FIGHTING AGAINST MALARIA: PREVENT WARS WHILE WAITING FOR THE "MIRACULOUS" VACCINE*

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ABSTRACT

The World Health Organization estimates that 300 million clinical cases of malaria occur annually and its incidence increased during the 90's. There are basically two factors behind the incidence of malaria: "geographical destiny", or ecological conditions, and social conditions, which are related with unstable populations or movements of people. In this paper we explore the influence of civil wars and refugees from wars on the incidence of malaria in the asylum countries using a large panel data. The panel structure helps to separate "geographical destiny" from other social conditions. The results of the estimation show the importance of civil wars' refugees on the increase of malaria during recent years.

Keywords: Malaria, migrations, ecological conditions.

RESUMEN

La Organización Mundial de la Salud estima que cada año se producen 300 millones de nuevos casos de malaria y su incidencia ha aumentado durante los años 90. Hay básicamente dos factores explicativos de la incidencia de la malaria: "destino geográfico", o condiciones ecológicas, y el contacto social, que está relacionado con movimientos de la población. En este trabajo estudiamos la influencia de las guerras civiles y los refugiados generados por dichas guerras sobre la incidencia de la malaria en los países de asilo usando datos de panel. Esta estructura ayuda a separar el "destino geográfico" de las condiciones sociales. Los resultados de la estimación muestran la importancia de los refugiados de guerras civiles sobre el incremento de la incidencia de la malaria.

Palabras clave: malaria, migraciones, condiciones ecológicas.

1 Introduction.

With the number of clinical cases of malaria on the rise, reaching the 300 millions a year, there is an increasing concern on the economic and public health burden of this disease. The negative effect of malaria on growth have been recognized for a long time. Initially the studies on the economic impact of malaria were concerned with the loss of labor input (Ross 1911). However malaria has an important effect even if there is no human loss. Frequent malaria attacks increase school absenteeism[1] and lost work time. In addition they reduce productivity by affecting work intensity, reducing the scope for specialization and the intensity of workers mobility. The productivity effect is not only constraint to the agricultural sector. The areas with high incidence of malaria have difficulties promoting tourism and foreign direct investment, suffering also an infrastructure deficit since the cost of construction increases with the likelihood of malaria and the need to invest in protection measures.

Recent estimates of the growth cost of malaria vary depending on the length of the sample and the econometric specification. Gallup and Sachs (2000) use a cross-country empirical growth regression for the period 1965-90 in the style of Barro (1991). They find that, even after controlling for other factors like initial income level, life expectancy and tropical location countries with endemic malaria in 1965 had a 1.3% lower growth per year[2]. McCarthy et al. (2000) use also the standard growth regression and data from the period 1983-98 to estimate the impact of malaria on growth. Their results show that malaria is not only an important explanation for economic growth but also for productivity. They estimate that the growth reduction

[1]Bleakley (2002) uses individual level data to analyze the effect of malaria erradication on schooling in American South. Miguel and Kremer (2001) show evidence of the effect of the hookworm and other infectious diseases on schooling using randomized experiments.

[2]Sachs (2001) presents also a viewpoint in which ecological zones and per capita income are closely related. Hall and Jones (1999) use also latitude as a key explanatory variable for economic development.

due to malaria is larger than a quarter of a percent annual per capita growth for about a quarter of their sample[3].

There are several explanations for the relationship between diseases and underdevelopment in the tropics. McCarthy et al. (2000), using a classification tree methodology, find that, together with climate and the accessibility of the public health system, poverty and inequality have an important role on malaria morbidity. Nevertheless any assessment on the impact of poverty on malaria is plagued with endogeneity issues because, as we argued before, malaria has a large impact on economic development. It is also true that the endogeneity problems can go in the other direction and, for this reason, the studies reported above consider methods to deal with this problem[4].Gallup et al. (2000) argue that malaria is simply geographical destiny being determine by climate and ecology[5]. They insist in the fact that poverty, per se, do not have a significant impact on malaria. By contrast Acemoglu, Johnson and Robinson (2001) argue that the basic factors behind large differences in income per capita are institutional and related with the process of colonization. The incidence of malaria and other infectious diseases was important in the institutional design of colonization which turns out to be the final explanation of underdevelopment. Europeans empires settled down in countries with low incidence of infectious diseases while setting up extractive states in areas with high incidence of diseases[6].

