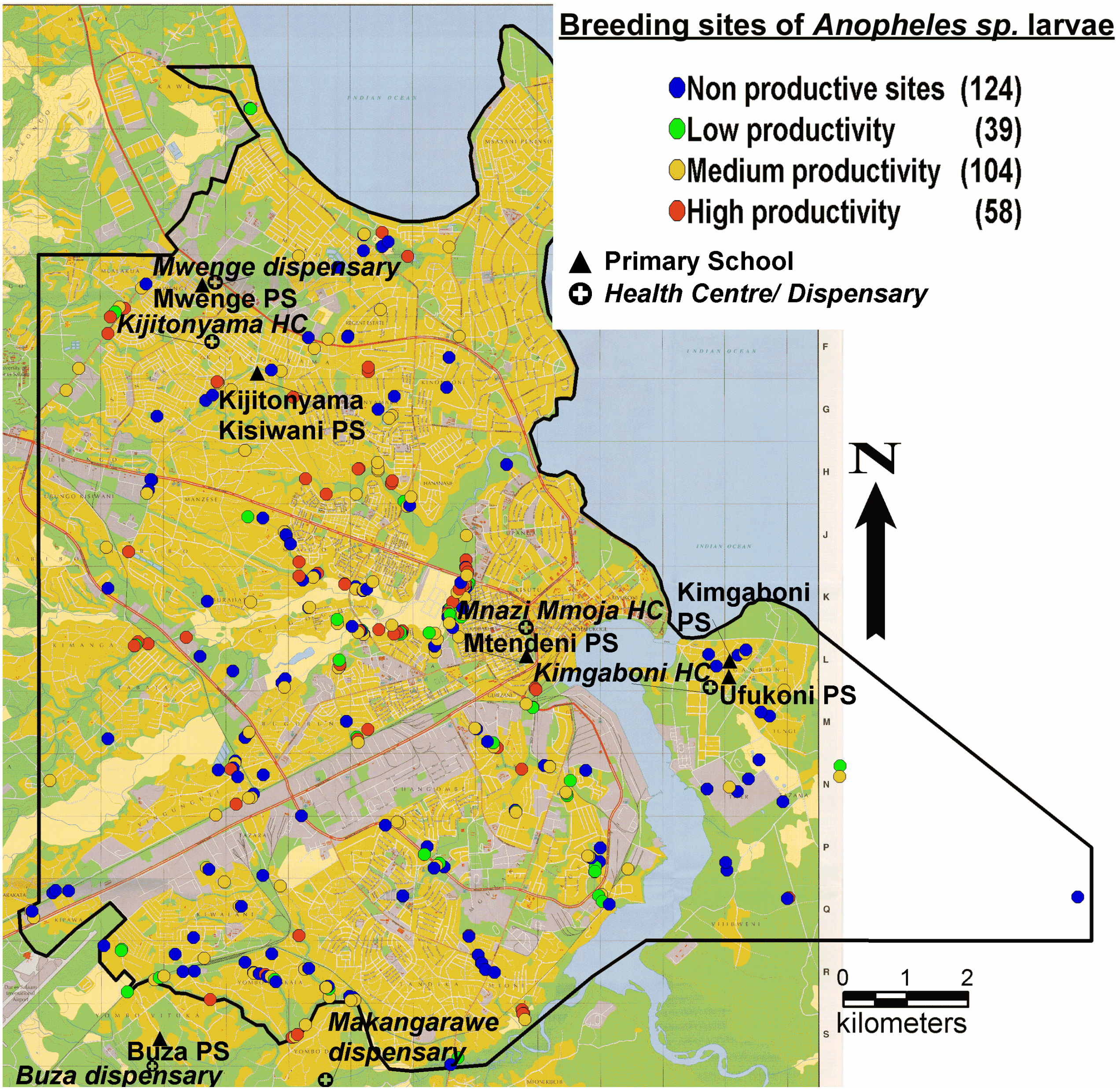

Figure 6-1 Map of selected schools and health facilities in relation to Anopheles sp. breeding sites.

School parasitaemia surveys

A cross-sectional school parasitaemia survey was conducted during the dry season (July 20-30, 2003). Roughly 200 students aged 6-12 years were recruited in each zone, with the exception of Ufukoni primary school (389 children). Consent forms were given to the guardians or household heads. Only children who returned the consent forms had an axillary temperature measurement and a blood sample taken. Both thin and thick films were taken, stained with Giemsa and examined in the laboratory of the main municipal hospital (Amana hospital). Parasite density was defined as the number of parasites per 200 white blood cells. The children were interviewed with the assistance of school teachers regarding their family situations and malaria infection history.

Health facility fever surveys

The health facility surveys aimed at determining the malaria prevalence among fever cases and the fraction of malaria responsible for febrile illness in patients who were considered as clinical malaria cases (Smith et al., 1994). The surveys were carried out between July 16 and August 15, 2003. 200 fever cases and 200 non-fever controls were recruited from one-two clinics located in each area. About 50% of the sample population was aged ≤ 5 years. Outpatients with a history of fever (past 36 hours) or with a measured temperature of ≥ 37.5°C were defined as cases. A control group was recruited from another department of the same hospital without current or past fever, matched by age and by residency with the case group.   Exclusion criteria were: patients with signs of severe disease, patients returning to the health facility for follow-up visits, non-permanent town residents (less than 6 months per year). After being recruited and giving informed consent, each patient had an axillary temperature measurement and a blood film taken. An armpit temperature reading is usually 0.3°C to 0.6°C lower than an oral temperature reading and therefore 0.5 °C was added to the reading. Patients were further interviewed concerning their socio-economic status, ITN usage, travel and malaria treatment history and health care seeking strategy.

The odds ratio (OR) that was calculated is the ratio of the odds of having parasitaemia in fever cases over non-fever controls. The formula for the fraction of fever episodes attributable to malaria parasites is: (1-1/Odds Ratio)*P, with P being the proportion of fever episodes in which the subjects also had malaria parasites present (Smith et al., 1994).

In order to evaluate the quality of the slide reading, 200 slides were re-examined at the Ifakara Health Research and Development Centre in Tanzania and then a second time at the Swiss Tropical Institute in Basel, Switzerland. Quality control readings agreed for 197 slides. The sensitivity, specificity, and accuracy rates of slide readings were: 83.3%, 99.0% and 98.5%.

Mapping activities

a) Malaria risk mapping: the breeding sites mapping was done in conjunction with another project. The mapping was carried out in 151 km^2 of inner Dar es Salaam from March 1 to May 29, 2003. A detailed review of habitat characterization and spatial distribution of *Anopheles sp*. larvae is already published (Sattler et al., 2005).

b) Mapping of health facilities: it was carried out within 3 weeks by 3 geography students of the university of Dar es Salaam using a global positioning system (GPS). With the guidance of public and private health facilities supervisors and the Geographic Information System (GIS) unit of CMOH, all existing health facilities were visited and the locations were recorded.

Brief description of the health care system

The quality of health services determines the effectiveness of malaria case management. Three documents of the Dar es Salaam Urban Health Project (DUHP) were used as basis for a brief evaluation of the health care system in Dar es Salaam (Mtasiwa et al., 2003; Wyss et al., 2000; Wyss et al., 1996).

6.3.3 Statistical methods

The data were double-entered and validated in EpiInfo 6.04 (CDC Atlanta, USA, 2001). Data analysis was carried out in Stata 8 (Stata Corp. Texas, USA, 2003). The X^2 test was applied to assess associations between categorical variables. Logistic regression was performed to assess the association between binary outcomes (mainly parasitaemia) and explanatory variables.

6.3.4 Ethics

Ethical clearance was granted by the Medical Research Coordinating Committee of the National Institute for Medical Research, Tanzania. All patients gave written informed consent for the study. We paid for the prescription of sulfadoxine/pyrimethamine or amodiaquine and paracetamol if the patients presented a fever sign.

6.4 Results

From 1962-2004, 29 papers were found concerning malaria research in Dar es Salaam. Only three papers and one document were related to clinical malaria and malaria endemicity.

6.4.1 Brief description of the health care system

There are five levels in the public health care system in Tanzania but only three levels exist under the Dar es Salaam CMOH: districts (each with a municipal hospital), divisions (each with a health centre) and wards (with dispensaries and affiliated clinics). From October 1990 to the end of 2002, the Dar es Salaam Health Project supported by the Swiss Agency for Development and Cooperation and the Swiss Tropical Institute (STI) assisted the rehabilitation of health facilities, the process of decentralization of decision-making at all levels and it improved the drug and medical supply management (Wyss et al., 1996). In total 64 public (3 district hospitals, 5 health centres and 56 dispensaries) and 395 private health facilities were registered in July 2003 by the CMOH (Wyss et al., 2000). In addition, three hospitals in Dar es Salaam were under the prison, police or military authority (Figure 6-2). The privatization of health services is currently booming but the CMOH supervision and inspection of private health facilities is loose.

The public health services were fairly well distributed by ward. Daily attendance in the public health facilities were 2,387, 3,361 and 2,873 in Ilala, Kinondoni and Temeke, respectively. The private health service providers were distributed heterogeneously (156 in Ilala, 166 in Kinondoni and 73 in Temeke) and the majority of these facilities were located in the better-off inner city - obviously depending on the cash availability of patients. Voluntary services were well represented in the deprived areas at the city fringes. On average, 70% of the population lived within 5 km of a health facility(Kimambo, 2001). The pharmacy board of Tanzania has implemented an official drug registration procedure in 2000-01. In 2003, there were 190 prescription pharmacies (drug stores part-1) or 99, 69 and 22 in Temeke, Kinondoni and Ilala, respectively. Further, there were 1,027 non-prescription pharmacies (drug stores part-2) spread throughout Dar es Salaam (Figure 6-2). The marketing of poor-quality antimalarials was reported in Tanzania (Minzi et al., 2003).

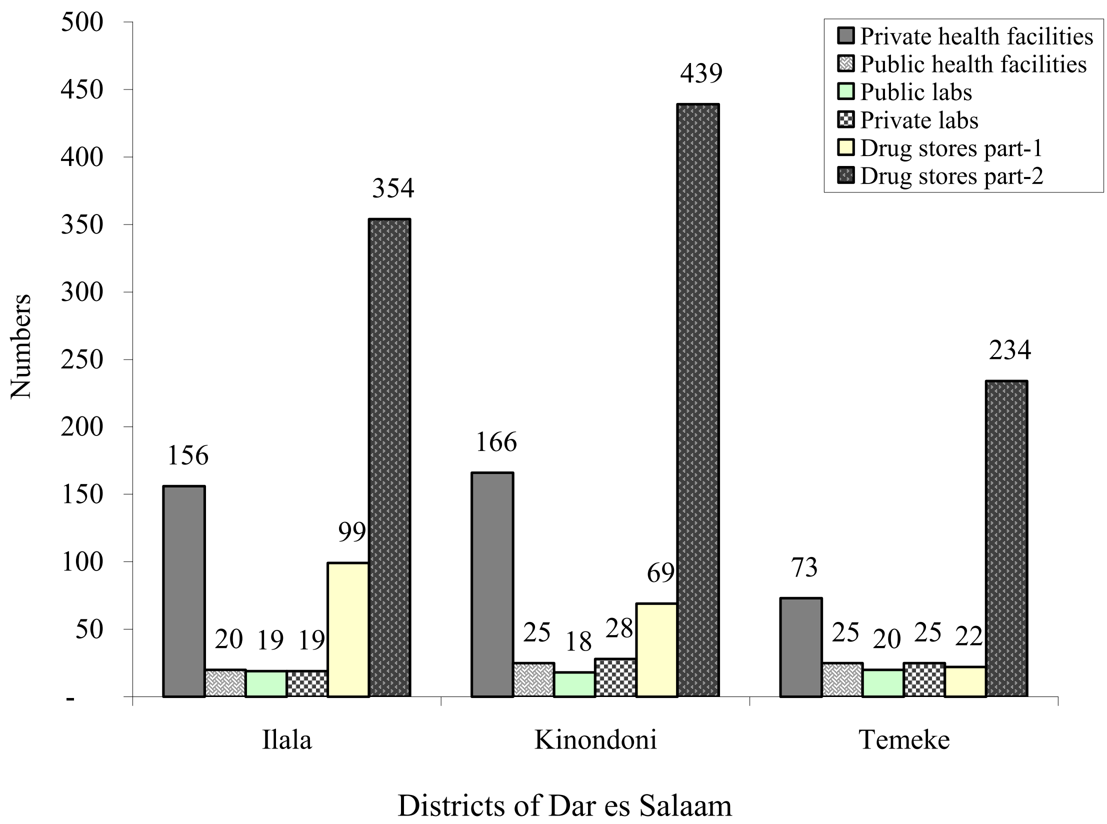

Figure 6-2 Distribution of public/private health facilities in Dar es Salaam.
Drug stores-1=Prescription pharmacies. Drug stores-2=Non-prescription drug outlets.

Results of malaria routine reports

Malaria morbidity and mortality was recorded in the "Infectious diseases weekly report" of all three DMO offices. However, problems with the records were noticed, particularly in Kinondoni District. Over 45% of consultations were diagnosed as clinical malaria in all age groups. According to one source (Mtasiwa et al., 2003), an estimated 1.1 million annual malaria cases were reported in 2000 from 2.2 millions outpatient visits in the health facilities, of which half a million were in Kinondoni. However, Stricker (Stricker, 2002) found only 320,000 malaria cases reported in the raw dataset of

Kinondoni District in 2000. According to the Ilala District Annual Plan 2002, a total of 163,311 malaria cases (under 5: 54,853 and 5 years and above: 108,458) were reported from all health facilities in 2000 while 400,000 cases were estimated in the “Minimum package of health-related management activities”(Mtasiwa et al., 2003). The reliability of these data has therefore to be questioned.

6.4.2 School parasitaemia surveys

P. falciparum was detected in 24 of the 1,054 valid samples (2.1%, 95% CI: 1.2-2.6). Although each of the selected schools had its own catchment area, attending children also came from different areas of the city. The parasitaemia prevalence ranged from 0.8% in the city centre to 3.7% in rural areas, while fever was present in 11.6-18.9% of children (Figure 6-3). The maximum parasite count was 30,000/µl found in a child in Kijitonyama Ward.

6.4.3 Health facility-based surveys

P. falciparum was detected in 59 (3.9%) blood films of the 1,498 valid samples (95% CI: 3.0-5.1). Overall, 37/717 (5.2%) fever cases and 22/781 (2.8%) non-fever controls were found positive. The prevalence rate of parasites detected in febrile episodes ranged from 2.0-7.2 % in under 1 year-old, 1-5 years-old, >5-15 years-old and adults, respectively, and the rate was lower in the control group, except for infants (Table 6-1). People living in the intermediate and peri-urban areas of Dar es Salaam had slightly higher parasite prevalence rates than those from the city centre or the rural zone, but the gradient was minimal (Figure 6-4).

The odds ratios (OR) for a malaria infection in fever cases varied between 0.59 and 2.2 in different age groups (Table 6-1) and the fraction of malaria-attributable fever was extremely low: -0.01, 0.03, 0.04 and 0.02 by the age categories shown above.

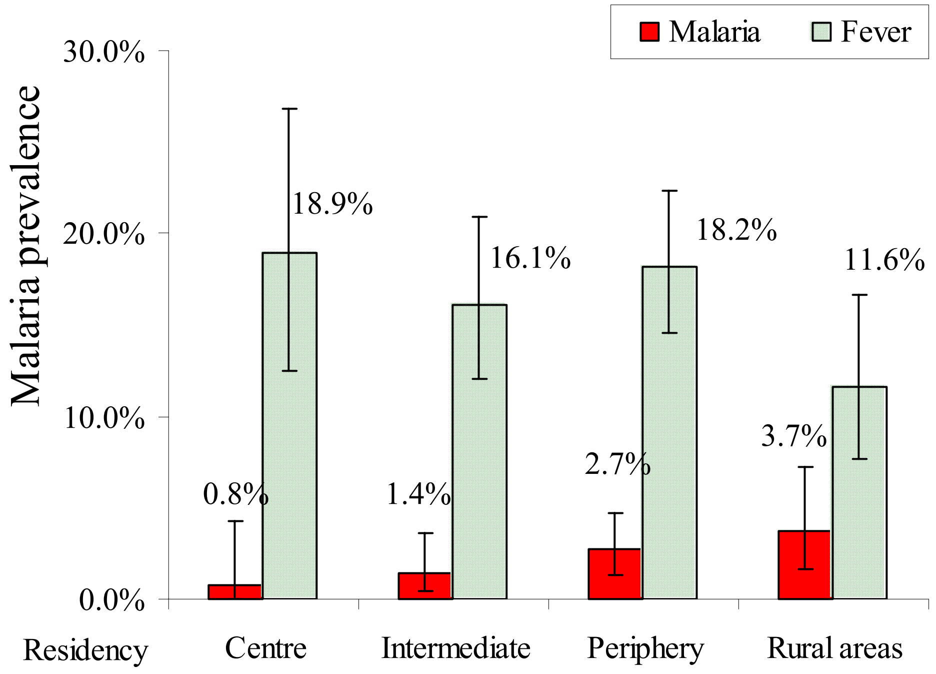

Figure 6-3 Malaria and fever prevalence by residency areas of schoolchildren. Vertical bars represent 95% CI. School parasitaemia surveys.

