Epidemiology of children malaria among the early married families in the Peruvian Amazon

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Introduction

Malaria is a vector-borne parasitic disease transmitted by an *Anopheles* mosquito and results in an estimated 800,000 deaths annually around the world. Approximately 86% of the deaths are children under 5 years of age (WHO 2011). Malaria is the result of infection by one of four *Plasmodium* parasites, the most deadly of which is called *Plasmodium falciparum*. In the Amazon Region, only 25% of cases are from *P. falciparum* infection, while the remaining 75% are almost entirely *P. vivax*, a parasite that rarely results in death, but causes significant morbidity and temporary disability. In Peru, nearly 50% of the population is at risk for malaria, among which children aged under 5 and young adults are the most susceptible populations (WHO 2010). In fact, in the Region of Loreto, where 75% of malaria cases in Peru are reported, ~70% of cases in 2011 were among people under 25 years of age.

Population growth and mobility is incipient throughout the Peruvian Amazon. Family and individual migration occurs for a myriad of reasons, ranging from settlement, logging, resource extraction and agriculture development, with mobility believed to be a key cause of malaria transmission, especially in the tropical rainforest areas. Labor migrants (mostly those involved in the logging industry) likely lack immunity against infectious disease in new locations as well as adequate knowledge of protection against vectors that differ from their place of origin, making themselves potential mobile human reservoirs of malaria parasites (Singer, 2003; Chuquiyauri et al, 2011). As the means of transportation are largely improved, movements can be extended to further distance and contribute to heightened risks of imported disease transmission in a short time frame. Malaria migration characteristics and disease evolution for susceptible populations such as children and young adults in Peruvian Amazon are still not well understood. These populations deserve special attention because it may increase the morbidity and mortality of this preventable and curable disease.

The minimum age of marriage in Peru is 18 years old; although in the Amazon, young women often get married and have their first child at an earlier age. This also coincides with the age when male adults first start to work. Our study is conducted in a rural area of Peru’s northern Amazon in the Region of Loreto. The study site ranges from 40 to 200km away from the city of Iquitos, the largest city in the Peruvian Amazon (pop ~400k) and the 4th largest city in the Amazon Basin. The working environment for this area is primarily along the rainforest fringe or working deeper in the jungle as a logger. Recent studies have shown that poor access to insecticide treated mosquito nets (ITN) and hospitalization among these populations result in higher malaria incidence (UNICEF, 2009; WHO 2011; Chuquiyauri et al, 2011). It is likely that young adults working in these environments have lower immunity to malaria, compared to older and more experienced male workers and farmers. In addition, if young male labor migrants are married, their families members are at greater risk for malaria infection as they are either more likely to travel with their husbands or, since their young husbands are at greater risk for malaria, have a greater risk of in-home transmission.

In this study, we will describe characteristics of malaria infection for children over the past 5 years and stratifying risk by the maternal age of marriage, migrant vs. non-migrant family laborers, socioeconomic status, household demographic structure, parental education, occupation and social networks. Our primary hypotheses are that younger age of marriage for females is associated with increased risk for malaria infection compared to older age of marriage, and that mobility interacts with younger age of marriage to multiplicatively increase malaria risk for this vulnerable population. We expect that results will help define the dominant malaria population risk profile in the Peruvian Amazon and identify strategies to improve child health.

Literature Review

1. Malaria Migration

Out of 20 countries with high risk of malaria, 16 consider human movement as the major cause for the persistence of the infection. Seasonal migration of workers has been associated with epidemics in Kenya (Bloland et al, 2003).

As the rapid growth of population in Peruvian Amazon, there are more human activities and movements than before. The increasing population exerts pressures on resources with major movement and redistribution of people as they seek to improve their economic status (Prothero, 1977). Also with the development in transportation, it enables people to move more frequently and work in a daily or weekly circulation of logging, gathering and farming in the rainforests. Therefore movements can take place over greater distance, where people may have little immunity to a strain of malaria; and in much less time, which causes heightened risks of imported diseases when the workers comes home.

Plasmodium vivax is the most common malaria parasite in Peru (and the Amazon in general), accounting for ~75% of all cases. Tropical rainforests provide good ecological conditions mosquito habitats and breeding. *Anopheles darlingi* is the main vector of malaria in the Peruvian Amazon. With the opening of new farming and logging areas, manmade modifications to the environment result in a dramatic increase in *An. darlingi* breeding sites. Among the many sites are pits left by mining; pools of stagnant water along unpaved roads, river margins, and in areas where a poor clearing resulted in irregular soils; and accumulated water due to obstruction of streams by fell trees (Marques, 1987; Sawyer, 1987; Coimbra, 1988). Furthermore, the daily biting pattern of *A. darlingi* is bimodal, with peaks in the early evening (6pm) and at dawn (5-6pm), exactly the hours when mobile workers carry out outdoor activities (Klein and Lima, 1990; Tadei, 1991). Such working pattern increases contacts with *Anopheles*' U-shape behavior and consequently makes workers as mobile human reservoirs once they are infected (Singhanetra-Renard, 1993).