Recently Ghobarah, Huth and Russett (2001) have found that the burden of death and disability incurred in 1999 from the indirect effect of civil wars in the period 1990-

[3]Other studies like Shephard et al. (1991) report an intemediate estimate of 0.6% for sub-Saharan Africa.

[4]Gallup and Sachs (2000) use the prevalence of different Anopheles mosquito vector in each country in 1952 as instruments in an instrumental variables estimation to check the robustness of their original results. McCarthy et al (2000) suggest a two stages least squares estimator to deal with the possibility of two sided causality between malaria and economic growth.

[5]In fact they go even further in assesing that economic development is basically determined by geography and disease burden (see also McArthur and Sachs 2001).

[6]See also Acemoglu (2002).

97 is equal to the direct effect of wars during 1999. In this paper we also study the health consequences of civil wars beyond the direct causalities. These effects span beyond the war period and the country that suffered the conflict. In particular we analyze the effect of refugees from civil wars on the incidence of malaria. We find that refugees coming from a country with a high incidence of malaria have a large impact on the incidence of malaria in the asylum country. Our estimation suggests that for each 1,000 refugees from a malaria endemic country involved in a civil war there are close to 1,400 new cases of malaria in the asylum country[7]. We also construct a theoretical model to derive the basic factors that explain forced migration caused by a civil war, considering in particular the influence of malaria. The model points out that the higher is the incidence of malaria in a country the smaller should be the flow of refugees given a particular intensity of the civil war, proportion of urban population and reservation consumption.

The paper is organized as follows. Section 2 describes a theoretical model that contains the basic elements to study the influence of the incidence of malaria on the movement of migrants in countries that suffer a civil war. Section 3 estimates that model for a large sample of countries and confirms the empirical importance of malaria on the explanation of war refugees. In Section 4 we discuss the basic explanations for the incidence of malaria and we analyze the relationship between malaria and civil war through the displacement of people. Section 5 presents the results of the estimation and quantifies the effect of refugees from wars in malaria endemic countries on the incidence of malaria in the asylum country. Section 6 checks the robustness of these results. Section 7 concludes.

[7]Notice that even if a vaccine was available there would be important problems for vaccination programs in areas suffering civil wars and high degree of social conflict.

2 Civil wars, migration and malaria: a theoretical model.

In this section we present a simple model to characterize the basic relationships among malaria, migration and civil wars. The model explains the migration decision of individuals using a mechanism different from the usual one, based on wage differences (Todaro 1969 or Cole and Sanders 1985). In developing and underdeveloped countries many mass migrations take place as a consequence of a civil wars, armed conflicts or ethnic tensions. However in many of these countries migration caused by a civil war involves to walk through damps, forest and rural areas where malaria is endemic and, therefore, there is a certain probability of getting infected by the disease. Therefore the individual has to decide between staying, and maybe die as a consequence of the civil war, or leaving, and maybe get infected with the malaria parasite[8].

Initially we assume that a country can be divided into two basic parts: cities and rural areas. In an endemic country, even though urban areas are not malaria endemic, rural areas are not a safe place for non-immune individuals. People living in rural areas are usually immune to malaria while people leaving in the city are not. The basic model considers that whenever there is a probability larger than 0 of dying from a civil war or ethnic unrest ($P_{CW}>0$) the individual can chose between staying or leaving the city. We denote the decision of staying by s, and the decision to flee by f. Given that most civil wars have a political or ethnic component it seems reasonable to assume that people fleeing from the cities will not stay inside the country but go to a different country. Individuals are indexed by the subindex j. The consumption of individuals in the city is heterogeneous and is represented by c_{0j} while the consumption when moving to the foreign country and in the refugees