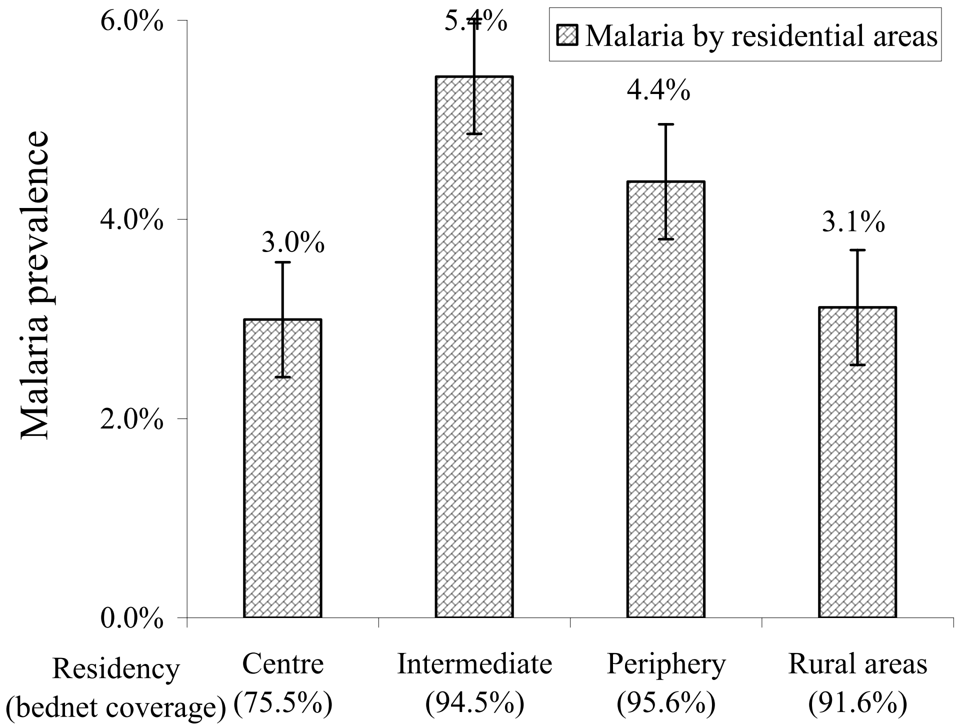

Figure 6-4 Malaria prevalence by residency areas of patients. Vertical bars represent 95% CI. Health facility-based surveys.

Fever of 2-4 days duration were found to be related to a malaria infection compared with fevers of less than 2 days duration (OR=1.78, 95% CI=0.93-3.42, P=0.08). Further, the risk of having malaria parasitaemia with a fever ≥39°C lasting for 2-4 days was 7.5 times higher compared to a fever <39°C lasting for 2-4 days (95% CI=1.81-28.93, P<0.05).

Table 6-1 Malaria infection rates in cases and controls, by age groups. Health facility-based surveys.

Age groups	Cases Positive/Total %	Controls Positive/Total %	OR	95% CI	P value
Infants 0-1 year	2/99 (2.0%)	4/116 (3.4%)	0.59	0.07-3.82	0.84
Children 1-5 years	15/213 (7.0%)	8/178 (4.5%)	1.57	0.61-4.14	0.43
Children 6-15 years	7/97 (7.2%)	2/56 (3.6%)	2.02	0.37-14.62	0.61
Adults >15 years	13/308 (4.2%)	8/423 (1.9%)	2.23	0.85-5.96	0.11

Socio-economic factors and awareness of preventing mosquito biting

A logistic regression model was used to assess the association between the education level of patients, sources of water supply, having agriculture land or a garden nearby and malaria infections. None of these associations were significant (Table 6-2). The few people living in a house built with leafs and mud had a higher risk of having malaria compared to those living in a house built with brick and/or concrete (OR=21.8, 95% CI=1.29-369.65, P<0.05). The bednet and insecticide-treated nets (ITN) coverage rates were high in Dar es Salaam (91.8% and 43.1%). Having an ITN seemed to reduce the risk of a malaria infection while the same level of protection was found for any net, but the result was not significant. The correlation between the amount invested per month in preventing mosquito biting and the risk of malaria was assessed. The OR were 0.54 if the investment ranged from USD 0.5 to 4.9 and 0.69 if the investment ranged from USD 5.0 to 25.0 per month, compared to a smaller amount, but the results were not significant.

Only 702 out of 1,273 (55.2%) subjects were born in Dar es Salaam, indicating that many were in-migrants. Among children under 5 years of age and those over 5 years, travelling to rural areas within the last 3 months appeared to be a significant risk factor for being infected with *P. falciparum* (Table 6-2).

In total, 425 subjects declared having had a malaria attack within one month of the survey. Among them, 60.7% were treated by traditional herbs and healers, 27.8% in health facilities, while 5.2% of the sample population only purchased drugs in a pharmacy or a drug outlet. For children under five years, there was a significant association between previous malaria treatment and the current presence of parasitaemia (Table 6-2).

Table 6-2 Socio-economic factors and the risk of malaria infection in a logistic regression model. Health facility-based surveys. NA=not available.

Socio-economic factors	%	OR	95% CI	P value
Education				
Primary	65.4%	1	-	-
Secondary	5.9%	0.33	0.04-2.44	>0.05
Superior	1.4%	NA	NA	NA
No education	27.3%	0.87	0.44-1.7	>0.05
Housing material				
Concrete/brick	99.1%	1	-	-
Leaf/mud	**0.7%**	**21.80**	**1.29-369.75**	**<0.05**
Water supply resource				
Tap water	74.0%	1	-	-
Well	24.4%	1.19	0.63-2.23	0.6
Living near a garden or agriculture land				
No	82.7%	1	-	-
Yes	17.3%	1.1	0.56- 2.16	0.8
Previous malaria treatment within 30 days with the presence of parasitaemia				
No		1	-	-
Yes (≤ 5 years-old)	**34.5%**	**2.84**	**1.33-6.07**	**<0.005**
Yes (>5 years-old)	27.4%	0.68	0.27-1.70	>0.05
Adjusted for the effects of age groups				
Bednet usage one night before the survey				
No	8.2%	1	-	-
Yes	91.8%	0.6	0.27-1.55	0.3
ITN ownership				
No	56.9%	1	-	-
Yes	**43.1%**	**0.6**	**0.34-1.07**	**0.08**
Adjusted for the effects of different residential areas				
Rural exposure within 90 days				
No		1	-	-
Yes (≤ 5 years-old)	**11.8%**	**3.62**	**1.48-8.88**	**<0.05**
Yes (>5 years-old)	**13.5%**	**2.80**	**1.23-6.37**	**<0.01**

6.5 Discussion and conclusions

The RUMA methodology is based on a cross-sectional study and the results of such a study may be different at another time of year and in different years. The present study was conducted during the dry season of an exceptionally dry year (Figure 6-5). Therefore the numbers of larvae breeding sites and clinical malaria cases detected in 2003 may be lower than in years with normal rainfall. These results need to be confirmed in another year and this work is currently ongoing in the frame of an ongoing UMCP.

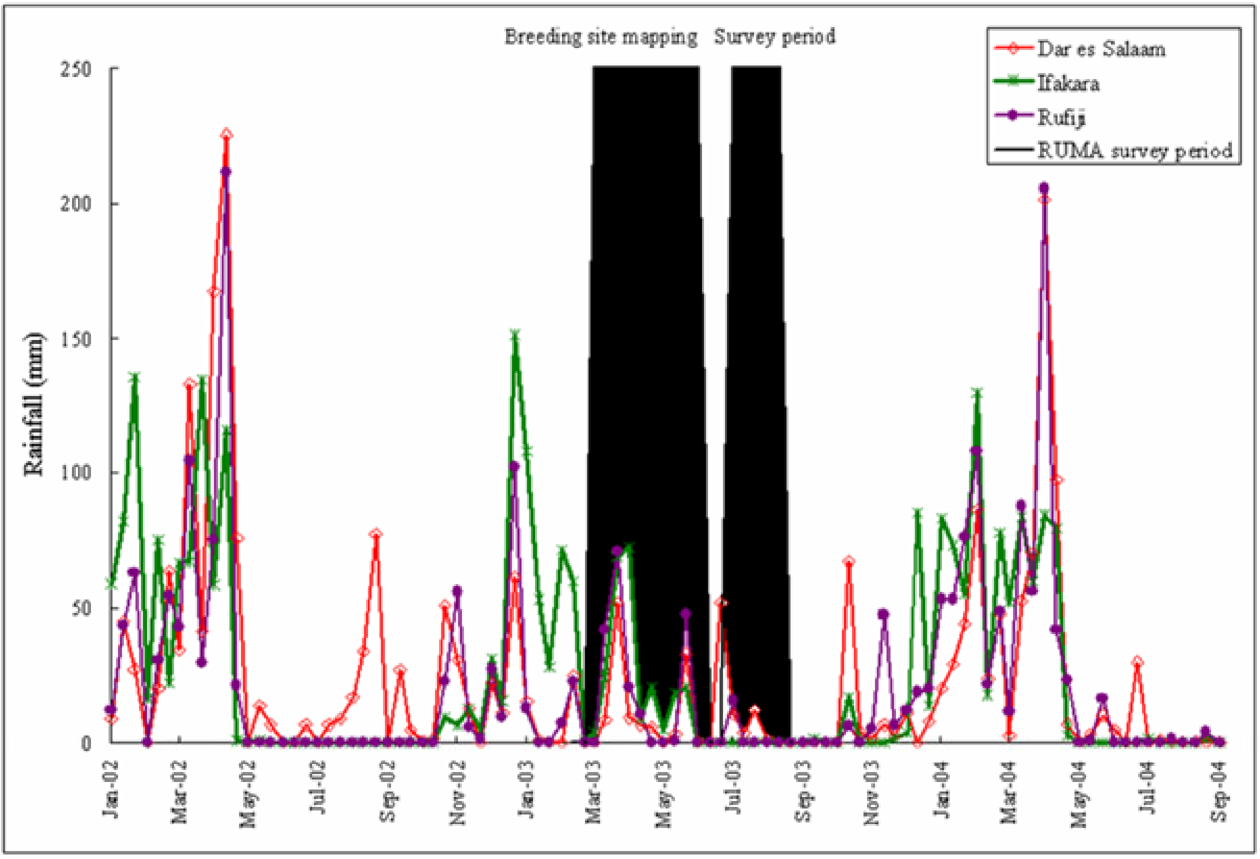

Figure 6-5 Estimated monthly and annual rainfall in Dar es Salaam/Ifakara/Rufiji areas in years 2002-2004.

Weekly epidemiological information was available from each health facility but the monitoring system did not function adequately. The quality of the routine health statistics was found to be low and it is not entirely clear how the planning of the patient load takes place, both at city level and for the different health facilities. In addition, the low malaria-attributable fraction of presenting fever episodes (see below) raises ever further the issue of the true malaria burden in this city and the best way to measure it.

The malaria risk mapping was done in conjunction with another project during the rainy season of early 2003. The breeding sites were identified and mapped over a period of three months. This work gave a good indication of malaria transmission levels in different areas of Dar es Salaam. Without such additional collaboration, mapping of breeding sites would not be possible in the time and budget frame of a RUMA and this component should be dropped from the standard protocol. On the other hand, the mapping of all health facilities is doable if the required list of public and private health service providers can be obtained from the health authorities. In the case of Dar es Salaam the production of such a map was highly appreciated by the authorities and this activity received appropriate support.

The first large post-independence UMCP was carried out between 1986-1994 as a collaboration between the government of Tanzania and the Japanese International Cooperation Agency (JICA). It concluded that in addition to rapid diagnosis and treatment in health facilities, health education, maintenance and cleaning of drains and active participation of the community were of prime importance. As a result of such activities, the JICA-supported UMCP reduced malaria transmission in Dar es Salaam (Caldas de Castro et al., 2004). Nearly ten years later, the community prevalence of *P. falciparum* in our study was even lower (Table 3). Kisarawe primary school was the only school in the city centre during JICA's intervention, but it no longer existed in 2003, so Mtendeni primary school**,** about 500 m away, was selected instead. The malaria prevalence was 31% in September, 1988, 7.2% in September, 1991 and then only 2.6% at the end of the UMCP in August, 1995. The parasitaemia rate was only 0.6% in the nearby Mtendeni primary school in July and August, 2003. In the intermediate area, the malaria prevalence was 3% in Sinza and 10% in

Kijitonyama Kisarawe primary school during September-December, 1994 (Yamagata, 1996), compared with Mwenge (0.9%) and Kijitonyama Kisarawe primary school (2.1%) in 2003. Due to administrative problem, Sinza was replaced by Mwenge primary school, around 1 km away. In the periphery, the malaria prevalence in Kigamboni primary school was 41% in 1988, 14.7% in September, 1991 and then only 9.3% in 1995, compared to 3.0% in Ufukoni primary school in August, 2003. Ufukoni is around 200 meters to Kigamboni primary school. In the surrounding rural area, Buza primary school was about five km closer to the urban zone than Chamzi primary school which was selected in the JICA study. The malaria prevalence was 28% in Chamzi in September-December 1994 and 3.8% in Buza primary school in August 2003. Hence, our results showed a lower level of endemicity compared to the 1990s. Results could be extremely different during and at the end of rainy season or in different year. A household survey was going on in 18 wards in Dar es Salaam (6 wards in each district) from May, 2004. The unpublished result showed that the malaria prevalence varied widely in different communities and different seasons: it ranged from 1.5-44.6% in 2004 and 3.7-50.9% in 2005 (G. Killeen, personal communication).

Table 6-3 Malaria prevalence in primary schools in Dar es Salaam in the JICA-UMCP study between 1988 and 1995 and the RUMA study in 2003, by geographical location.

Malaria prevalence	**Central**		**Intermediate**			**Periphery**		**Rural area**	
Primary schools	Kisarawe	Mtendeni	Sinza	Kijitonyama	Mwenge	Kigamboni	Ufukoni	Chamzi	Buza
Sep-88	31.0%	-	-	-	-	41.0%	-	-	-
Aug-89	11.7%	-	-	-	-	7.3%	-	-	-
Aug-90	9.5%	-	-	-	-	13.5%	-	-	-
Sep-91	7.2%	-	-	-	-	14.7%	-	-	-
Jul-92	0.9%	-	-	-	-	10.6%	-	-	-
Sep-94	6.5%	-	3.0%	10.0%	-	14.1%	-	28.0%	-
Aug-95	2.6%	-	-	-	-	9.3%	-	-	-
Jul-Aug 03	-	0.6%	-	2.1%	0.9%	-	3.3%	-	3.8%

The shaded cells are the schools selected in the JICA-UMCP study and the non-shaded cells are the schools selected in the RUMA study. The selected primary schools in the same city zone are close to each other.

It is difficult to assess whether this is a lasting trend, brought about, for example, by the high level of ITNs use or increasing urbanization, or whether this was the result of an especially dry season. In any case, the population of Dar es Salaam was well aware of malaria prevention, especially the use of ITNs and this was also reported by other studies (Pate et al., 2002; Stephens et al., 1995; Stricker, 2002).

In 1988, 20% of all persons of working age in Dar es Salaam were involved in some ways in urban agriculture (Smit et al., 1996). A recent study confirmed that urban agriculture is widespread in Dar es Salaam (Dongus, 2001). Unfortunately these activities create a suitable breeding ground for malaria vectors. Sattler *et al*. (Sattler et al., 2005)identified more than 400 *Anopheles* sp. breeding sites in central Dar es Salaam, which was surprising given the low level of endemicity. An ongoing survey showed that mosquito landing rates per person per night in Dar es Salaam were very low, implying that larvae and pupae of *Anopheles* sp. are perhaps unable to develop to adult mosquitoes (Y. Geissbühler and G. Killeen, personal communication).

The fractions of malaria-attributable fevers in health facilities were low in all age groups during the time of the present survey, suggesting that patients presenting at health facilities with fever were much more prone to suffer from other diseases than malaria. Less than 5% of all fever-related consultations in Dar es Salaam were likely to be due to malaria during the dry season of 2003 and this has important implications for fever case management. On one hand this leads to a substantial number of unnecessary treatments, a problem made much more serious with the forthcoming introduction of the more expensive artemisinins-based combination therapy. On the other hand, over-diagnosing malaria patients may also detract from other causes of fever, some of which may be dangerous to the patient. Meanwhile, it is urgent to estimate the fractions of malaria-attributable fevers during the rainy season and to review carefully the procedures for malaria diagnosis in health facilities. In a second step, revised guidelines for the management of fever cases may need to be considered.

Authors' contributions

SW participated in the design of the study, conducted the field work, analysed and interpreted data, drafted and revised the manuscript. CL conceived the study, coordinated the field work, interpreted the data and revised the manuscript. DM was the key local contact person, he coordinated and supervised the field activities. TM was in charge of laboratory work and quality control of slides. LM and GM participated in the data collection, the entry of data and the mapping of health facilities. MT participated in the conception of the work, and revised it critically at different stages.