2. Early marriage in Peru

The legal minimum age of marriage in Peru is 18 years old. However, early marriage is a common tradition in Peru. Reasons for early marriage are not entirely understood, although some could be due to population growth, lack of family planning, lack of family planning or lack of economic opportunities for young women. In 1996, 16% of 18-19 year old women were married and had their first child before 18 and 45.5% of rural women had a reproductive experience (UNFPA, 2000). Even though the mean age at first marriage of females increased from 18.4 in 1978 to 21.9 in 2000 (World Fertility Report, 2009), 20% of the 20-24 year-old women were married before 18 nationwide (UNICEF, 2010) and the birth rate for 15-19 year olds was 55 per 1000 women (UN DESA, 2005).

Early marriage of Peruvian women is regarded as a risk factor of female health, gender disparity and family violence and is well documented by government and most UN departments. However, few studies reflect the situation of early-married Peruvian males and how such marriages affect the health of their families. Better information about young Peruvian husbands is important given that the percentage of married men aged 15-19 has increased over the past decade (DHS, 2008).

Apart from their nuptiality, rural Peruvian males start to make labor income before 18 years old – aged 15 of self-employed and 16 of salaried labor (UNFPA, 2007). A large number of these young adults are mobile workers in Amazon rainforests. Compared to the older and senior workers, the younger are more likely exposed to malaria risks as they have little or no immunity to infected persons, nor adequate knowledge of the disease, especially when strains of malaria are drug-resistant or the mobile workers come from malaria-free regions or other labor patterns (Prothero, 1977). In reverse of this situation, once the young workers are infected with malaria during movements, they are mobile human reservoirs of the parasite and the source of malaria transmission to their children when they come back home. Even if the home region is generally free of malaria, mosquitoes can transmit the disease from infected individuals to those susceptible (Cruz Marques, 1987).

3. Awareness and Malaria Control

Malaria kills a child somewhere in the world every 30 seconds. It also contributes greatly to anemia among children – a major cause of poor growth and development. Despite the possibility that parents' movement may contribute to malaria infection of their children aged under 5, this disease is both preventable and treatable, and effective preventive and curative tools have been developed. Sleeping under ITNs can reduce overall child mortality by 20 per cent. There is evidence that ITNs, when consistently and correctly used, can save six child lives per year for every one thousand children sleeping under them (UNICEF, 2004).

According to DHS (1996), for the 15-19, 20-24 and 25-29 aged group women in Peru, the mean ideal numbers of children in family are 2.1, 2.2 and 2.3, respectively. In a family with multiple children, the application of ITNs can effectively prevent further spread of the disease when one child is already infected. Even in a single-child family, since the adults would continue working as migrants, the potential risk of transmission is not thoroughly eliminated and using ITN can still significantly reduce future infection for their children. Therefore in addition to their own knowledge of protection in the movements, adults' awareness of malaria and effective reaction would also affect family health. Their experience with malaria of children may also be reflected in the application of chemotherapy and hospitalization – whether children aged under 5 with fever are treated with appropriate antimalarial medicines (WHO, 2011). Such evaluation can be described as two-way approaches, whether parents seek treatment for the sick child and whether treatment is accessible, e.g. distance of the health post or clinic, transportation to reach the treatment and health insurance status.

Data Collection and Analysis

Data are from a longitudinal study of malaria risk in the Peruvian Amazon. The study site consists of two ecologically and economically distinct sites that are linked via a major river system and shared national health resources. The first site is the Iquitos-Mazan Road, which is an ~45km road whose construction began in 2008. Bi-weekly *Anopheles* collections were conducted on the road between March 2009 and August 2010 to assess changes in *Anopheline* ecology and vector responses to environmental (land use, climate) changes. Baseline demographic and health surveys were administered to all homes located within 2km of the highway in February 2009, which included a health history (for malaria in particular), anthropometrics, and blood tests for anemia and malaria parasitemia. Follow-up surveys for these households were conducted in 2009, 2010, 2011 and 2012 to record demographic events (births, deaths, migrations), economic activities, and screen for primary health outcomes. Activities of households on this road include agriculture, fishing, logging, and manual labor in Iquitos. The second site consists of 8 rural communities located on the Napo River, which extends from the end of the Iquitos-Mazan Road to Ecuador. These communities were enrolled in 2011 with follow-up in 2012. The same baseline and follow-up surveys were conducted with the same content obtained as for the Iquitos-Mazan Road. Activities of families living on the river consist primarily of logging, fishing and agriculture. Riverine families are considerably more poor than "road" families and have less access to health services as the major health center is located in the city of Mazan (or in Iquitos).

Data analysis will focus on married couples and their families. For each survey round, we will compare the total number of malaria cases reported in the past 12 months to the age of marriage for the female and male heads of household, involvement of families members in labor migration, and other important confounding factors such as SES, education, and household structure. The outcome will be stratified by age (under-5, 5-14, 15-24, 24+) and we will use Poisson regression to compute incidence rates over time. We expect that younger age of marriage and a family member involved in labor migration will be associated with higher malaria incidence.