[8]In this sense the model is related with the inclusion of behavioral choices in epidemiological models as in Kremer 1996 or Phillipson 2000.

camps is simply the survival or minimum consumption c_1, which is equal for all the individuals. We assume that $c_{0j} > c_1$ for all i. There is no production. If an individual stays in the city she dies with probability P_{CW}. If she stays in the city, and she is alive her level of health will be h_0. If she dies obviously consumption and health will be zero. If she decides to leave the city she will not be infected in the first period but, afterwards, if she gets infected her health will drop to $h_1$where $h_0 > h_1$. The probability of being infected (state i) is characterized as follows:

$$\begin{aligned} \Pr(i|ni) &= P_M \\ \Pr(i|i) &= 1 \\ \Pr(ni|i) &= 0 \end{aligned}$$

where ni means not infected. The second and the third equations are convenient simplifications that do not alter the qualitative results of the model. In the case of malaria the probability of changing from the infected state to the non infected situation is not 0 but depends on the parasite family that causes the infection[9]. In particular while the *P. vivax* can live in the human liver for close to four years, the *P. malariae*, the most extended variant, could persist for as many as 50 years which is basically consistent with our assumption. However, in general it is also possible that after being infected, and without re-infection, an individual will change her status to not infected[10]. Notice also that P_M could change over time and depend on the number of people that has abandon the city up to time t. From the basic epidemiological model (see Anderson and May 1992) we can represent the number of

[9]Malaria is not a mortal illness if treated. For this reason we assume that once infected there is no death from malaria. The addition of this probability of dying from malaria will complicate the model marginally without changing the basic results.

[10]We also assume that the individuals in the city are not inmune to the malaria parasite and that malaria is not a problem in highly urbanized areas. Both are realistic assumption (see Najera et al. 1992).

new cases of malaria infection as

$$\frac{di}{dt} = \alpha_1 \alpha_2 \delta_1 \delta_2 ni - \gamma i$$

where α_1 is the number of bites per unit of time of the average mosquito, α_2 is the proportion of bites by infected mosquitos that lead to human infection, δ_1 is the proportion of infected mosquitos, δ_2 is the total number of mosquitos over total population, γ is the proportion of infected people that die and ni is the number of susceptible individuals[11]. If we would consider that $\Pr(ni|i)$ is not equal to 0 then we should subtract from the above expression the rate of recovery times the number of infected[12]. In order to keep the model as simple as possible we abstract from these conditions although its introduction would not change the basic qualitative results[13].

Under this assumptions there are four possible states in this economy: an individual with consumption c_{0j} could stay in the city and survive (s, nd, c_{0j}), stay in the city and die (s, d), flee from the city and is not infected (f, ni), and flee but gets infected (f, i). Therefore the individual takes the decision of migrating or staying by solving the following stochastic dynamic programming problem:

$$\begin{aligned} V(s, nd, c_{0j}) &= \max\{u(c_{0j}, h_0) + \beta[(1 - P_{CW})V(s, nd, c_{0j}) + P_{CW} * 0], \\ &\qquad u(c_1, h_0) + \beta[P_M V(f, i) + (1 - P_M)V(f, ni)]\} \end{aligned} \quad (1)$$

$$V(s, d) = 0 \quad (2)$$

[11]Susceptible individuals are equal to non infected individuals if inmunity is not a possible state.

[12]Gersovitz and Hammer (2001).

[13]Philipson (2000) and Geoffard and Philipson (1996) consider the dynamics of AIDS infected populations where the conditional probability of infection depends on the number of infected people. However notice that we assumed before that individuals will not stay at the rural areas in the same country but will cross the border to a different country. This implies that the number of infected individual will not increase in the origin country.

$$V(f,ni) = u(c_1,h_0) + \beta[P_M V(f,i) + (1-P_M)V(f,ni)\} \tag{3}$$

$$V(f,i) = \frac{u(c_1,h_1)}{1-\beta} \tag{4}$$

where $V(s,nd,c_{0j})$, is the value function of an individual with consumption c_{0j} that decided to stay and did not die; $V(s,d)$ is the value function of any individual that decided to stay and died; $V(f,ni)$, is the value function of an individual that decided to flee and has not been infected; and finally $V(f,i)$ is the value function of an individual that decided to flee and has been infected. The coefficient $\beta \in (0,1)$ is the discount factor.