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List of abbreviations

CMOH	City Medical Office of Health (of Dar es Salaam)
DMO	District Medical Office
DUHP	Dar es Salaam Urban Health Project
GIS	Geographic Information System
GPS	Global Positioning System
ITN	Insecticide-Treated Nets
JICA	Japanese International Cooperation Agency
MOH	Ministry of Health (of Tanzania)
MUCHS	Muhimbili University College of Health Sciences
OR	Odds Ratio
RUMA	Rapid Urban Malaria Appraisal
STI	Swiss Tropical Institute
UMCP	Urban Malaria Control Project

Chapter 7

Cotonou

7. CHAPTER: COTONOU

Rapid urban malaria appraisal (RUMA) IV:

Epidemiology of urban malaria in Cotonou (Benin)

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7.1 Abstract

Background: An estimated 40 % of the population in Benin lives in urban areas. We tried to estimate the malaria endemicity and the fraction of malaria-attributable fevers in health facilities in Cotonou.

Methods: A health care system evaluation and a series of school parasitaemia surveys and health facility-based surveys were carried out during the dry season in February-March 2003, applying a standard Rapid Urban Malaria Appraisal (RUMA) methodology. This study was part of a multi-site assessment supported by the Roll Back Malaria Partnership.

Results: The field work was carried out in February-March 2003. In 2002, there were 100,257 reported simple malaria cases and 12,195 complicated malaria cases for 289,342 consultations in the public health facilities of Cotonou. Between 1996 and 2002, on average 34% of total consultations were attributed to simple malaria cases and 1-4.2% to complicated cases.

In the school parasitaemia surveys, a malaria infection was found in 5.2 % of all samples. The prevalence rates of parasitaemia in the centre, intermediate and periphery zones were 2.6%, 9.0% and 2.5%, respectively. In the health facility surveys the malaria infection rates in presenting fever cases were 0% (under 1 year-old), 6.8% (1-5 years-old), 0% (>5-15 years-old) and 0.9% (over 15 years-old), while those in the control group were 1.4%, 2.8%, 1.3% and 2.0%. The MAFs among presenting fever cases were 0.04 in the 1-5 years-old and zero in the three other age groups. Hence, malaria played only a small role in fever episodes at the end of the rainy season.

In total, 69.2% of patients used a mosquito net the night before the survey and 35.1% used an insecticide-treated net, which was protective (OR= 0.23, 95% CI 0.07-0.78). Traveling to a rural area (5.8% of all respondents) did not increase the infection risk.

Conclusions: The homogenously low malaria prevalence might be associated with urban transformation and/or a high bednet usage. Over-diagnosis of malaria and over-treatment with antimalarials was found to be a serious problem.

7.2 Background

Diversity in malaria transmission pattern is driven by human activity, urban development and environmental determinants. The dynamics of urbanisation in sub-Saharan Africa (SSA) greatly affect the eco-system and population health and this calls for more research on urban malaria (Donnelly et al., 2005; Hay et al., 2005; Keiser et al., 2004; Omumbo et al., 2005a).

In 2000, it was estimated that 40.1 % of the population in Benin lived in urban areas, and the country can be considered urbanized by SSA standard (MISAT, 2000). The climate in Cotonou is characterized by two rainy seasons and two dry seasons. A major dry season starts from December to the end of March, followed by a major rainy season from April to the end of July. A minor dry season starts from August to the middle of September, followed by a minor rainy season to the end of November. One of the most serious environmental problems in Cotonou is the abundance of water, especially during the two rainy seasons. Over half of Cotonou suffers from yearly flooding during several months, and this creates freshwater puddles allowing mosquito larvae breeding, leading to an increase in malaria transmission.

The variability of malaria transmission and vector densities in Cotonou and their associations with lagoon salinity have been well described (Akogbeto, 1995; Akogbeto et al., 1992a; Akogbeto et al., 1992b; Akogbeto and Romano, 1999; Brock, 1999).

In June 2002 a standard protocol for a Rapid Urban Malaria Appraisal (RUMA) was developed on the basis of a WHO proposal and an Environmental Health Project draft protocol (Warren et al., 1999; WHO, 2001). The present work was carried out as a part of multi-site assessment in three francophone countries (Ivory Coast, Burkina Faso and Benin) and one anglophone country (Tanzania). The standard RUMA includes: a literature review, the collection of available health statistics, a series of school parasitaemia surveys, a series of health facility surveys, a malaria risk mapping and a brief review of the country's health care system. In each of the four sites the RUMA aimed to provide an overview of the urbanization history, parasite rates for different zones, an estimate of the fraction of malaria-attributable fevers, an outline of health care services and highlights of the "lessons learned". This paper is the fourth in a series of four country assessment papers. A separate overview considers this work in a wider context (Wang et al., 2005).

7.3 Methods

7.3.1 Study sites and sample selection

Cotonou is situated in the smallest department of Benin, Littoral. Cotonou as a whole counts as one "commune" (urban district), consisting of 6 administrative zones and 138 sub-zones. It is the largest city and main port of Benin situated between latitude 6.2°-6.3° N and longitude 2.2°-2.3° E. It was built on a sandy beach to create a harbour close to the only waterway between the Gulf of Guinea and Lake Nokoué. The total area is 74 sq. km. In general, the coastal areas are better planned and developed than the lakeside ones. The population has multiplied rapidly from 3,300 habitants in 1921 to 383,000 in 1981 and it reached 780,657 inhabitants in 2002 (Institut National de la Statistique et de l'Analyse Economique Bénin (INSAE), 2003). The territory of Cotonou was divided into three different zones (centre, intermediate, and periphery) based on population density, distance to the centre and physical characteristics. In each area one health facility and one school were selected for the surveys.

Centre: Centre de Santé St. Michael and Gbéto primary school are at the geographical centre of Cotonou, near the new bridge crossing the inlet channel, where the biggest market of Benin is located.

Intermediate zone: Hôpital St. Luc and Ste-Rita primary school are located in the north of Cotonou 5, which is affected by flooding. Hôpital St. Luc is the biggest hospital in Benin under catholic administration.

Periphery: Centre Médical de Ménontin and Ménontin primary school are situated on the north-west department border besides the town of Godomey. This area is frequently affected by floods. The last few years, an urban upgrade plan in Ménontin was carried out, partially financed by the World Bank.

7.3.2 RUMA methodology

Review of literature and collection of health statistics

Published information on malaria epidemiology was reviewed systematically through a literature search in the main bibliographic databases (PUBMED and EMBASE), through scanning reference lists and through contacting relevant experts, nationally and internationally. The demographic and health system information, as well as routine malaria reports were collected from the Ministry of Health of Benin (MOH), the Institut National de la Statistique et de l'Analyse Economique (INSAE) and USAID-Benin.

School parasitaemia surveys

A cross-sectional parasitaemia survey was carried out in the three selected primary schools from March 18-30, 2003. In urban areas, an estimated 5 % to 50% of fever cases among children under 15 years old were due to malaria. A sample size of 200 in each facility gave an estimate of the proportion of cases with parasites with the following approximate lower 95% confidence limits (for 5%, lower 95% CI: 2; for 50%, lower 95% CI: 46). Only the children six-12 years of age were available in the schools and rarely, children under fiver were seen. After obtaining informed consent from parents and teachers, thick and thin blood smears were collected from approximately 200 school children six–12 years of age in each school and stained with Giemsa. Both thin and thick blood slides were read at the Centre de Recherche Entomologique de Cotonou (CREC). The parasite density was defined as the number of parasites per 200 white blood cells. The children were interviewed with the assistance of school teachers regarding their family situations, malaria infection history and malaria prevention. Each of the selected schools was close to the health facility chosen for the fever survey. In total of 234, 296 and 204 of children from Gbéto, Ste-Rita and Ménontin primary schools, respectively, were recruited. There were much more returned consents from the parents of children in Ste-Rita, so more children were recruited in the survey.

Health facility fever surveys

From the end of March to April 21, 200 fever cases and 200 non-fever controls were recruited from each of the 3 selected health facilities, with half the participants being under 5 years of age. The recruitment of participants follows the following inclusion and exclusion criteria. The inclusion criteria for cases were: outpatients with a history of fever (past 36 hours) or a measured temperature of $\geq$ 37.5°C. The controls were recruited from another department of the same clinic without current or past fever, matched by age and residency. Exclusion criteria were: patients with signs of severe disease, patients returning to the health facility for follow-up visits, non-permanent town residents (less than six months per year). About 50% of the sample was aged $\leq$5 years. After being recruited and giving informed consent, each patient had an axillary temperature measurement and a blood film taken. Each participant had an axillary temperature measurement with an electronic thermometer and an interview about socio-economic status and malaria treatment and prevention history. An armpit temperature reading is usually 0.3°C to 0.6°C lower than an oral temperature reading and therefore 0.5 °C was added to the digital readout. From these results odds ratios (OR) were calculated as the proportion of odds of having parasitaemia in fever cases over the odds of having parasitaemia in controls. Further, the fraction of fevers attributable to malaria was calculated using the following formula: (1-1/Odds Ratio)*P , with P being the proportion of fever episodes with malaria parasites (Smith et al., 1994).

Brief description of the health care system

Senior officers of the MOH and INSAE provided information about the structure of the government health care system, the reforms of health service delivery and the number of providers for malaria diagnosis and treatment in Cotonou.

Mapping

Due to technical and manpower limitations, we were unable to proceed with the mapping of health facilities and mosquito breeding site, as proposed in the standard RUMA methodology. This part was actually found to be too demanding in terms of manpower and time to fit in the framework of a rapid assessment of 6-10 weeks duration. This component could only be carried out in Ouagadougou and Dar es Salaam where the support of outside expertise could be relied upon (Wang et al., 2005). In any case, this component should not be part of a standardized basic RUMA.

7.3.3 Statistical methods

The data were double-entered and validated in EpiInfo 6.04 (CDC Atlanta, USA, 2001). The data analysis was carried out in Stata 8 (Stata Corp. Texas, USA, 2003). The X^2 test was applied to assess associations between categorical variables. Logistic regression was performed to assess the association between binary outcomes and different explanatory variables.

7.3.4 Ethics

In the absence of a national ethic committee, the study received clearance from the national institution al review board of the CREC. All the patients gave informed consent. A prescription of chloroquine or amodiaquine was paid for if the patients presented fever signs or if they had parasitaemia.

7.4 Results

An outline of the main results is given below. A comprehensive report on the work in Cotonou is available elsewhere (Wang et al., 2004b).

7.4.1 Brief description of the health care system

The public health system is divided administratively into three levels: central/national, departmental, and peripheral/community (Centre Africain de Formation et de Recherche Administrative pour le Développement (CAFRAD), 2002; Moko, 1998). The MOH of Benin has been in the process of reorganizing its structure through the creation of an intermediate level in each department: health zones (in French: zones sanitaires), designed to facilitate decentralized planning and increase the efficiency of resource allocation. Each health zone authority is in charge of two levels: 1) regional hospitals (hôpitaux de zone) at the intermediate level and 2) community health districts (circonscriptions sanitaires de commune), which consists of health centres, dispensaries, maternity wards and village health units at the periphery level.

In November 2002 there were 34 public health facilities in Cotonou and only 368 beds for hospitalisation (Table 7-1), serving a total population of 780,000 (Houndekon and Bachabi, 1999; MOH of Benin, 1999). There were 331 private health services including many NGO/religious facilities, which offered a significant amount (30%) of health services in Cotonou. The workload of public health services was found to be heavy, with one doctor/nurse serving more than 2,000 people and one laboratory serving at least 52,000 people (9,000 people for each laboratory technician). The provision of public and private health services is heterogeneous in Cotonou. Most of them are located in zones 3 and 6, near the business centre and the residencies of the upper class and foreigners.

Table 7-1 Public and private health services in Cotonou in 2002.

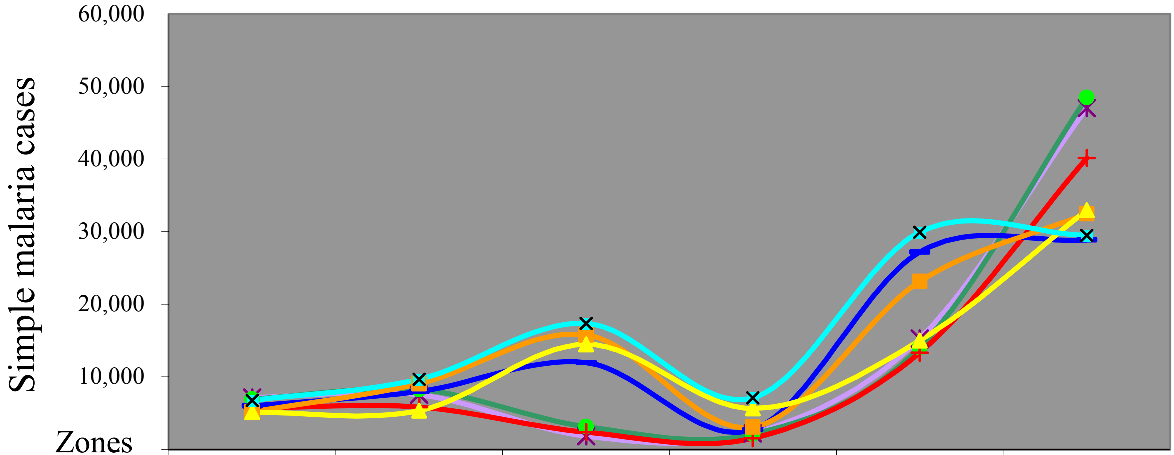
Zone	Public health facilities										Total public health facilities	Total Private health facilities (NGOs & private)	Total
	CSSP/CSSCU	CCS		Other health facilities						UVS			
	Without operating theaters	MCH	Dispensary	MCH	Dispensary	TB control clinic	Leprosy centre	Nursing school	Labs	Open			
Cotonou 1	1	0	1	1	3	0	1	3	1	0	**11**	**24**	**35**
Cotonou 2	1	1	2	0	0	0	0	1	1	2	**8**	**47**	**55**
Cotonou 3	1	0	0	0	0	0	0	0	1	0	**2**	**78**	**80**
Cotonou 4	1	0	0	0	0	0	0	0	0	0	**1**	**39**	**40**
Cotonou 5	1	0	1	0	0	0	0	2	1	0	**5**	**68**	**73**
Cotonou 6	1	0	1	0	0	1	0	3	1	0	**7**	**75**	**82**
Total	**6**	**1**	**5**	**1**	**3**	**1**	**1**	**9**	**5**	**2**	**34**	**331**	**365**

CCS : Complexe Communal de Santé, **CSSP :** Centres de Santé de Sous-Préfecture, **CSSCU :** Centres de Santé de Circonscription Urbaine, **MCH :** Maternal and child health clinic, **NGOs :** Non-Governmental Organisations, **UVS :** Unités Villageoises de Santé, **TB** : Tuberculosis.

Results of malaria routine reports

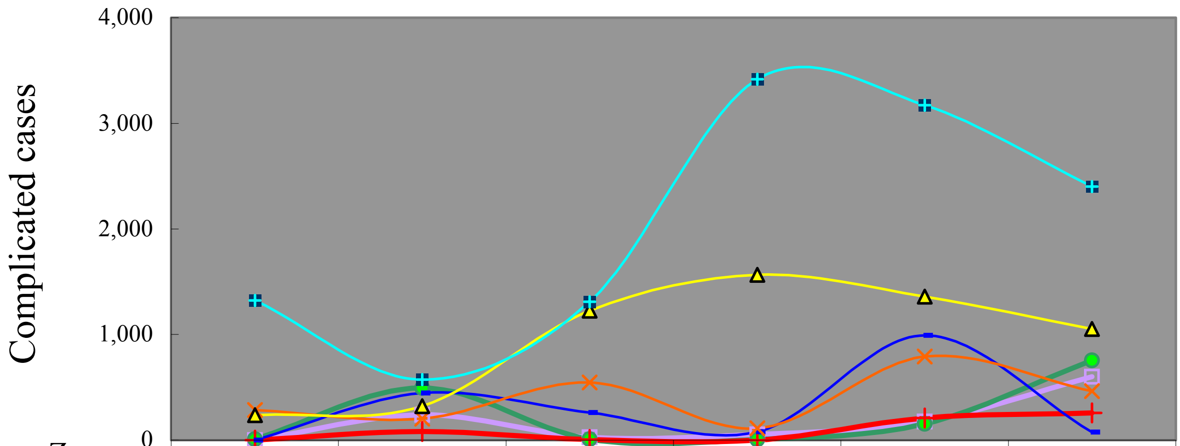
Malaria morbidity and mortality data in Cotonou are collected on an annual basis. The original datasets and monthly reports were not available at the INSAE, and their accuracy and completeness could, therefore, not be ascertained. The available reports summarized all the clinical diagnoses in public health facilities from 1996 to 2000 and classified simple (mild) malaria and complicated (severe) malaria by age and sex. Unfortunately, the data were not broken down by month and so the seasonality could not be investigated. Only the inter-annual and intra-city patterns could be observed. There was no information regarding how many health facilities reported regularly to INSAE and municipal health department. How many malaria were laboratory confirmed was not mentioned in the report.