Plugging program (4) into program (3), we obtain and expression for $V(f,ni)$. Plugging this resulting expression for $V(f,ni)$ and (4), into program (1) we obtain the following stochastic dynamic programming problem:

$$\begin{aligned} V(s,nd,c_{0j}) \quad &= \quad \max\{u(c_{0j},h_0) + \beta(1-P_{CW})V(s,nd,c_{0i}), \\ &\frac{1}{1-\beta(1-P_M)}u(c_1,h_0) + \frac{1}{1-\beta(1-P_M)}\frac{\beta P_M}{1-\beta}u(c_{1,h_1})]\} \end{aligned} \tag{5}$$

We can now solve this problem and find the value function of the marginal consumer, the individual that is indifferent between staying or fleeing from the city. The value function of the marginal consumer is $V(s,nd,\bar{c}_0)$, where we denote by $\bar{c}_0$ the consumption of the marginal consumer or reservation consumption. This value function has the following expression,

$$V(s,nd,\overline{c_0}) = \frac{u(c_1,h_0) + \frac{\beta}{1-\beta}P_M u(c_1,h_1)}{[1-\beta(1-P_M)](\beta(1-P_{CW})} - \frac{u(\overline{c_0},h_0)}{\beta(1-P_{CW})} \tag{6}$$

Therefore, the marginal consumer solves the following problem:

$$\begin{aligned}
&\frac{u(c_1,h_0)+\frac{\beta}{1-\beta}P_M u(c_1,h_1)}{[1-\beta(1-P_M)](\beta(1-P_{CW})} - \frac{u(\overline{c_0},h_0)}{\beta(1-P_{CW})} \\
= \quad & \max\{u(\overline{c_0},h_0)+\beta(1-P_{CW})V(s,nd,\overline{c_0}), \qquad (7)\\
& u(c_1,h_0)(\frac{1}{1-\beta(1-P_M})+u(c_{1,h_1})(\frac{1}{1-\beta(1-P_M)})(\frac{\beta P_M}{1-\beta})] \qquad (8)
\end{aligned}$$

From here we find an implicit function for the reservation consumption

$$u(\overline{c_0},h_0)=\frac{[1-\beta(1-P_{CW})]}{[1-\beta(1-P_M)]}[u(c_1,h_0)+\frac{\beta}{1-\beta}P_M u(c_1,h_1)] \qquad (9)$$

Now we can define the policy function given $P_{CW}, P_M, c_1, h_0, h_1$,and $\overline{c}_0$. If $c_{0i} < \overline{c}_0$, then the optimal would be to flee from the city. If $c_{0i} > \overline{c}_0$ the optimal decision is to stay in the country.

That is the j individual with initial consumption in the city c_{0j} will abandon the city if her consumption is below the reservation consumption, $\overline{c}_0$,given the probability of dying in the civil war and the probability of being infected with malaria if she leaves. The initial consumption only increase the utility of staying, therefore if an individual has a consumption lower(higher) than the marginal consumption, then the expected utility of staying will be lower(higher) than the expected utility of fleeing. Therefore from the distribution of total consumption in the city we know that the individual that will flee are the ones whose consumption is below the consumption of the marginal consumer

$$\int_{c_1}^{\overline{c}_0} N(c)dF(c)$$

where $N(c)$ is the proportion of individuals of type c.

We adopt the convention that indifferent individuals migrate, and then, an individual migrate if and only if

$$P_M V(f,i) + (1-P_M)V(f,ni) \geq (1-P_{CW})V(s,nd) \tag{10}$$

Comparative statics.