1a)



Zones	Cotonou I	Cotonou II	Cotonou III	Cotonou IV	Cotonou V	Cotonou VI
1996	7,169	7,532	1,814	2,206	15,260	47,050
1997	6,936	8,232	3,130	2,131	14,051	48,468
1998	5,754	5,804	2,389	1,548	13,317	40,139
1999	5,994	7,995	11,973	2,733	27,180	28,834
2000	5,214	9,062	15,770	3,103	23,098	32,492
2001	5,138	5,326	14,474	5,651	14,987	32,935
2002	6,759	9,678	17,339	7,108	29,890	29,483

1b)



Zones	Cotonou I	Cotonou II	Cotonou III	Cotonou IV	Cotonou V	Cotonou VI
1996	0	241	26	55	176	600
1997	9	493	9	7	155	755
1998	1	83	6	1	208	259
1999	1	445	261	79	993	77
2000	286	204	547	112	792	465
2001	237	320	1,224	1,565	1,358	1,051
2002	1,321	573	1,310	3,417	3,172	2,402

Figure 7-1a Reported malaria cases in Cotonou in 1996-2002.

Figure 7-1b Reported complicated malaria in Cotonou in 1996-2002.

In 2002, there were 100,257 simple malaria cases (34.5% of total) and 12,195 complicated cases (4.2% of total) reported among 289,342 consultations in the public health facilities of Cotonou. Between 1996 and 2002, on average 34% of total clinical consultations were attributed to simple malaria and 1-4.2% to complicated malaria cases (Figure 1a & 1b). In Cotonou 1 and 2, the annual total remained fairly stable during the last 6 years, while the reported malaria cases increased substantially in Cotonou 3, 4 and 5. The reason for this might be that Cotonou 3-4 was seriously affected in recent years by flooding. In addition, there are many health facilities and pharmacies in this area to identify malaria cases and provide treatment. The malaria cases declined over time in Cotonou 6, which may have been due to the systematic urban development and construction of sanitary systems in this area. Cotonou 6 used to be a remote area, but it is now almost entirely occupied by a well-to-do community. However, no information about the possible reasons of such difference can be generated from routine report.

7.4.2 School parasitaemia surveys

Malaria infections were found in 34 of 734 valid blood films (5.2 %, 95% CI: 0.04-0.07). The prevalence rates of parasitaemia in the centre, intermediate and periphery areas were 2.6% (95% CI: 0.01-0.05), 9.0% (95% CI: 0.06-0.13) and 2.5% (95% CI: 0.01-0.06), respectively. Parasitaemia was only found in 7 sectors: 1) centre: Gbéto, Jonquet and St Michael, 2) intermediate: Agontinkon and Ste-Rita, 3) periphery: Kindonou and Ménontin (Figure 2). Overall, the prevalence rates were much lower than expected.

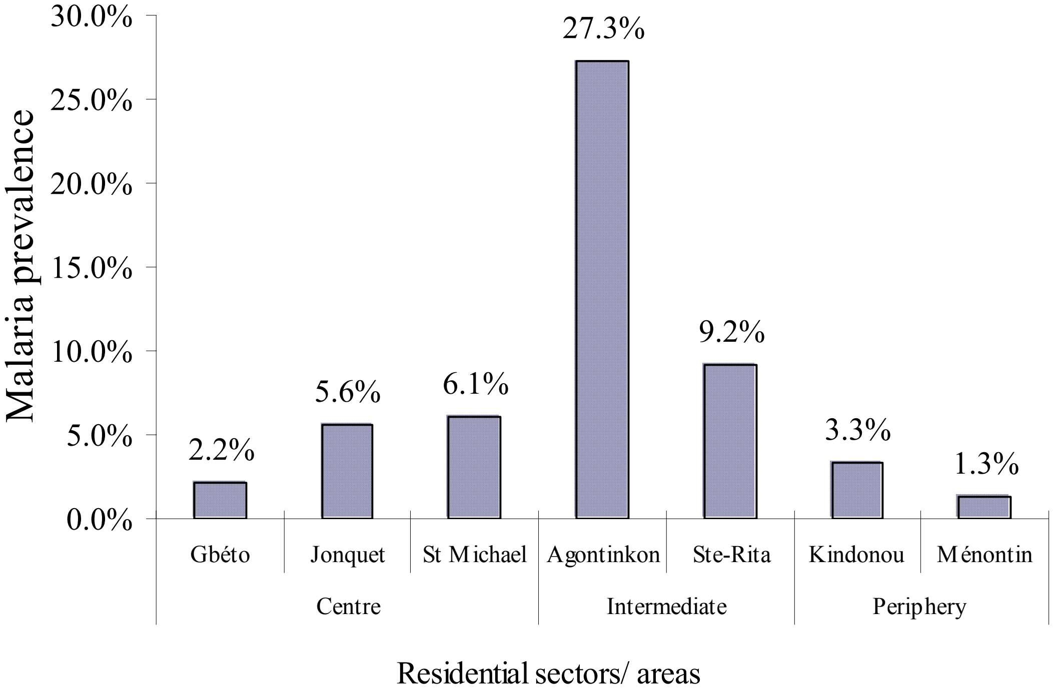


Figure 7-2 Distribution of malaria cases by different zones of Cotonou 5. School parasitaemia surveys.

7.4.3 Health facility-based surveys

Among 1,288 blood films, we detected 22 samples with trophozoites and 3 with gametocytes of *P. falciparum* (1.9%). Only 7 (1.8%) of 386 fever cases and 18 (2.0%) of 902 non-fever controls were positive. The mean density in the positives was 2,729 trophozoites /µl (maximum: 25,600 /µl). The majority of infected patients had low parasitaemia (1-400 /µl) with only three having hyperparasitaemia (> 6,400 /µl).

All samples were divided into 4 age groups: infants <1 year old, children of 1-5 years-old, children >5-15 years-old and adults (>15 years-old). The overall prevalence rates of parasitaemia were 1.0%, 4.2%, 0.9% and 1.7%, respectively. Malaria parasites were found in 0%, 6.8%, 0% and 0.9% of fever cases (same age categories) and in 1.4%, 2.8%, 1.3% and 2.0% of the control group (Table 3). The odds ratio for parasitaemia in fever cases ranged from 0 to 2.64. The fractions of malaria-attributable fevers could not be calculated using the standard formula for the infants and 6-15 years-old (division by zero) but since the cases did not have any parasites the fractions were equaled to zero. Hence, the MAFs were very low: 0, 0.04, 0 and -0.01 for the age categories above.

Table 7-2 Malaria prevalence in fever cases and controls and the fractions of malaria-attributable fevers by age group.
Health facilities surveys. na=not applicable, since the OR=0 this value can not be calculated using the standard formula.

Age group	Fever	Control	OR	95% CI	Fractions of malaria attributable fevers
Infants 0-1 year	0/63 (0%)	2/140 (1.4%)	0.00	0.00-9.16	Na
Children 1-5 years	5/68 (6.8%)	4/137 (2.8%)	2.64	0.59-12.19	0.04
Children 6-15 years	0/35 (0%)	1/78 (1.3%)	0.00	0.00-40.03	Na
Adults >15 years	2/213 (0.9%)	11/529 (2.0%)	0.45	0.10-2.05	-0.01¥

¥ Since the OR<1, the fraction of malaria attributable fevers is <0, indicating that the true rate of malaria fevers is very small.

The results of the health facility surveys were similar to the results of the school surveys: people living in the intermediate zone of Cotonou had similar risk of malaria infection than those from the city centre and the periphery (Figure 7-3). The result of logistic regression model adjusted by age groups was not significant for the risk gradient, which is probably due to the small number of malaria cases (intermediate area: OR=1.19, 95% CI=0.45-3.13, periphery: OR=0.47, 95% CI=0.16-1.36). The bednet usage and ITN ownership rates were high in Cotonou: 69.2% and 35.1%, respectively (Figure 7-4). A logistic regression model adjusted for residential areas and age groups showed that all bednets seemed to reduce the malaria risk but this was not significant (OR=0.61, 95% CI 0.26-1.40), while treated nets (ITNs) significantly reduced malaria infections (OR=0.23, 95% CI= 0.07-0.78, P=0.018).

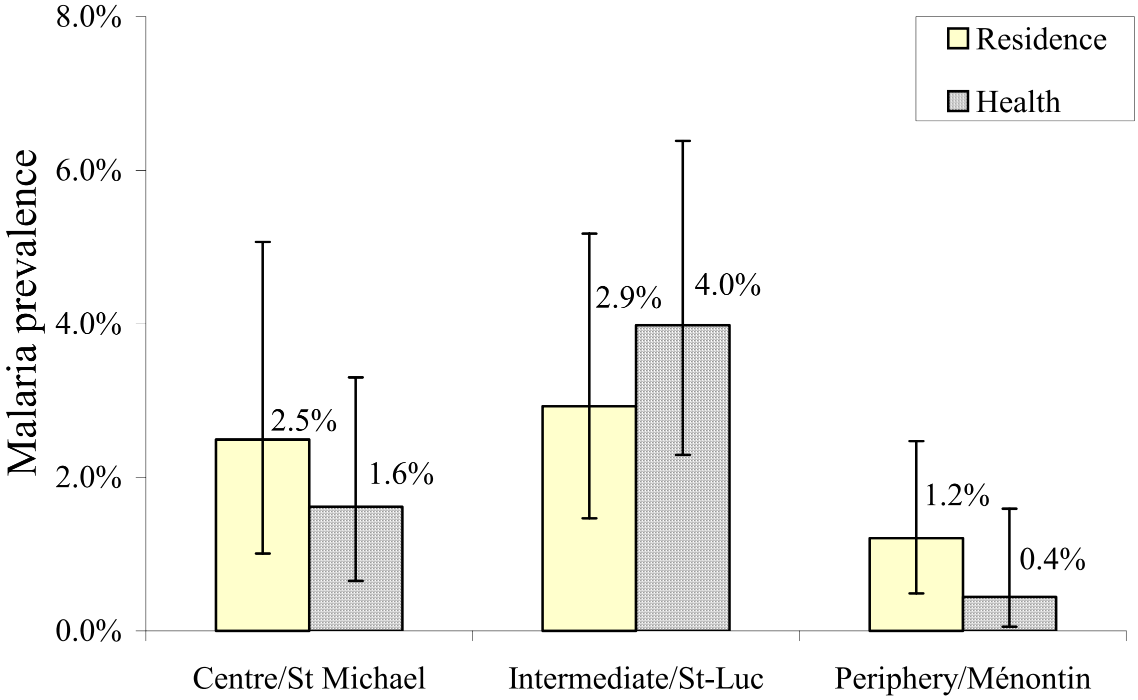


Figure 7-3 Malaria prevalence by residential areas and location of health facilities. Vertical bars represent 95% CI. Health facility-based surveys.

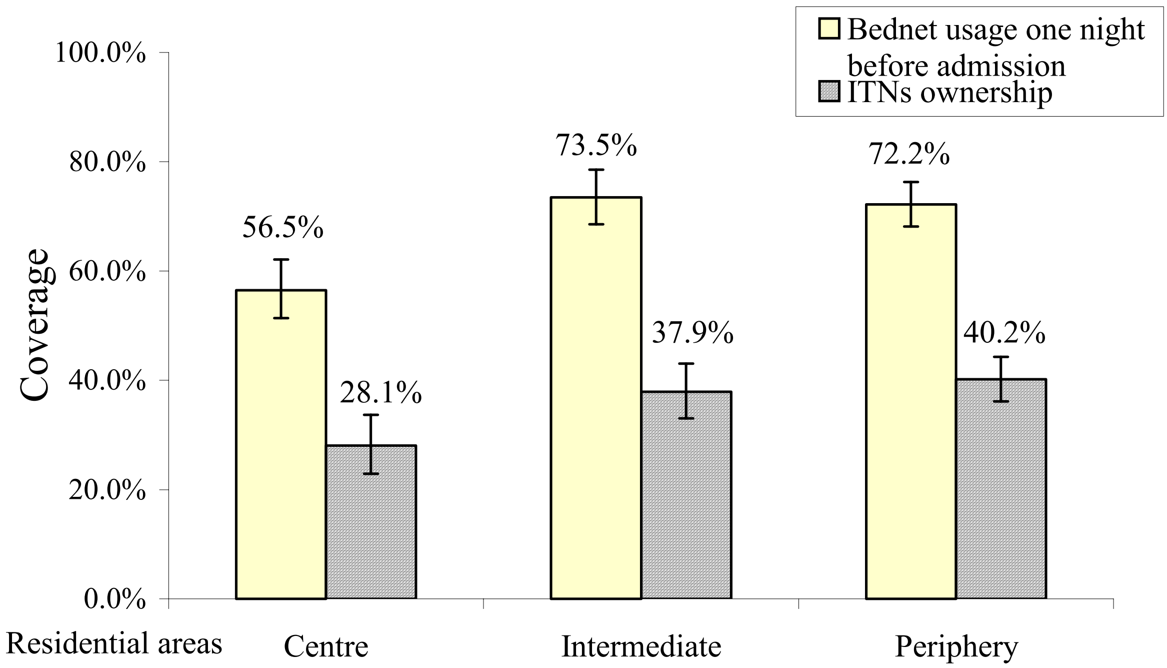


Figure 7-4 Use of bednets the night before admission and the ITNs ownerships by different residential areas. Vertical bars present 95% CI. Health facility-based surveys.

The education level of residents and the water supply resource were homogeneous throughout Cotonou. More residents in the periphery areas lived nearby agriculture land or gardens. A majority of people lived in concrete/brick houses. After adjusting for different residential areas, the logistic regression analysis showed that there was a strong association between malaria infections and housing material: the OR of mud buildings was 6.2 compared to concrete/brick buildings (95% CI=1.3-29.6, $P<0.05$). The proportions of residents lived in the concrete/brick building in central, intermediate and peripheral areas of Cotonou were 96.1%, 97.1% and 97.9%, respectively, while the proportions of mud buildings were 0%, 1.3% and 0.5%, respectively. Only 5.8% (N=75) of the study population had travelled to rural areas within the last three months and none had malaria parasites in their blood.

Overall, 32% (N=425) of the participants claimed having had malaria treatments one month prior to the survey. Among them, nearly 50% self-treated at home and 46.0 % were previously treated in health centres or in a hospital.

7.5 Discussion and conclusion

This study brought to light a number of important and relevant pieces of information. But it is good to also appreciate the limitations of the current RUMA, which is a cross-sectional study performed during a single season. The present assessment was carried out during the dry season (February-March) and similar surveys need to be repeated during the rainy season. If the RUMA survey would have been done in the rainy season, or just after the rainy season, more malaria would be detected and the figure would be quite different. Both the levels of infection and the frequency of malaria parasites in presenting fever cases are likely to be higher then. Unfortunately, the routine statistics were not disaggregated by month, and hence seasonality of reported malaria cases could not be described.

The annual routine data showed that on average 34% of the consultations in health facilities had a diagnosis of "clinical malaria" and this fraction was fairly constant over the last seven years. However, our results suggest that only a small fraction of these cases could really be attributed to malaria (0-4% depending on the age groups). A similar situation is found in the three other cities (Abidjan, Ouagadougou, Dar es Salaam) in which studies were carried out in the frame of the present multi-site RUMA (Wang et al., 2005). In Cotonou, another health facility survey was conducted in the paediatric ward of the main university hospital from April, 1988 to March, 1989. The overall malaria infection rate was 20% among 480 hospitalized children aged 0-14 years (Boulard et al., 1990). The malaria infection rate was around 15% in February and 5% in March and it increased to 30% in April. Another fever survey was carried out between April 1994 and March 1995, with 325 randomly selected households being visited weekly (Rashed et al., 2000). The results showed that city children had 0.3 febrile episodes annually. Both studies showed that in March (at the end of one of the two dry periods) malaria accounted for less than 10% of all consultations in public health facilities.

These findings clearly indicate that there is a high level of over-diagnosis of malaria in dry season in Cotonou and a resulting over-treatment. This raises two important issues. Firstly, over-treatment with antimalarials leads to a waste of resources and exposes patients unnecessary to the side-effects of antimalarials. Secondly, there is a high risk of missing another diagnosis because the health care provider will focus on malaria and might not further investigate alternative diagnosis. Even more than for simple malaria the latter is an issue in the case of patients diagnosed with severe malaria, as shown by two recent studies in Tanzania (Makani et al., 2003; Reyburn et al., 2004). Beyond medical considerations, over-diagnosis and over-treatment might affect disproportionately the poor segment of the population (Amexo et al., 2004). In view of the introduction of the next generation of more expensive malaria therapies a coordinated action on the systematic diagnosis of malaria in all presenting fever cases is urgently required. These findings do also have serious implications for the assessment of the burden of malaria in this urban environment, since the routine statistics might seriously inflate the true situation.

The efficacy of ITNs in preventing malaria morbidity has been demonstrated convincingly in Cotonou (Akogbeto et al., 1995). The ITNs distribution started in 1993-4 in Cotonou in a small part of area and it expanded to many areas in Cotonou in 2000s. The use of ITN affected the malaria prevalence in Cotonou. Akogbeto *et al.* found that the parasitaemia rate among 2-9 year-old children was 57.1% (N=252) in Gbéto in March-April 1990 before the introduction of ITNs. The use of mosquito nets (treated or not with insecticide) increased in Cotonou after this intervention. The parasitaemia rate among school children of 6-12 year-old in Gbéto was only 2.6% (N=236) in our survey in 2003. It is likely that the reduced malaria prevalence over the last decade in Gbéto was due at least in part to the successful promotion of ITNs. Our descriptive results confirm that both untreated and treated nets protect individuals from malaria.