The comparative statics allows us to characterize the size of the flow of migrants as a function of the probability of dying from a civil war or being infected with malaria given a particular utility function.

Proposition 1: *The consumption of the marginal consumer, $\overline{c_0}$ increases with P_{CW}, the probability of dying if there is a civil war (intensity of the civil war).*

Proof: The derivative of the RHS of the expression (9) with respect to P_{CW} is positive. That is,

$$\frac{\partial[\frac{u(c_1,h_0)+\frac{\beta}{1-\beta}P_M u(c_1,h_1)}{[1-\beta(1-P_M)]}[1-\beta(1-P_{CW})]]}{\partial P_{CW}}$$
$$= \frac{u(c_1,h_0)+\frac{\beta}{1-\beta}P_M u(c_1,h_1)}{[1-\beta(1-P_M)]}\beta > 0 \tag{11}$$

This means that if P_{CW} increases, the RHS increases. In order to maintain the equality, then the LHS, $u(\overline{c_0}, h_0)$, also must increase. We know that $u(c,h)$ is an increasing function of c. Given that all individuals have h_0 at the initial period, therefore it should be that $\overline{c}_0$ increases. Therefore if the probability of dying because of civil war increases, so it does the consumption of the marginal consumer.■

Corollary 1: *The number of individuals that migrate as a consequence of the civil war increases with P_{CW},*

Proof: We know that the individual that flee are the ones whose consumption, c_{0j}, is below the consumption of the marginal consumer, $\overline{c_0}$,

$$\int_{c_1}^{\overline{c_0}} N(c)dF(c)$$

From Proposition 1, we know that $\overline{c}$ increases with P_{CW} and, therefore, if $\overline{c}$ increases with P_{CW}, the number of individuals with a consumption below $\overline{c}$ increases, and therefore the number of migrants increases.

Proposition 2: *The consumption of the marginal consumer,* $\overline{c_0}$*, decreases with* P_M*, the probability of getting infected by the malaria parasite.*

Proof: the derivative of the RHS of the expression (9) above with respect to P_M is negative. That is,

$$\frac{\partial[\frac{u(c_1,h_0)+\frac{\beta}{1-\beta}P_M u(c_1,h_1)}{[1-\beta(1-P_M)]}[1-\beta(1-P_{CW})]]}{\partial P_M}$$
$$= \frac{1-\beta(1-P_{CW})}{[1-\beta(1-P_M)]^2}\beta[u(c_1,h_1)-u(c_1,h_0)] < 0 \qquad (12)$$

This means that if P_M increases, the RHS of (12) decreases. In order to maintain the equality, the LHS, $u(\overline{c_0},h_0)$, also must decrease. We also know that $u(c,h)$ is an increasing function of c. Given that all individuals have h_0 at the initial period, therefore it should be that $\overline{c_0}$ decrease. Therefore if the probability of dying because of civil war increases, consumption of the marginal consumer decreases.■

Corollary 2: *The number of refugees that migrates from civil war decreases with* P_M*, the probability of being infected with the malaria parasite.*

Proof: We know that the individual will flee if her consumption, c_{0j}, is below the consumption of the marginal consumer, $\overline{c_0}$,

$$\int_{c_1}^{\overline{c_0}} N(c)dF(c)$$

From Proposition 2, we know that $\overline{c}$ decreases with P_M, therefore, if $\overline{c}$, decreases with P_M, the amount of people that has a consumption below $\overline{c}$ decreases, and therefore the number of refugees decreases. Therefore we expect to see that migration will increase as a consequence of an increase in the probability of dying from the civil war (more intense war) and decrease with the probability of being infected.

3 Malaria and migration caused by civil wars.

Following the results of the model of section 2 in this part we estimate the incidence of the different elements consider in the theoretical discussion in the flow of migrants from countries with civil wars. In principle the intensity of the flows of migrants is positively related with the intensity of the civil war and negatively related with the proportion of urban population in countries with high malaria incidence. In addition the distribution of consumption/income is also important since the flow of migrants depend on the accumulated density around the trigger point $\overline{c}$.