It was surprising that there was a lower malaria prevalence rate in the periphery compared to the intermediate zone. This could be explained by the salinity of the lagoon and/or by the higher level of urbanisation. The population density and the distribution of *Anopheles sp.* vectors is highly dependent on the salinity of the lagoon, with a higher proportion of *Anopheles melas* compared to the much more efficient vector *Anopheles gambiae s.l.* as salinity increases (Akogbeto et al., 1992a). As a result, the level of malaria transmission was markedly lower in communities near the beach (where standing water was much saltier) than in other areas: about 5 infected bites per person per year versus 29 infected bites per person in the center of Cotonou. As a consequence, the parasitaemia rate for children in Ménontin was lower than in the intermediate area and the city centre, although the difference was not significant. The World Bank had implemented an urban upgrade plan in the Ménontin neighbourhood at the periphery, including a low-income household water-pipe connection program, emergency roads and drainage operations, as well as the construction of the Centre Médical de Ménontin (USAIDS, 2002). By contrast, the intermediate zones such as the surroundings of the Hôpital St Luc, have many unplanned settlements and are underserved. The higher risk of malaria infections may also have been associated with poor urban agriculture irrigations systems.

The present work confirms much of what was also seen in the three other cities investigated by the standardized RUMA (Wang et al., 2005) and it further stresses the importance of collecting more information on urban malaria, especially on the level of risk, the heterogeneity of transmission, and on the fraction of fevers that are due to malaria. Such information will then allow a more evidence-based and integrated planning of control activities specifically adapted to the urban environment.

Authors' contributions

SW participated in the design of the study, conducted the field work, analysed and interpreted data and drafted the manuscript. CL conceived the study, coordinated the field work and revised the manuscript. TS and PV assisted in the statistical analysis. MA supervised the data collection and laboratory work at each site and commented on the manuscript. MT participated in the conception of the work, facilitated the overall coordination and revised critically the work at all stages.

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List of abbreviations

CREC	Centre de Recherche Entomologique de Cotonou
INSAE	Institut National de la Statistique et de l'Analyse Economique
ITNs	Insecticide-Treated Nets
MISAT	Ministère de l’Intérieur, de la Sécurité et de l’Administration Territoriale
MOH	Ministry of Health
OR	Odds Ratio
RUMA	Rapid Urban Malaria Appraisal
SNIGS	Evaluation du Système National d’Information et de Gestion Sanitaire

Chapter 8

Yopougon municipality of Abidjan

8. CHAPTER: YOUPOGON/ABIDJAN

Rapid urban malaria appraisal (RUMA) III:

Epidemiology of urban malaria in the municipality of Yopougon (Abidjan)

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8.1 Abstract

Background: Currently, there is a significant lack of knowledge concerning urban malaria patterns in general and in Abidjan in particular. The prevalence of malaria, its distributions in the city and the fractions of fevers attributable to malaria in the health facilities have not been previously investigated.

Methods: We carried out a health facility-based survey and health care system evaluation in a peripheral municipality of Abidjan (Yopougon) during the rainy season of 2002, applying a standardized Rapid Urban Malaria Appraisal (RUMA) methodology.

Results: According to national statistics, approximately 240,000 malaria cases (both clinical cases and laboratory confirmed cases) were reported by health facilities in the whole of Abidjan in 2001. They accounted for 40% of all consultations. In the health facilities of the Yopougon municipality, the malaria infection rates in fever cases for different age groups were 22.1% (under 1 year-old), 42.8% (1-5 years-old), 42.0% (>5-15 years-old) and 26.8% (over 15 years-old), while those in the control group were 13.0%. 26.7%, 21.8% and 14.6%, respectively. The fractions of malaria-attributable fever were 0.12, 0.22, 0.27 and 0.13 in the same age groups. Parasitaemia was homogenously detected in different areas of Yopougon. Among all children, 10.1% used a mosquito net (treated or not) the night before the survey and this was protective (OR=0.52, 95% CI 0.29-0.97). Travel to rural areas within the last three months was frequent (31% of all respondents) and associated with a malaria infection (OR=1.75, 95% CI 1.25-2.45).

Conclusions: Rapid urbanization has changed malaria epidemiology in Abidjan and endemicity was found to be moderate in Yopougon. Routine health statistics are not fully reliable to assess the burden of disease and the moderate level of the fractions of malaria-attributable fevers indicated substantial over-treatment of malaria.

8.2 Background

During the last two decades, African countries have experienced rapid urban growth without a corresponding development of urban infrastructure and services. This has profoundly changed the environmental and disease patterns. Recently there has been a growing interest in the study of urban malaria epidemiology, with the aim of developing specific control strategies (Donnelly et al., 2005; Hay et al., 2005; Keiser et al., 2004; Omumbo et al., 2005a).

In 2000, approximately 7.4 million people or 45.8% of the total population of Côte d'Ivoire lived in urban areas, thus the country was considered highly urbanized (United Nations, 2003; World Bank, 2002a). In 1990, 15-17% of the population lived in informal settlements and among them, 60% lived in slums with poor road and sanitation infrastructure (Antoini and Herry, 1983) as the local government finds it difficult to cope with the most urgent demands of this uncontrolled growth.

A retrospective study from 1985 to 1998 in the unit of infectious diseases of the Centre Hospitalier Universitaire (CHU) of Treichville showed that 274 cases of severe malaria (0.5%) were detected among 54,098 hospitalizations (Eholie et al., 2004). The records in the paediatric department of the CHU of Yopougon from January 1998 to December 2001 showed that 57.2% of children diagnosed as severe malaria had anaemia, and 55% of them took antimalarials before being admitted to the hospital (Adonis-Koffy et al., 2004). There were also several studies focusing on the evaluation of antimalarials therapeutic efficacy in uncomplicated *P. falciparum* cases (Diawara et al., 1996; Kone et al., 1990; Penali et al., 1993).

A standard study protocol for Rapid Urban Malaria Appraisal (RUMA) was developed in June 2002 based on a WHO proposal and an Environmental Health Project draft protocol (Warren et al., 1999; WHO, 2001). RUMAs were commissioned by the Roll Back Malaria (RBM) for three francophone countries (Côte d'Ivoire, Burkina Faso and Benin) and one anglophone country (Tanzania). The

RUMA includes: a literature review and the collection of health statistics, a school parasitaemia survey, a health facility survey, malaria risk mapping and a brief review of the health care system. Each of the four assessments provided an overview of the urbanization history, an estimate of the fractions of malaria-attributable fevers, parasite rates for different areas, an outline of health care services, and highlights of the “lessons learned” from the survey. A separate overview considers this work in a wider context (Wang et al., 2005).

This paper is the third in a series of four country assessment papers. Due to political troubles and resulting security concerns in Abidjan from September 2002 onwards, the breeding site and health facility mapping activities, as well as the school parasitaemia surveys were interrupted. Hence, the study in Yopougon could only collect data on the rate of reported malaria cases through routine statistics and on the fractions of malaria-attributable fevers in health facilities.

8.3 Methods

8.3.1 Study sites and sample selection

Abidjan is situated between latitude 3.7°-4.0° N and longitude 5.7°-6.0° E, with a surface area of 261 sq. km. It is divided into 5 districts: Central, East, North, South and West (Table 8-1). The districts are divided into 10 municipalities: Abobo (Abidjan North), Adjamé, Attécoubé and Plateau (Abidjan Central), Cocody (Abidjan East), Koumassi, Marcory, Port-Bouét, Treichville (Abidjan South), and Yopougon (Abidjan West)(Figure 8-1).

Yopougon is the largest and most recent municipality (117 sq. km) of Greater Abidjan (Figure 8-2). It comprises both urban and peri-urban areas. The population in Yopougon has grown very fast, from 564 habitants in 1955 to 112,700 in 1975 (Daigl, 2002; Institut National et de la Statistique (INS), 1998). In 1998, it comprised one quarter of the total Abidjan population: 774,200 people (density: 5,900 per sq. km). The population is young (50 % of the total population is less than 20 years-old) and of great ethnic diversity.

Figure 8-1 Map of Greater Abidjan with its municipalities.

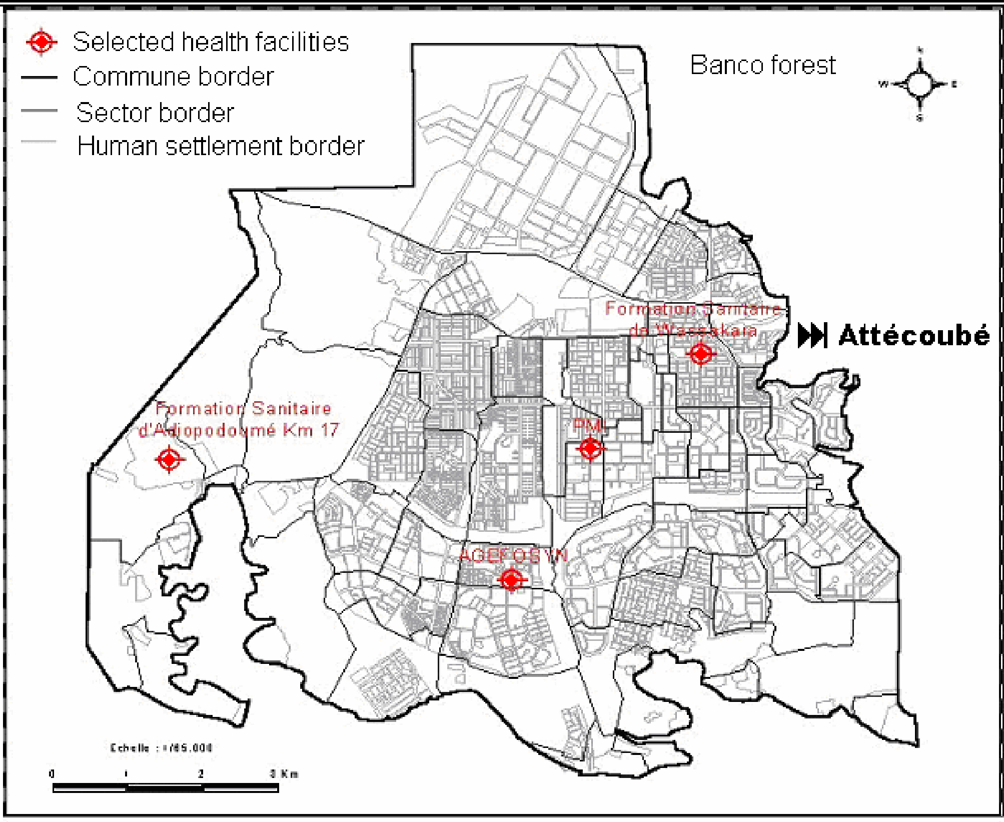


Figure 8-2 Map of Yopougon municipality and selected health facilities.

8.3.2 RUMA methodology

Details for the RUMA methods are given in an overview publication (Wang et al., 2004a). As explained above, there was a military conflict in the city centre and intermediate areas of Abidjan since September, 2002 and there was movement control by the military. As a result, the planned mapping activities and school surveys could not be carried out. Briefly, the following components were included in Abidjan.

Review of literature and collection of health statistics

Unpublished data on malaria were collected from the Pasteur Institute of Côte d'Ivoire and the National Institute of Public Health. Published information on malaria epidemiology was reviewed systematically through a literature search in the main bibliographic databases (PUBMED and EMBASE), through scanning reference lists and through contacting relevant experts, nationally and internationally. Available demographic and health system information, as well as routine malaria reports were collected from the Ministry of Health (MOH), the Direction Régional de la Santé Publique et des Affaires Sociales , the Institut National de la Statistique and the Programme National de Lutte Contre le Paludisme (PNLP) in Abidjan.

Health facility fever surveys

The study was carried out September 9-27, 2002. The 27 sectors in Yopougon were classified into three different zones (centre, intermediate, and periphery), according to their population density, distance to the centre and physical characteristics. Due to the time constraints of a RUMA, only one representative health facility with a sufficient patient number could be selected in each zone (Figure 8-2).

Centre: Formation Sanitaire Urbaine à base Communautaire (FSU-com) Wassakara, a commercial centre in the sector Gare-Sud Sodeci-GFCI, located at a traffic junction to downtown Abidjan.

Intermediate zone: Formation Sanitaire Urbaine (FSU) Yopougon Attié, also called “Protection Maternelle et Infantile”, the biggest FSU and the only hospital specialised in maternal and child care in Yopougon. It is situated in the geographical centre of Yopougon, and has an average of 200 outpatients per day.

Periphery: FSU-com Niangon Sud, also called Ageforsi, is located beside the lagoon. Unfortunately, the health centres were all shut down from September 19th 2002 onwards, due to an attempted coup and military actions. As a result it was impossible to recruit a sufficient number of patients in Niangon Sud. A fourth health centre, which was still accessible, had thus to be selected: Centre de Santé Communautaire d’Adiopodoumé, located in the periphery sector KM 17 in the west end of Yopougon.

The study aimed to recruit 200 fever cases and 200 non-fever controls from each health facility, with half of the patients being less than 5 years-old. The following criteria were used as case definition: outpatients with a history of fever (past 36 hours) or a measured axillary temperature of $\geq$ 37.5°C. The control group consisted of patients without current or past fever recruited from another department of the same health facility. Controls were matched by age and residency with the fever cases. Participation was voluntary and parents were required to sign a consent form. After giving written consent, questionnaires were administered inquiring about demographic data, socio-economic status and the malaria history for each survey participant. An axillary temperature measure was taken and both thin and thick blood films were prepared on the same slide. Parasite density was defined as the number of parasites per 200 white blood cells. In the end, less than 300 cases and controls could be recruited from each health facility since people were afraid of violence in the street and attendance had fallen sharply.

The odds ratio (OR) that was calculated is the ratio of the odds of having parasitaemia in fever cases over non-fever controls. The formula for the fraction of fever episodes attributable to malaria parasites that was used is the following: (1-1/Odds Ratio)*P, with P being the proportion of fever episodes in which the subjects had malaria parasites (Smith et al., 1994).

The samples were read at the Centre Suisse de Recherches Scientifiques (CSRS) in Abidjan. For quality control, 133 slides were re-examined at the Swiss Tropical Institute (STI) in Basel. For these 133 slides, 116 readings were accurate. The sensitivity, specificity and accuracy rate were found to be 87.9%, 89.2% and 88.79%, respectively, which was considered acceptable.

Brief description of the health care system

Senior officers of PNLP and INS provided essential information regarding the distribution and number of existing providers for malaria diagnosis and treatment in Abidjan. A meeting with representatives of the CSRS and PNLP was held to review the organizational structure of the PNLP, to clarify the national policy and implementation of malaria control, as well as to review the history of resistance to antimalarials.

8.3.3 Statistical methods

The data were double-entered and validated in EpiInfo 6.04 (CDC Atlanta, USA, 2001). Data analysis was carried out in Stata 8 (Stata Corp. Texas, USA, 2003). The X^2 test was applied to assess associations between categorical variables. Logistic regression was performed to assess the association between binary outcomes and explanatory variables.

Ethics

The study received ethical clearance from the Ivorian national ethics committee. All the patients gave informed consent. We paid for the prescription of chloroquine or amodiaquine if the patients presented fever signs or had parasitaemia.

8.4 Results

8.4.1 A brief description of the health care system

The public health care system in Abidjan consists of a number of different units. The Centre Hospitalier Universitaire (CHU) functions as the first-level referral and teaching hospital (3 CHU in Abidjan: CHU-Treichville, CHU-Cocody and CHU-Yopougon).

The two most populated municipalities of Abidjan, Yopougon and Abobo, had striking deficiencies in health care delivery. In 1992, there were only two primary health care centres, one serving approximately 530,000 people in Abobo and the other serving 540,000 people in Yopougon (Tano-Bian A et al., 1992). At the end of 1997, 11 Formation Sanitaire Urbaine à base Communautaire (FSU-com) had been established and a new pricing policy for the Formation Sanitaire Urbaine (FSU) and FSU-com were introduced to help low-income families (Brunet-Jailly, 1999; Ortiz, 1998).

By the end of 2002, there were 135 public and 238 private medical services in the greater Abidjan (Figure 8-3), as well as 667 private paramedical services, usually run by nurses and specialized in gynaecology, paediatrics or internal medicine. The distribution of private paramedical services in the different municipalities was heterogeneous. There were 165 paramedical services in Yopougon and 156 in Abobo, nearly 40% of all Abidjan.

One public health centre serves an average of 21,300 inhabitants in Abidjan. Not surprisingly, better-off people benefit from more health care resources despite the recent health system reform. Plateau, being the smallest and richest municipalities in Abidjan has the highest coverage of public and private health services. In 1998, one public health centre served only 1,200 inhabitants, and one private health facility served only 270 inhabitants there. By contrast, there were 30,400 and 51,900 inhabitants for one public health centre in Yopougon and Attécoubé.

The Programme National de Lutte Contre le Paludisme (PNLP) was started in 1992 (Daigl, 2002; Programme National de Lutte Contre le Paludisme (PNLP), 2002) and Roll Back Malaria (RBM) strategies were introduced in January 2001: case management, chemoprophylaxis for pregnant women, individual and household protection against vectors, reinforcing the health care system, community activities and building up the RBM Partnership. Unfortunately, none of these strategies have been implemented on a large scale.