For the empirical exercise the dependent variable, the flow of migrants, is the proportion of refugees from a country with respect to the population of that country. There are two basic sources of information for the data on refugees: the United Nations High Commission for the Refugees (UNHCR), and the US Committee For Refugees (USCR). The data on refugees that we use come from the United Nation High Commission for the Refugees[14]. This data is publicly available only from 1993 until 1999. Thanks to Susanne Schemeidl we have had access to the internal data of the UNHCR from 1951 until 1999[15]. Following the UNHCR definition, refugees are persons recognized as refugees under the 1951 United Nations Convention relating to

[14]We also have the complete dataset from 1960 to 1999 of refugees from the USCR. In other papers we explore the sensitivity of the results to the different definitions of refugees.

[15]The data from 1951 to 1992 is not public and come from the work of Schemidl and Jenkins (2001). We are indebeted to them for providing us this data, which is not publicly available. Schemidl and Jenkins (2001) also describe the difference between the data compiled by the UNHCR and the USCR.

the Status of Refugees or its 1967 Protocol, the 1969 Organization of African Unity (OAU) Convention Governing the Specific Aspects of Refugee Problems in Africa, persons recognized as refugees in accordance with the UNHCR Statute, persons granted humanitarian or comparable status and those granted temporary protection. This data set is organized by country of origin and country of asylum and provides information on the number of refugees that arrive to the asylum country at time t coming from different origin countries. Notice that in this part of the paper we consider the origin country of the refugees independently of the asylum country in which they end up[16].

Internally Displaced (IDPs) are persons who are displaced within their country. The data on IDPs collected by the UNHCR are very scarce and only provide information on IDPs where they provide assistance. We also have information on IDPs from the USCR which is the only systematic data base for internal displacement that exists. However, being the only systematic source of data it only cover a few years and it is also plagued with missing data because of irregular reporting. Given these shortcoming, the used of this variable is very problematic, and we decided to work only with refugees.

We are also interested in measuring the effect of the probability of being infected by the malaria parasite on the intensity of migrants' flows. The probability of being infected depends on the percentage of not immune population and also on the extension of country land where the vector can survive. As we argued before, the infection is mostly associated with non-immune people fleeing from cities. For this reason we include the proportion of population living in cities obtained from the World Development Indicators. To proxy for malaria enhancing conditions we could not use the percentage of the country area with malaria (MALCID[17]) coming from the geograph-

[16] In next section we analyze the effect of those refugees in the asylum country.

[17] The dataset only provides information for 1966, 1982 and 1994 although it is reasonable to

ical data set of Gallup and Sachs (2001), because this variable is constructed using the number of infected individuals in the country, which implies that there would be endogenous with respect to the flow of migrants. Instead the extension of land irrigation captures the area of the country where the vector could survive independently, whether infected with the malaria parasite or not.

For the purpose of the empirical investigation, and given the determinants discussed above, we need to obtain data on civil wars and its intensity. For the definition of civil war we use data from Doyle and Sambanis (2000) (DS), which involves, as part of the definition, an intensity indicator. Their definition is nearly identical to the definition of Singer and Small (1982,1994) and Licklider (1993,1995). The intensity of the civil war is measured by the yearly average number of deaths during an armed conflict divided by urban population. Therefore we have the number of deaths per year and per capita in the urban area. The original number of deaths come from the World Bank Project on the Economics of Civil Wars.

Income distribution and the level of consumption are two of the factors that explain the intensity of the flow of migrants when there is a civil war. In principle in the steady state $\overline{c}$ is function of other variables as the intensity of the civil war or the incidence of malaria. However, it will also depend on the level of consumption of the country, that is, on the amount of resources devoted to consumption. As a proxy we use the so called standard of living from the World Development Indicators. We also include the level of development of the country (GDP) per capita.