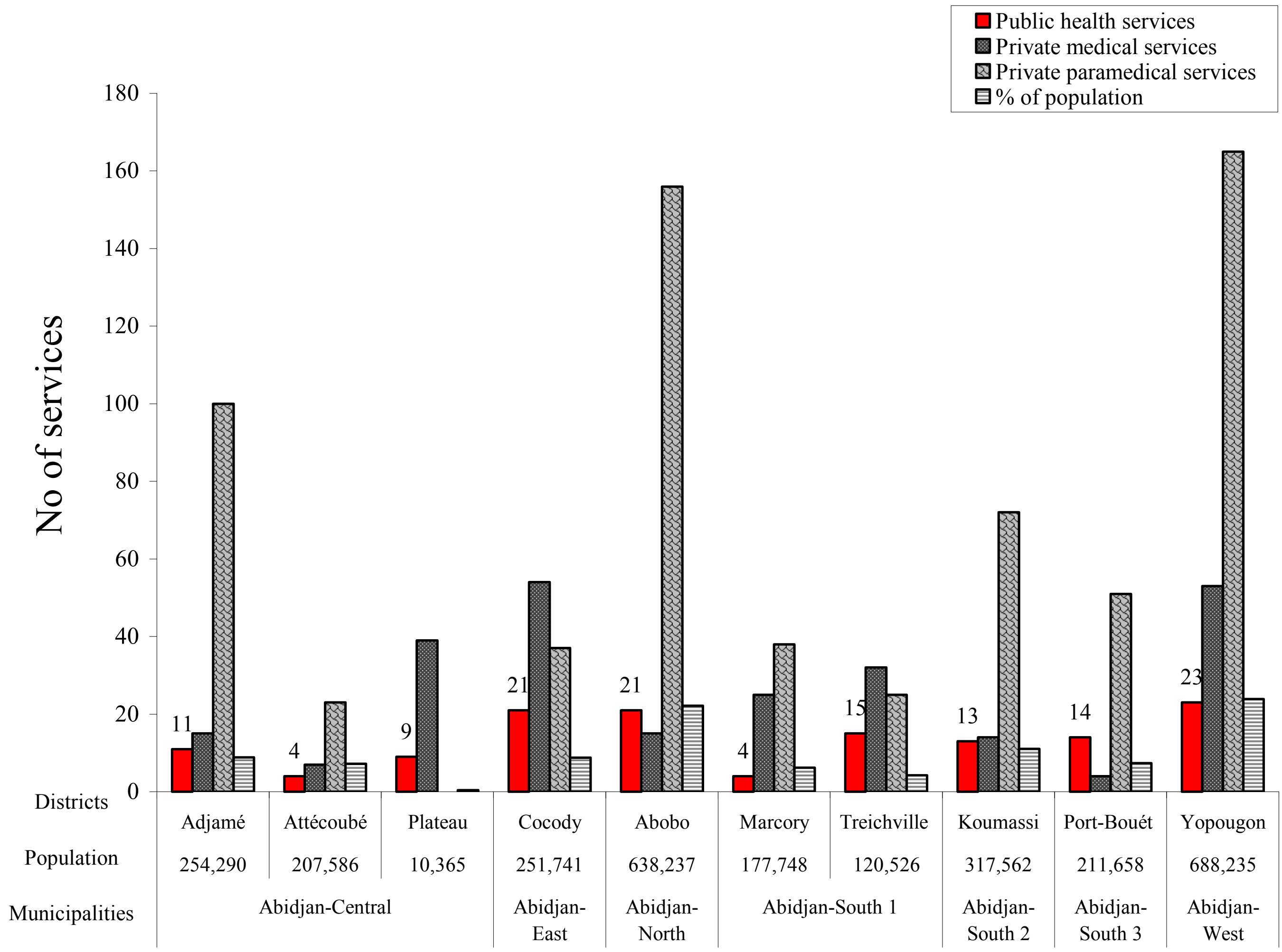


Figure 8-3 Distribution of public, private and paramedical facilities in Abidjan, 2001.

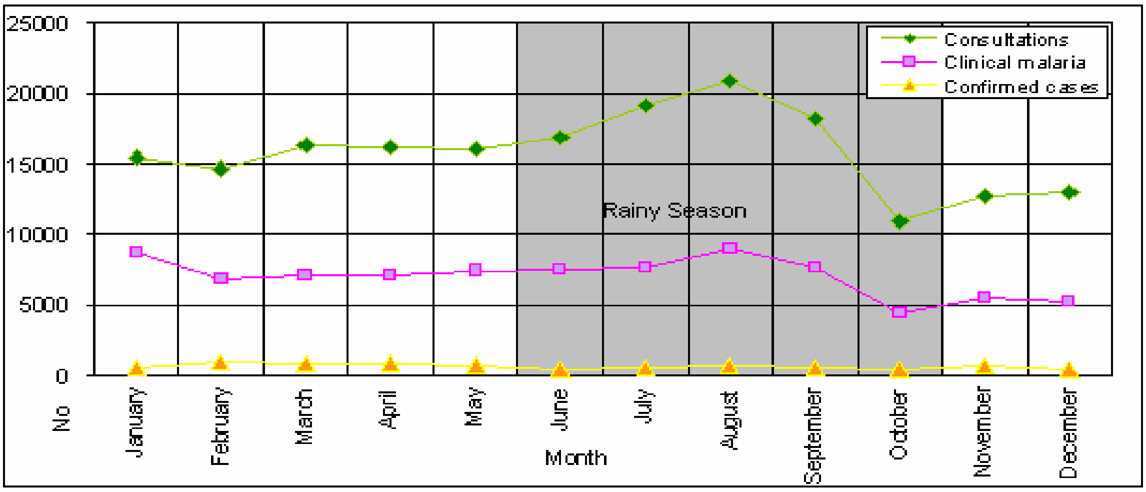
Results of malaria routine reports

The estimation of malaria incidence rates was based on the routine data collected by the PNLP in 2001. Reporting of malaria is neither systematic nor consistent in Abidjan (Programme National de Lutte Contre le Paludisme (PNLP), 2002). In 2001 the data from CHU-Yopougon, and Yopougon and Plateau municipalities were missing (Table 8-1). The malaria cases reported from CHU-Cocody and CHU-Treichville were separated from the other data since these teaching hospitals had patients referred from the countryside or from other health centres in Abidjan. Malaria cases from the CHUs are therefore not representative of the area they are located in. In 2001, there were around 600,000 consultations for all causes in public health facilities, and roughly 240,000 cases (40.9%) were due to malaria. Very few cases (5.2 %) were laboratory confirmed.

Table 8-1 Demographic information and annual malaria cases reported in Abidjan in 2001. Source: Programme National de Lutte Contre le Paludisme. CHU: Centre Hospitalier Universitaire.

Districts or CHU	Municipality	Population	Area in km^2	Reported malaria cases
CHU-Cocody		-		2,525
CHU-Treichville		-		12,375
CHU-Yopougon		-		-
Abidjan-North	Abobo	717,930	112.70	71,437
Abidjan-Central	Adjamé &		12.10	
	Attécoubé	519,548	38.60	35,714
Abidjan-East	Cocody	283,174	76.10	55,500
Abidjan-South 1	Plateau	11,659	4.0	-
Abidjan-South 2	Marcory &		12.60	
	Treichville	335,518	8.90	-
Abidjan-South 3	Port-Bouét &		60.50	
	Koumassi	595,301	11.40	62,607
Abidjan-West	Yopougon	774,171	117.00	-
	Total	**3,237,300**	**453.90**	**237,633**

4a)



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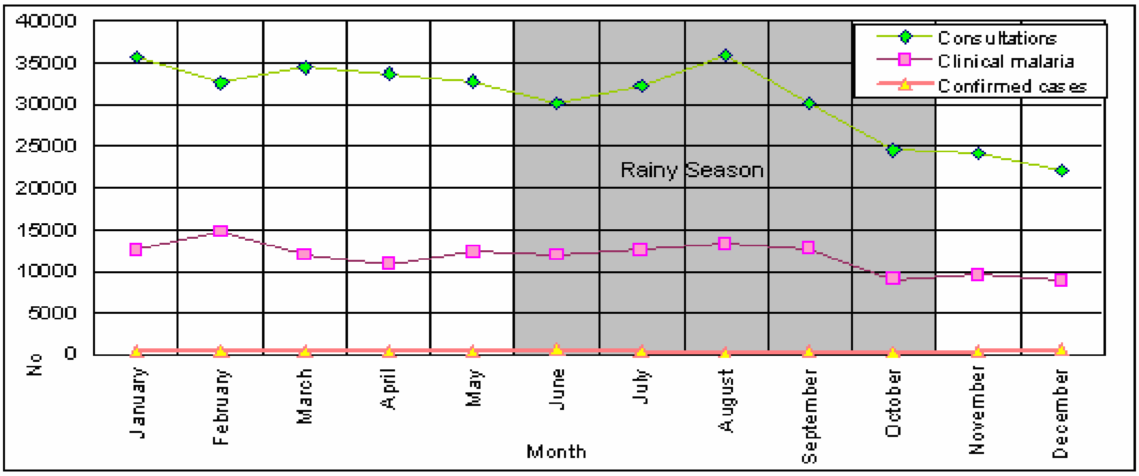

4c)

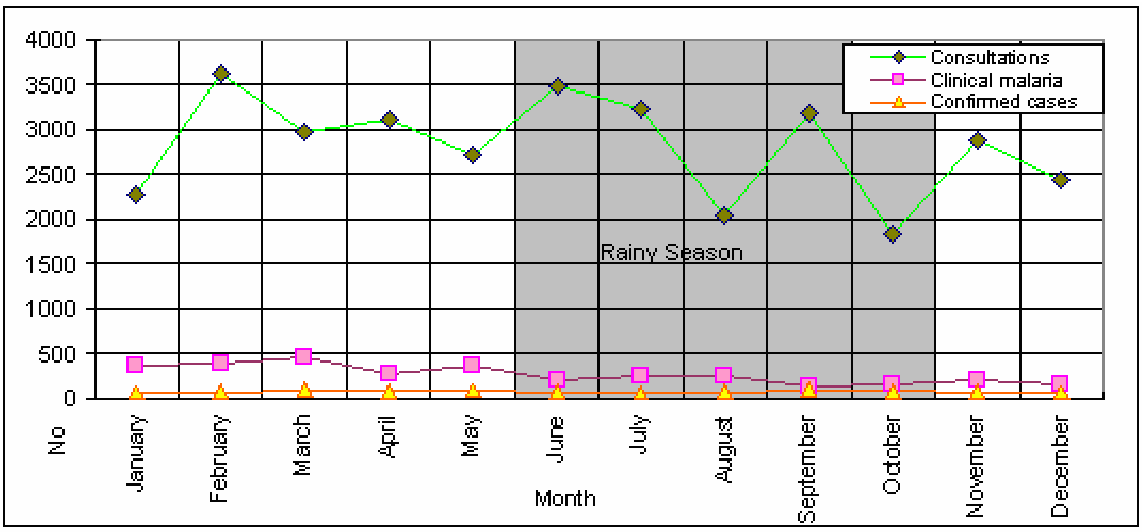

Figure 8-4 Numbers of overall consultations, suspected and confirmed malaria in Abidjan, 2001. a) under 5 years; b) over 5 years; c) pregnant women.

There are three seasons in Abidjan, (1) the hot and wet season from June to October, (2) the warm and dry season from November to March, and (3) the hot and dry season from March to May. Maximum rainfall usually occurs between August and September. However, seasonality of malaria in the dataset was minimal and only a slightly lower number of cases was registered in October-December. Figure 8-4 shows the number of reported total consultations (all causes), reported and confirmed malaria cases by month for children under five years (4a), persons over 5 years (4b) and pregnant women (4c).

8.4.2 Health facility-based surveys

Plasmodium falciparum was detected in 26.1% of all blood slides. A total of 149 (34.7%) of 429 fever cases and 63 (16.4%) of 383 controls were malaria positive. The participants were stratified into four age groups: under one year old, one to five years old, > five to 15 years old, and adults >15 years old. The percentages of parasites detected in febrile cases were 23.1%, 43.0%, 43.8% and 25.6% for these age groups, while the parasitaemia rates in the controls were 13.0%. 26.7%, 22.9% and 14.3% (Table 8-2). The difference between age groups was statistically significant ($P<0.05$). In the 1-15 years old group over 40% of fever cases and only 22%-26% of the controls were parasitaemic. The overall malaria prevalence in infants ≤six months was 14.5 % and among them 28% had a hyperparasitaemia of more than 6,400/µl.

The risk of having parasitaemia in fever cases was significantly higher than for the control group, with odds ratios (OR) of 2.00, 2.07, 2.63 and 2.09 for the above age groups. As a result, the fractions of malaria-attributable fevers were 0.12, 0.22, 0.27 and 0.13, respectively, suggesting that malaria played a low to moderate role in fever episodes during this season (Table 8-2).

Parasitaemia was more frequently found associated with a high fever. For children under 5 years, the OR of having parasitaemia with a fever ≥39°C that was lasting for 2-4 days was 3.35 (95%

CI=1.36-8.32, P<0.005) in comparison to a fever <39°C of the same duration (Table 8-3). The OR of having malaria parasites with a fever ≥39°C lasting for 5-7 days was 6.8 times greater than having a fever <39°C lasting the same duration (95% CI=1.32-38.95, P<0.01).

Table 8-2 Malaria infection rates in fever cases and controls in Yopougon. By age groups. Health facility-based surveys.

	Fever cases	**Controls**	**OR**	**95% CI**	**P value**	**Fractions of malaria-attributable fevers**
Age groups	N=429	N=383				
Infants 0-1 year	18/78 (23.1%)	22/169 (13.0%)	2.00	0.95-4.22	<0.05	0.12
Children 1-5 years	61/142 (43.0%)	16/60 (26.7%)	2.07	1.02-4.24	<0.05	0.22
Children 6-15 years	39/89 (43.8%)	8/35 (22.9%)	2.63	1.00-7.11	0.05	0.27
Adults >15 years	31/120 (25.6%)	17/119 (14.3%)	2.09	1.04-4.25	<0.01	0.13

Table 8-3 Fever intensity and malaria infection in Yopougon. Health facility-based surveys.

All age groups	**Fever intensity**	**Positive/Total %**	**OR**	**95% CI**	**P value**
Fever duration ≥2, <5 days	<39°C	71/215 (33.0%)	1	-	-
	≥39°C	26/46 (56.5%)	2.64	1.32 -5.30	<0.005
Fever duration ≥5, <8 days	<39°C	26/100 (26.0%)	1	-	-
	≥39°C	11/16 (68.8%)	6.26	1.78 -23.17	<0.001
≤5 years-old	**Fever intensity**	**Positive/Total %**	**OR**	**95% CI**	**P value**
Fever duration ≥2, <5 days	<39°C	35/109 (32.1%)	1	-	-
	≥39°C	19/41 (46.4%)	3.35	1.36-8.32	<0.005
Fever duration ≥5, <8 days	<39°C	13/46 (28.3%)	1	-	-
	≥39°C	8/11 (72.7%)	6.77	1.32 -38.95	<0.01

Socio-economic factors

Malaria infection rates were fairly similar in fever cases across the three residential zones that were defined, and the same was true for non-fever controls (Figure 8-5). Further, a logistic regression model was used to assess the association between parasite infections and the different zones. The OR was 1.27 (95% CI=0.86-1.86) in the intermediate zone and 1.17 in the periphery (95% CI=0.80-1.81) compared to the centre (Table 8-4).

The percentage of patients sleeping under a bednet on the night before admission to the hospital was low at 10.1%, with only 6.9% of the total study population having ITNs. Usage rates were low and similar in the three zones (9.9%, 9.5% and 11.2%, Figure 8-5). While infrequent, the use of bednets had a strong protective effect against a malaria infection in Yopougon (OR=0.52, 95% CI=0.29-0.97).

The OR of having a malaria infection was lower if the patients or caretakers had a higher education level (secondary schools: 0.54, 95% CI=0.35-0.84; college and above: 0.37, 95% CI=0.18-0.77)(Table 8-4). There was no evidence of association between housing type, water supply sources, and proximity to urban agriculture land with a malaria infection.

Traveling to rural areas within the last 3 months was a risk factor for being infected with *P. falciparum* (OR=1.75, 95% CI: 1.25-2.45). In Yopougon, 38.2% of patients with parasitaemia had been outside Abidjan within the last 3 months. There was no association between previous malaria treatment and the current presence of parasitaemia (Table 8-4). In total 304 respondents claimed to have had a malaria infection within 30 days of the survey; of those, 65.7% reported having been treated in health facilities and about 31.9% used an informal therapy: they went to a pharmacy/drug outlets, used traditional healers, self-treated at home or underwent no treatment.

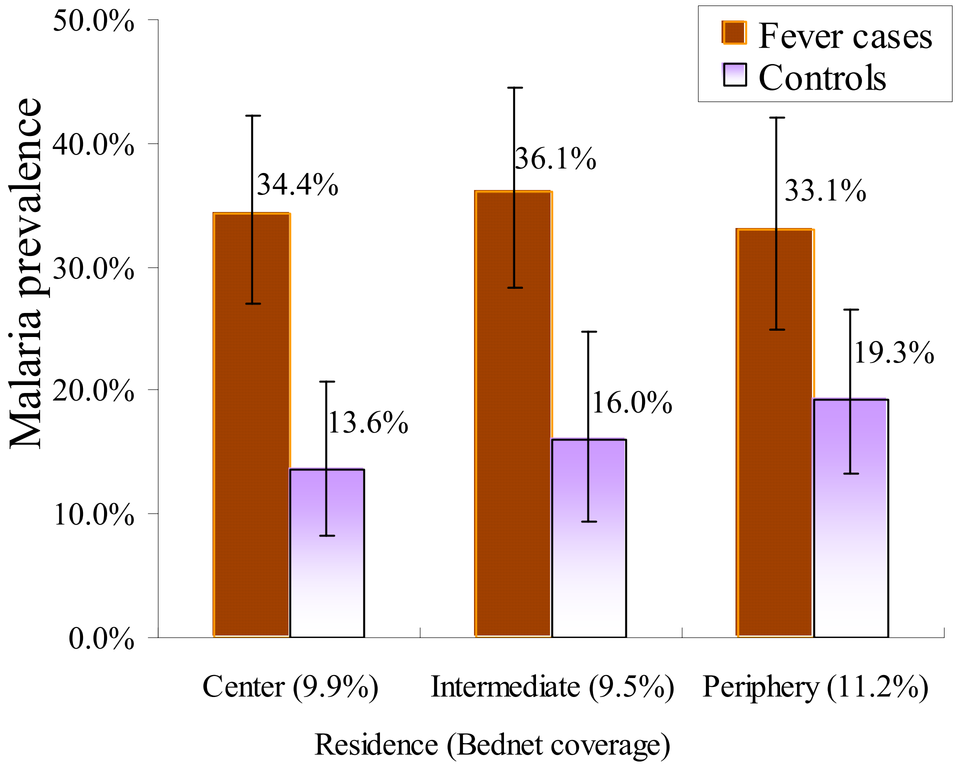

Figure 8-5 Malaria prevalence within fever cases/controls in Yopougon, by residences of patients. Health facility-based surveys. Vertical bars represent 95% CI.

Table 8-4 Socio-economic factors and the risk of malaria infection in fever cases and controls in Yopougon by logistic regression model. Health facility-based surveys.

Socio-economic factors	%	OR	95% CI	P value
Education level				
Primary	29.4%	1	-	-
Secondary	**26.7%**	**0.54**	**0.35 -0.84**	**<0.01**
Superior	**8.7%**	**0.37**	**0.18 -0.77**	**<0.01**
Othe	35.2%	0.76	0.51 -1.12	0.17
Housing material				
Leaf/mud	7.7%	1	-	-
Concrete/brick	91.7%	0.65	0.35 -1.2	0.1
Water supply resource				
Well	1.4%	1	-	-
Tap water	95.6%	1.67	0.34-11.14	0.74
Fountain	2.0%	1.07	0.11-11.54	1.00
Living nearby agriculture land or gardens				
No	20.9%	1	-	-
Yes	75.4%	1.05	0.70 -1.59	0.8
Bednet usage (treated and untreated)				
No	89.9%	1	-	-
Yes	**10.1%**	**0.52**	**0.29 -0.97**	**<0.05**
Rural exposure within 90 days				
No	68.9%	1	-	-
Yes	**31.1%**	**1.75**	**1.25-2.45**	**<0.001**
Previous malaria treatment within 30 days with the presence of parasitaemia				
No	63.3%	1	-	-
Yes	36.7%	1.09	0.79-1.53	0.6
Residence of patients				
Centre	35.3%	1	-	-
Intermediate	30.2%	1.27	0.86-1.86	0.2
Periphery	34.5%	1.17	0.80 -1.72	0.4

8.5 Discussion and conclusions

One of the limitations of this assessment was that the study was done in only one municipality and results are therefore not representative for the whole city (with the exception of the routine statistics, which were compiled for all municipalities). In future, an in-depth assessment in the other municipalities of Abidjan would help to describe more comprehensively malaria patterns in this large city, and help resolve the question of whether the malaria risk is similar everywhere. Given the steep socio-economic gradient within the city this is very unlikely, but it needs to be described.

Remarkably, there was almost no seasonality in reported clinical malaria cases in Abidjan in 2001. This was unexpected and does not fit observations from other cities in SSA, especially recent reports for similar settings in Cotonou and Dar es Salaam (Wang et al., 2005). However, the accuracy of PNLP routine malaria report is uncertain. In addition, there is a high rate of malaria over-diagnosis, as evidenced by the low-to-moderate malaria-attributable fractions (see also below), If most fever cases are not due to malaria, this might explain at least in part why so called "malaria" cases present with such regularity over the year.

The RUMA methodology is based on a cross-sectional design during a single season. Hence, the results of the parasitaemia survey may be different at another time of the year, especially during the dry season (November to May). As a result, we could unfortunately not cross-check the pattern of malaria cases reported through routine health services with our own observations. Repeating this work at a different season might shed some interesting light on transmission patterns.

Unfortunately, a good part of the planned RUMA activities could not be accomplished due to the political instability (the school parasitaemia surveys and the mapping of *Anopheles* breeding sites). School parasitaemia surveys in the same zones would have given a more representative (community-based) measure of parasitaemia in Yopougon and would therefore have better defined local endemicity. It would also have helped to cross-check the results from the health facility fever surveys. The present results from the control group in the health facilities surveys suggest that endemicity is moderate, ranging from 13 to 27% for the different age groups. The distribution by the different zones (range: 14-19%) did not show much variability. This finding was rather unexpected since Yopougon borders on more rural areas and one would have expected parasite prevalence rates to be higher at the periphery. It is possible that since the whole of Yopougon is located along the major roads to downtown Abidjan, the heterogeneity of transmission was reduced. Another reason could be that the sample population attending FSU-com was homogenous in their socio-economic characteristics and hence in their malaria risk. Based on unpublished results of the Abidjan Health Project (*Projet Santé Abidjan)*, the patients attending FSU-com and CSU were similar in terms of their income and education level (Ette et al., 1998).

An important finding was that the fractions of malaria-attributable fevers in health facilities were low to moderate in all age groups during the time of the present survey. Between 73 and 88% of all fever cases presenting at health facilities are unlikely to have suffered from malaria. This has two main implications for the health system. Firstly, there is substantial over-treatment with antimalarials, which exposes patients to unnecessary side-effects and wastes precious resources. Secondly, other potentially dangerous conditions might be missed. It is not clear whether this high level of over-treatment is constant throughout the year in Abidjan but it is certainly consistent with three other studies carried out recently in SSA (Wang et al., 2005).

In high transmission areas, children under the age of five years bear the highest risk for malaria. In this study, malaria infections and hyperparasitaemia were not rare in infants and simultaneously there were higher infection rates in elder children. This might suggest a mixed or transitional pattern of high/low malaria transmission levels in Yopougon.

In conclusion, the malaria seasonality and endemicity in different areas of Greater Abidjan needs to be further assessed. Given the low to moderate attributable fractions of malaria in febrile episodes and the resulting high rate of misdiagnosis, health facilities should consider introducing a proper diagnosis of "malaria cases", possibly through the use of rapid tests.

Authors' contributions

SW participated in the design of the study, conducted the field work, analysed and interpreted the data, drafted and revised the manuscript. CL conceived the study, coordinated the field work and revised the manuscript. TS and PV participated in the design and statistical analysis. GC was the key contact person in the field, managed and supervised the data collection and laboratory work. MT participated in the conception of the work, revised it critically at all stages and contributed to the writing of the manuscript.

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List of abbreviations

CHU	Centre Hospitalier Universitaire
CSRS	Centre Suisse de Recherches Scientifiques, Côte d'Ivoire
FSU	Formation Sanitaire Urbaine
FSU-com	Formation Sanitaire Urbaine à base Communautaire
ITNs	Insecticide-Treated Nets
INS	Institut National de la Statistique, Côte d'Ivoire
MOH	Ministry of Health (of Côte d'Ivoire)
OR	Odds Ratio
PNLP	Programme National de Lutte Contre le Paludisme, Côte d'Ivoire
RUMA	Rapid Urban Malaria Appraisal
STI	Swiss Tropical Institute

Chapter 9

Conclusions and Recommendations

9. CHAPTER: CONCLUSIONS AND RECOMMENDATIONS

Based on a series of RUMA, a number of conclusions and suggestions can be made concerning future research and interventions in urban malaria.

9.1 General conclusions

- The malaria prevalence in the schools was low during the dry season in Dar es Salaam (0.6-3.8%) and Cotonou (2.5-9.1%) and it was at moderate to high level in Ouagadougou (31.-73.1%) during the cold and dry season. The low prevalence of malaria could be due a number of factors, including: urban development, high use of ITNs, and various environmental factors such as the amount of rain.
- The fractions of malaria-attributed fevers were low (0-0.27) in the health facilities in all settings. Children with fever are more likely to suffer from other diseases and fever alone is no longer a good indicator for the diagnosis of malaria in SSA urban areas.
- The over-diagnosis and over-reporting of malaria challenge SSA urban health care systems. From a public health perspective, over-treatment of malaria contributes to the waste of resources, it leads to more clinical visits and might give a bad reputation for the health sector.
- The risk of malaria infection is associated with the socio-economic situation and with environmental conditions. Different cities have different environments. Based on our data, in Abidjan and Dar es Salaam, traveling to rural areas was a risk factor for malaria infection. In Ouagadougou, the water resources of households and urban agriculture were associated with malaria. In Cotonou, ITN coverage, lagoon salinity, and urban planning had a significant impact on vector distribution.
- The intensity of malaria transmission varies within small distances and depends on the degree of urban development and local environmental conditions. In big cities there are complex

mixed patterns of malaria transmission.

- The awareness and practices of malaria prevention is high in urban areas.

9.2 Recommendations for health care professionals:

The corner-stone of case management is accurate identification and treatment of malaria cases. In SSA urban health facilities diagnosis of malaria is almost always based on clinical symptoms and mainly on the fever sign. However, many other infectious diseases have similar clinical symptoms.

Misdiagnosis not only leads to a waste of drugs and other resources, but also to the under-diagnosis of other problems such as upper respiratory infections. These might then develop to severe stages. Sometimes, health professionals blame repeated malaria treatment failures on drug resistance, consequently prescribing another type of antimalarial drug. Second line antimalarial drugs are expensive, and the poor and vulnerable cannot afford these repeated treatments which only result in prolonged suffering and worsened health.

Many urban health care providers were trained to treat “rural malaria” and follow clinical guidelines developed for rural areas. These providers were taught that younger children are at a high risk of malaria and were trained to treat all febrile episodes with antimalarial drugs. Clearly, health care providers need to consider multiple causes for fever episodes and follow “Integrated Management of Childhood Illness” guidelines. Both the age distribution and the clinical symptoms were related to the place of residence of the patients. The duration, severity and diversity of malaria symptoms reflect the diversity of local malaria endemicity, leading to more difficulties for malaria diagnosis.

Improving the diagnosis of malaria is the core requirement for better case management of fevers in children and adults. Finding ways to do this is a challenge for all public health workers and researchers. In addition, existing antimalarial treatments are going to be replaced by artemisinin combination treatment (ACT) as first line treatment for simple malaria. At 5-10 times the cost of other antimalarial treatments, its introduction creates an urgent need to review the diagnostic and treatment practices that have been based on cheap and safe antimalarials. One of the solutions could be the massive introduction of the Rapid Diagnosis Tests (RDT) and the implementation of the RDTs as part of fever/malaria screening at the registration in all clinics. The current price of 0.5-2.0 USD for RDTs will drop as soon as there is a large demand. The use of RDT will be cost-beneficial in low transmission areas where ACT is going to be used.

9.3 Recommendations for laboratory technicians:

Giemsa thick and thin blood films remain the gold standard for malaria diagnosis. However, this diagnosis is time consuming and requires microscopic expertise and maintenance of equipment. In SSA urban areas the major hospitals are likely to be equipped with good laboratory facilities and qualified laboratory technicians. However, even in such settings, few cases are confirmed by laboratory diagnosis because most of the health professionals prescribe antimalarial drugs based on clinical assessments alone. It normally takes at least few hours and sometimes days to obtain the result of microscopy and patients are rarely willing to leave the hospital without having received any treatment. Patients will eventually return to the hospital for a follow-up in the event their illness is not cured. When health professionals do not rely on laboratory tests for complete diagnosis, it sends a discouraging message to the laboratory technicians: their work appears to be devalued and ignored. This can result in poor work performance and technicians might start to neglect their duties. Owing to the low endemicity in urban areas, it is more difficult and time-consuming for the laboratory technician to detect a low-level parasitaemia. Therefore, there is urgent demand for the introduction of a RDTs. Their reported sensitivity and specificity is acceptable. Adopting RDTs in the urban health facilities can improve the problem of slide-reading and save unnecessary costs and suffering of patients.

9.4 Recommendations for municipal health departments:

Health Information Management Systems (HIMS) do not collect health data systematically and reliably in major SSA cities. Over the years, most of the HIMS developments were either technology-driven or adopted without due consideration of local settings. For examples, many surveillance officers in the town may be computer illiterate or may not familiar with database software. It requires a lot of efforts and training to redesign data recording, reporting formats, to computerize key data management procedures at district and national levels, and to improve communication tools. Due to poor application of case definition, poor documentation, deficiency in reporting and communications, the health data do not reflect the malaria reality in most of settings.

Given the exceptional importance of having reliable health statistics for the planning and management of the health system, a high priority should be given to improving the quality of these data.

The high coverage of ITNs in urban areas has certainly contributed to a significant reduction of malaria transmission. The government should continue their investments to strengthen malaria awareness education campaigns and the existing public/private partnerships for the commercial distribution of ITNs. Low income families and new migrants from the city fringe often cannot afford this form of malaria prevention and using vouchers to support low-income and high-risk individuals might provide a good solution (Magesa et al., 2005).

It was observed at all RUMA sites that a patient's choice of fever or malaria management was related to the geographical accessibility of the health care providers, the cost of care and treatment, the reception given to patients, the seriousness of the illness and to a great degree the kinship and reputations of the health personnel in the services visited. It is recommended that the municipal health policy-makers evaluate health care services coverage and distribution, in order to improve planning, allocation of resources and to strengthen the networking between the public and the private sectors.

Traditional medicines were important in some urban communities, even though western remedies were readily available. Traditional herbs were still sought in cases where CQ and SP did not work, particularly in Dar es Salaam. Traditional healers and drug outlets were seen as the primary source of treatment, potentially decreasing the effectiveness of case management. The municipal health department must integrate traditional healers and the private sector into the government health planning and routine monitoring system. Regular training should be provided to improve their knowledge on malaria case management.

9.5 Recommendations for urban malaria control

Urban malaria is usually unstable and changing due to a diverse and rapidly evolving environment. Both human interventions and ecological changes will alter malaria transmission rapidly in SSA urban areas. It may be possible to achieve local malaria elimination in urban areas where the parasite prevalence rate is already low, since breeding sites are localized and easily targeted. A better understanding of the heterogeneity of transmission and environmental risks is an essential basis for any transmission-reducing intervention. Large scale, multi-site entomological surveys should be carried out for identifying the permanent, semi-permanent, and temporal breeding sites. Urban environments present unique opportunities for vector control. Drain cleaning, chemical larvicide, and environmental management could be considered as effective and applicable urban malaria control strategies and these interventions should be integrated into the urban upgrade plan.

Implementation of urban malaria control measures used to be easier during the colonial period, when the population size and urban areas were much smaller. Most of the vector control or environmental manipulation activities were done under the coordination and instruction of commissioners or the military. All the instructions were taken seriously and control activities were implemented systematically. Urban malaria control and elimination activities require good coordination at central level, which enables a consistent approach with strong political commitment and a sustainable budget for long-term activities. In addition, ensuring that these control activities achieve the program expectations requires a high level of enforcement, discipline and efficiency.

9.6 The RUMA process

It took 6-10 weeks to conduct the fieldwork of RUMA but it may not be feasible for a local municipal malaria control program to do it if they lack commitment and budget. RUMA is a feasible and simple tool for the international community to obtain essential malaria information from a town or city without adequate system of malaria surveillance. However, it is not reasonable to expect comprehensive information about the malaria situation in any African city within a short time period if with only a minimal investment (8,500-13,000 USD). If a malaria survey is to be undertaken in a large city it is likely that it will exceed a simple RUMA in order to provide a more comprehensive assessment of the situation. In addition, local municipal malaria control programmes may consider the weekly malaria reporting and surveillance system as their priority. It was of great interest and importance to carry out a RUMA in different cities in 2002-2004 because little was known about urban malaria at the time. Since then, much additional information was obtained from various urban malaria studies and a set of reviews, and now cities need more comprehensive cross-sectional surveys at different seasons and years to monitor the local endemicity.