Finally we include some other variables that may have an incidence in the intensity of migration. In principle the intensity of the flows of migrants can be affected by natural disasters and the degree of openness of the country since this is a proxy for easy access to countries with common borders.

Therefore the basic specification can be written as

assume that these variables do not vary on a short period of time.

$$\begin{aligned} PREF_i &= \beta_0 \ln GDP_i + \beta_1 CW_i + \beta_2 STLIV_i + \beta_3 STLIV_i * CW_i \\ &+\beta_4 IRRIG_i + \beta_5 IRRIG_i * CW_i + \beta_6 URB_i + \beta_7 URB_i * CW_i \\ &+\beta_8 URBDEATH_i + \beta_9 OPEN_i + u_i + v_{it} \end{aligned}$$

where PREF is the proportion of the flow of refugees from the origin country to any other country in a particular year over the population of the origin country, CW is a dummy variable that takes value 1 if there is a civil war, STLIV is the standard of living index, URB is the proportion of urban population, IRRIG is the extension of land irrigated over the size of the country, URBDEATH is the number of violent deaths from a civil war per year as a percentage of urban population, OPEN is the degree of openness measure as the proportion of import plus exports over GDP. The openness variable is expected to capture the degree of porosity of boundaries. We also include in some specifications droughts and other natural disasters that may generate also mass migration.

Table 1 shows the results of the regression using the fixed effect panel data specification. The sign of the coefficients are consistent with the theoretical model of the previous section. The proportion of refugees is negatively related with the standard of living, the proportion of urban population, and the extension of land irrigation, conditional on the country suffering a civil war. The intensity of the civil war generates also an increase in the flow of refugees. However, once the civil war is taken into account, natural disasters have no effect on the intensity of refugees' flows. The degree of openness of the economy has no effect on the number of refugees[18]. Therefore the empirical results do not seem to contradict the theoretical findings.

The results are basically the same if we use a direct proxy of the distribution of

[18]Since the endogenous variable is a proportion we run also several regressions using a grouped logit specification. The qualitative results are basically the same as the ones in table 1.

Table 1. Determinants of the flow of refugees: Fixed effects model.

Dependent variable: flow of refugees						
Model	1	2	3	4	5	6
LNGDP	0.0000	0.0002	0.0002	0.0002	0.0002	0.0002
	(0.36)	(1.59)	(1.45)	(1.44)	(1.49)	(1.54)
CW	**0.004**	**0.104**	**0.1211**	**0.1274**	**0.1330**	**0.1389**
	(5.75)	**(20.53)**	**(23.27)**	**(23.80)**	**(24.53)**	**(24.39)**
CW*STLIV		-0.0012	-0.0012	-0.0013	-0.0014	0.0015
		(-20.14)	(-21.65)	(-22.04)	(-22.78)	(-2255)
STLIV		0.00002	0.0000	0.0000	0.000	0.000
		(0.92)	(0.51)	(0.76)	(1.15)	(1.66)
CW*URB			**-0.0004**	**-0.0003**	**-0.0003**	**-0.0002**
			(-9.36)	**(-5.97)**	**(-5.18)**	**(-4.54)**
URB			0.00005	0.00005	0.00006	0.000
			(1.04)	(1.08)	(1.24)	(1.02)
CW*IRRIG				**-0.1733**	**-0.1698**	**-0.1622**
				(-5.50)	**(-5.35)**	**(-4.90)**
IRRIG				-0.025	-0.0252	-0.024
				(-0.80)	(-0.81)	(-0.75)
URBDEATH					**5.810**	**7.27**
					(1.75)	**(2.10)**
OPEN						0.000
						(0.91)
Drought						-0.002
						(-0.70)
NATDIS						Yes
Constant	0.00009	-0.0038	-0.0043	-0.0042	-0.0054	-0.007
	(0.09)	(-1.51)	(-1.47)	(-1.34)	(-1.71)	(-2.03)
R-squared	0.0123	0.1107	0.2073	0.2250	0.2191	0.2187
N	3366	1136	1136	1075	1066	997

Numbers in parentheses are t-statistics

income/consumption instead of the standard of living. One such a proxy could be the proportion of income accruing to the richest quintile, Q5. The data come from Deninger and Squire (1996). The correlation of the Gini coefficient with Q5 is very high: 0.89 in 1960, 0.92 in 1970, 0.95 in 1980 and 0.98 in 1990[19]. One explanation for such a high correlation is the fact that Q5 has a larger standard deviation than other quintile shares. The estimation shows that the higher is the proportion of income accruing to the richest quintile the smaller is the flow of refugees.