List of abbreviations

CQ	Chloroquine
ITNs	Insecticide-Treated Nets
HIMS	Health Information Management System
OR	Odds Ratio
RUMA	Rapid Urban Malaria Appraisal
SP	Sulfadoxine/pyrimethamine
STI	Swiss Tropical Institute

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Annexes

11. ANNEXES

11.1 Annex 1 Questionnaire for school parasitaemia survey

Form 1 Parasitaemia Survey in the Schools (English version)

Swiss Tropical Institute, in collaboration with World Health Organisation and Dar es Salaam City Council, are glad to inform you that our survey team will conduct a malaria survey in the school. Dar es Salaam city council is planning a malaria control program, thus we need to collect the basic information. We will take the blood smear and exam whether your child has malaria parasite. The procedure will be safe and easy. We will provide the free laboratory examination and treat the clinical malaria **without any charge**. Please kindly fill and return the form, thus the doctor can treat your child properly. Our team will arrive in the school this week.

You AGREE your child to participate in the survey: Yes___or No___

Name of child: _________________

1. Where do you live: Ward: ___________Street_____________________
2. Where the child born: 1) Dar es Salaam 2) other urban area 3) rural area 4) other country __
3. How long the child have been in Dar es Salaam: __________years
4. Have your child been or travelled in a rural area in last 3 months: 1) Yes or 0) No___

   4.a Dates: ____/____ Locations: _______________________________ Duration: ________

   4.b Dates: ____/____ Locations: _______________________________Duration: _______
5. Have the child ever been sick of malaria last month? 1) Yes or 0) No___, if no, go to 7
6. Where was your child treated for malaria last time: 1) home 2) health centre/dispensary 3) referral hospital 4) traditional healer or herbs 5) let them sleep 6) no treatment 7) others _________

7. Who is responsible for family health at home? 1) Mother 2) father 3) elderest sister or brother 4) grand-parents 5) other family member 6) others___
8. Did your child sleep in the mosquitoes net last night: 1) Yes or 0) Non __
9. Your mosquitoes net were treated by insecticide? 1) Yes or 0) Non __
10. Housing style: 1) concrete/brick 2) Nyumba ya Malcuti 3) Nyumba ya Bati 4) others___
11. Your water resource: 1) Tap water 2) well 3) public fountain/pool 4) water tank 5) river 6) other___
12. How much money you spent on lunch per day? ___________Your income resource: ___________
13. Do your child have allergy or feel uncomfortable with SP? 1) Yes or 0) No___
14. Axillary Temperature: ___ ___. ___ ^{0}C
15. Serial number ___-___-________(1-250)
16. Survey site: ____________ ward:____________
17. Age: _____ years ____ months or ___/___/____(dd/mm/yy)
18. Sex: 1) Male or 2) Female____

Laboratory result

Plasmodium 1) Positive or 0) Negative__ Total density __________μL/blood

Density	*P. falciparum*	*P. Vivax*	*P. Ovale*	*P. malariae*
Trophozoite				
Scehizoite				
Gametocyte				

Examen de la parasitémie – étude transversale dans les écoles (français)

Prélèvement sanguin

1 Depuis quand êtes vous à Ouagadougou ? ________________ ans

2 Température corporelle ________°C

3 Résultat Plasmodium : Négatif [0] ou positif [1] --------

(a) Espèce parasitaire : P falciparum Charge __________ pa/uL de sang

P vivax Charge __________ pa/uL de sang

P ovale Charge __________ pa/uL de sang

P malariae Charge __________ pa/uL de sang

4 Site de l'étude : __________________

5 Numero d'enqueté (1-800) : _______

6 Lieu d'habitation : ____________________________________ (vérifier sur la carte)

7 Age : _____ ans _______ mois

8 Sexe : Masculin [1] ou Feminin [2] ______________

Histoire de voyage et de la maladie

9 Avez-vous été dans une zone rural durant ces trois derniers mois passés ?

(a) Date___/____/_____ Lieu : ______________ Durée : __________

(b) Date___/____/_____ Lieu : ______________ Durée : __________

(c) Date___/____/_____ Lieu : ______________ Durée : __________

10 Lieu de naissance : Ouagadougou [1], autre ville [2], zone rurale [3], autre pays [4] _____

11 Avez-vous été traité pour le paludisme durant le mois écoulé ? oui [1] /non [2] ________ (si non Q14)

12 Ou avez-vous été traité ? Domicile [1], pharmacie [2], centre de santé [3], hôpital [4], herbes locales[5], dormir [6], guérisseur [7], autre [8] _____________

13 Si autre, préciser ____

14 Qui est le responsable de la santé à la maison ? Mère [1], père [2], sœur ou frère plus âgé [3], grand parents [4], autre membres de la famille [5], autre [6] ___________

15 Utilisation de moustiquaire durant la nuit passée : oui [1], non [0] ____________

16 Moustiquaire traité ? oui [1], non [0] ____________

17 Maison : ciment/briques cuites [1], paille/terre [2], paille [3], autre [4] ____________

18 Source d’eau : robinet [1], puits [2], fontaine publique [3], autre [4] __________________

11.2 Annex 2 Questionnaire for health facility-based fever survey

Form 2 Passive Case Detection in the Health Facilities (English version)

Criteria of enrolment of survey

1. How long have you been in Dar es Salaam: __________years
2. Have you been treated for your illness before this visit 1) No, 2) Home therapy, 3) Go to referral hospital or other health centres, 4) For the control check, 5) Herbal, 6) Give Paracetamol 7) Give chloroquine 8) Traditional healer 9) Go to pharmacy 10) Others___
3. If others, please specify: __________________________
4. Axillary Temperature: ___ ___. ___ ^{0}C
5. How many days the fever have been presented before visiting: ___days
6. 1) CASE / 0) CONTROL __

7. Serial number ___-___-________(1-400) and name of patients_______________________
8. Survey site:____________ ward:____________
9. Location of patient's residence: Ward: ___________Street____________________ (Mark location on map)1) Centre, 2) Intermediate, 3) Peri-urban, 4) Rural areas___
10. Age: _____ years _____ months or ___/___/____(dd/mm/yy)
11. Sex: 1) Male or 2) Female____

Social Economic state

12. Education: ________years (care taker or patient if > 5 years):1) Primary school 2)Secondary school 3) College or higher degree 4) non 5) others_____________
13. Mosquitoes net use in last night: 1) Yes or 0) N __

14. Your mosquitoes net treated by insecticide? 1) Yes or 0) N __
15. Housing style: 1) concrete/brick 2) Nyumba ya Malcuti 3) Nyumba ya Bati 4) others___
16. What's your water resource: 1) Tap water 2) well 3) public fountain or pool 4) water tank 5) river 6) others___
17. Do you have or do you live near by the agriculture land or garden? 1) Yes or 0) N _
18. How much money you spent on lunch per day? ___________Your income resource:___________
19. How much money you are able to spend on preventing mosquitoes biting per month? ________

Travel and malaria history

20. Have you been or travelled in a rural area in last 3 months: 1) Yes or 0) No___, if no, go to 21

    20.a Dates: ____/____ Locations: ______________________________ Duration: ________

    20.b Dates: ____/____ Locations: ______________________________Duration: ________

21. Where is the patient's birthplace: 1) Dar es Salaam 2) other urban area 3) rural area 4) other country __
22. Have the patient ever been treated for malaria last month? 1) Yes or 0) No___, if no, go to 24
23. Where were you or your child treated for malaria last time: 1) home 2) pharmacy or drug outlet 3) health centre/dispensary 4) referral hospital 5) traditional healer or herbs 6) just go to sleep 7) several of these 8) no treatment 9) others

    ____

Clinical diagnosis

24. Do you have allergy or feel uncomfortable with SP? 1) Yes or 0) No___
25. What symptoms do you have? 1) Fever 2) cold 3) diarrhoea 4) vomit 5) headache 6) dizziness 7) stomach ach 8) back pain 9) lack of appetite 10) others______________(multiple choice)

26. Clinical Diagnoses: _______________________________________

27. Doctor's compliance on prescription of drug dose: _____________________________________

Laboratory result

Plasmodium: 1) Positive or 0) Nagative___Total density ______________µL/blood

Density	*P. falciparum*	*P. Vivax*	*P. Ovale*	*P. malariae*
Trophozoite				
Scehizoite				
Gametocyte				

Etude détection passive de cas de fièvres palustres (français)

Critères d'inclusion d'enquête

1. Combien de temps le patient est déjà à Ouagadougou ? ___________ ans_
2. Qu'avez-vous fait avant de venir ? rien [1], médicament à la maison [2], hôpital de référence ou autre centre de santé, [3] pour des visites de contrôle [4], herbes locales [5], Paracétamol [6], Guérisseur traditionnel [7], pharmacie [8], autre [9] ______
3. Si autre, précise____
4. Température corporelle ___ ___. ___ ^{0}C
5. Combien de jours de fièvre avant de visiter le médecin ici? _______ jours
6. Contrôle [0] ou Cas de fièvre [1] :_____________

7. Numéro d'enquêté (1-450) : ___ -___- _________
8. Site de l'étude: Arrondissement:____, ________________________________
9. Lieu d'habitation: Quartier : ________, N°de Carré : ______________________ (vérifier sur la carte!)
10. Age : ___ ans ___ mois ou Date de naissance :___/___ /____
11. Sexe: Masculin [1] ou Féminin [2] _________

Données socio-économiques

12. Niveau d'instruction du patient (ou mère pour enfant de < 5 ans) : Premiere [1], Secondaire [2], Supérieure [3], Non [4], Autre [5], ________________________________
13. Utilisation de moustiquaire durant la nuit passée: Oui [1] ou Non [0] _______
14. Moustiquaire traitée ?: Oui [1] ou Non [0] _______

15. Maison: ciment/briques cuites [1], paille/terre [2], paille [3], autre [4] __________

16. Source d'eau ? robinet [1], puit [2], fontaine publique [3], autre [4] ____

17. Avez vous un champs agricole chez vous ou aux alentours de votre maison? Oui [1] ou Non [0] ___

Histoire de voyage et de maladie

18. Avez-vous été dans une zone rurale durant les 3 mois passés? Oui [1], Non [0] ____

    (a) Date____/____/____Lieu :______________________________________ Durée :___ semaines

    (b) Date____/____/____Lieu :______________________________________ Durée :___ semaines

    (c) Date____/____/____Lieu :______________________________________ Durée :___ semaines

19. Lieu de naissance: Ouagadougou [1], autre ville [2], zone rurale[3], autre pays [4] ________

20. Avez-vous été traité pour le paludisme durant le mois écoulé? Oui [1] / Non [2] _____ (si non, Q 23)

21. Où avez-vous été traité? Domicile [1], pharmacie [2], centre de santé [3], hôpital [4], herbes locales [5], laisser l'enfant dormir [6], guérisseur [7], autre [8] ____________

22. Si autre, préciser ____

Diagnostic clinique

23. Symptômes (choix multiple): fièvre [1], froid/frissons [2], diarrhée [3], vomissement [4], mal de tête [5], vertiges [6], blessure [7], mal de ventre [8], sang dans l'urine [9], démangeaison [10], autres [11] ________

24. Si autres, précise____

25. Diagnostics présomptif: ____

Prévèlement sanguin

26. Résultat Plasmodium: Négatif [0] ou positif [1] ________

(a) Espèce parasitaire: Charge __________ p.a/µL de sang

	P. falciparum	P. Vivax	P. Ovale	P. malariae
Trophozoite				
Scehizoite				
Gametocyte				

11.3 Curriculum Vitae

Name: Shr-Jie Sharlenna WANG 王詩潔

Date of Birth: April 29,1972 **Sex**: Female

Contact Address:

Socinstrasse 57, P.O. Box 4001, Switzerland

Email address: shrjie.wang@unibas.ch, Sharlen.wang@gmail.com

EDUCATIONAL QUALIFICATIONS

PhD in Epidemiology, September, 2005 supervised by Dr. Christian Lengeler
University of Basel, **Switzerland**

Master in Public Health (MPH), 1997
Yale University School of Medicine, New Haven, CT, USA
Dept. of Epidemiology and Public Health

B.Sc. in Medical Technology, 1995
Taipei Medical Univeristy, Taipei, Taiwan

WORK EXPERIENCE

Researcher: Swiss Tropical Institute, Basel, Switzerland **April 2002 to March 2004**

Responsible for the design and implementation of research protocol for urban malaria epidemiology in Abidjan, Cotonou, Ouagadougou and Dar es Salaam.

Epidemiologist: Médecins Sans Frontières **May 2000 to March 2002**

Oromia and southern state, Ethiopia: Responded to meningitis outbreaks, supervised outbreak surveillance, vaccination campaign and vaccine safety.

Gederaf, Sudan: Carried out case-control studies to evaluate the Visceral Leishmaniasis (VL) curative treatment intervention and evaluated the effectiveness of the insecticide treated nets distribution programme.

Puthukuddiyiruppu, Sri Lanka: Assessed early warning system, maternal and child health program and malaria control program, to develop evidence-based advocacy/lobbying strategies in the war-affected areas. Evaluated the expanded Program on Immunization (EPI), to study the vaccine coverage rate.

Epidemiologist: Taiwan Root Medical Peace Corps. **Feb. to March 2000**

Nimba, Liberia: Facilitated the setting of mobile clinics. Monitored the emergency preparedness and provided health education on MCH and AIDS.

Survey Director: HelpAge International **1999**

Siem Reap, Cambodia: Supervised a population-based survey on cataract and blindness prevalence in 84 villages. Assisted in implementing primary eye care programme at provincial level. Conducted mobile clinics for repatriated refugees and landmine victims.

Project coordinator: Taipei Overseas Peace Service, Cambodia **Aug. to Dec. 1998**

Supervised the reintegration of street families into the community.

Internship: Taipei City Psychiatric Center and Taipei Pathology Center, Taiwan **Sept. to Jan. 1994**

Conducted screening for illegal drugs and STDs, worked in medical laboratory and neurology unit

RESEARCH EXPERIENCE

Inter-Africa Committee (IAC), Genèva, Switzerland (Summer, 2001)

Reviewed literature and audio-visual document of female genital mutilation.

Roll Back Malaria and UNDP/World Bank/WHO TDR, Genèva, Switzerland (1996)

Prepared the report "WHO 1994 Malaria Situation" and evaluated overall budget distribution and resource allocation of TDR Program during 1962-1996.

Grace Project, Yale University, New Haven, CT USA (1996)

Developed best practice model to reach HIV-infected women/children in New Haven.

National Institute of Biomedical Science Academic Sinica, Taipei, Taiwan (Part time 1994 - 1995)

Research Assistant in the project "NGFI-B Expression in Cerebral Ischemia"

Green Cross Health Service Corporation, Chi-Gu, Taiwan (Summer, 1993 - 1995)

Participated in health education and surveyed the lead poisoning in blood in industrial reservation areas.

Professional Skills: Fluent in English, Chinese, advanced level in French, beginning level in German, few Khmer and Arabic. Proficient in EpiInfo 2003, Stata 8.0, MapInfo 7.0, Epidata 3.02, MS Office, Photo Editor, Endnote, Reference Manager, some knowledge of Arcview, SAS and HTML language.

PUBLICATIONS

- Darfur bi-annual report: www.emro.who.int/sudan/pdf/WMMB%20**bi-annual**%20**report**.pdf
  Darfur Weekly Morbidity and Mortality Bulletin:
  http://www.emro.who.int/sudan/InformationCentre.htm#wmmb

- Wang S-J, Lengeler C, Smith TA, Vounatsou P, Cisse G, Diallo DA, Akogbeto M, Mtasiwa D, Teklehaimanot A and Tanner M: **Rapid urban malaria appraisal (RUMA) in sub-Saharan Africa**. *Malar J. 2005; 4: 40.*

- Wang S-J, Lengeler C, Smith TA, Vounatsou P, Diadie DA, Pritroipa X, Convelbo N, Kientga M, and Tanner M: **Rapid urban malaria appraisal (RUMA) in sub-Saharan Africa I: Epidemiology of urban malaria in Ouagadougou**". *Malar J. 2005; 4: 43.*

- Wang S-J, Lengeler C, Mtasiwa D, Mshana T, Manane L, Maro Godson and Tanner M*:* **Rapid urban malaria appraisal (RUMA) in sub-Saharan Africa II: Epidemiology of urban malaria in Dar es Salaam**, in press. *Malaria Journal.*

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- Wang S-J, Lengeler C, Smith TA, Vounatsou P, Akogbeto M and Tanner M**: Rapid urban malaria appraisal (RUMA) in sub-Saharan Africa IV: Epidemiology of urban malaria in Cotonou**, in press. *Malaria Journal.*

- Ritmeijer Koert, Davies C, van Zorge R, Wang S-J, Schorscher J, Dongu'du I. S, Davidson R. N: **Evaluation of a mass distribution programme for fine-mesh impregnated bednets against *visceral leishmaniasis* in eastern Sudan**. Submitted to Tropical Medicine & International Health.

- Wang SJ, "The Prospect of Malaria Control by Transgenic Vectors: **The Sigma virus Injection into Mosquitoes and *Drosophila*"**. *New Haven:* In *MPH* thesis. Yale University, 1997.

- Lin TN, Chen JJ, Wang SJ, Cheng JT, Chi SI, Shyu AB, Sun GY, Hsu CY. "Expression of NGFI-B mRNA in a rat focal cerebral ischemia-reperfusion mode". **Brain Res Mol Brain Res.** *1996 Dec 31;43(1-2):149-56.*