4 Refugees and malaria in the asylum countries.

In section 3 we have shown the relationship between the incidence of malaria, the intensity of a civil war and the flow of refugees out of the country that suffered the armed conflict. In this section we examine the relationship between those refugees and the incidence of malaria in the asylum countries. There are two basic approaches to the war against malaria: the epidemiological approach and the socio-economic approach. Some researchers emphasize the need to continue the search for a vaccine in order to reduce the number of infections[20]. From the economic perspective papers like Kremer (2000a, 2000b) discuss the institutional design of such an effort in the face of the usual externalities associated with this kind of problems.

There is a different perspective which relies on the investigation of the causes of the malaria that are not strictly epidemiological or immunological. In the introduction to the first edition of Bruce-Chwatt's reference book on malaria the emphasis is placed on the technical problems[21]. He observes that

[19] Barro (2000).

[20] The recent completion of the DNA map of the Plasmodium parasite and the Anopheles mosquito open some new hopes for the future of malaria vaccines. However the prediction of Najera et al. (1992) is valid for the future: "Even if vaccines, new drugs, or new insecticides are developed, in view of the time required for their final testing in the field, it is difficult to expect a significant impact on malaria in the 1990s".

[21] Increasing resistance of mosquitoes to known drugs, its changing behavior (i.e. not resting inside

> "Malaria continues to be a major problem of tropical developing countries and the recent years have seen the return of it to areas freed from the disease in the 1960's. The causes of this setback to a unique international health endeavor have often been analyzed and commented upon. Certainly technical factors such as the resistance of insect vectors to insecticides played a major role in these reverses of fortune. Not less and probably more important were other, often imponderable factors. Inadequacy of planning, administrative shortcomings, financial stringency, shortage of personnel, poor training were equally responsible for the recent shift in strategy from malaria eradications to malaria control." (1978)

It is noticeable the change in the general vision of the problem from the first edition to the second were the focus shifted from technical problems to adverse social and economic conditions.

> "During the few years that have elapsed between the first and the second edition of this book the world's malaria situation has deteriorated. This is particularly evident in many developing countries situated in the tropics, where the revised strategy of malaria control (seen as an alternative to malaria eradication) has not been implemented because of adverse social and economic conditions, due either to general recession or to various internal difficulties" (1985).

Therefore as the efforts to eradicate malaria fade by the end of the sixties, as a consequence of technical problems, the attempts to control the disease encounter different challenges based on the internal problems of the countries where the incidence of malaria is the highest. The most relevant internal problems are civil wars and social conflicts. Therefore the original objective of the war against malaria, eradication

houses after feeding), the DDT prohibition and new vectors resistent to insecticides.

of the diseases, was substitute by control measures to keep the diseases at a low level. It is important to notice that technical problems are aggravated by the difficulties derive from civil wars and social conflicts. Moreover many wars take place in countries with a high incidence of malaria. For instance the Afghan civil war takes place in a country where the incidence of malaria is high, and has generated six millions of refugees that, in principles, are at a very high risk of being infected.

Najera et al. (1992) distinguish different patterns of reported malaria cases. The so called "group B" is the one that produces most of the cases of malaria. Najera et al. (1992) argue that "these countries are characterized by recent efforts to increase the exploitation of natural resources (through agricultural colonization of forest or jungle areas) or by civil war and socio-political conflict (including illegal drug trade) and large movements of refugees or other mass migrations".

4.1 Geographical and social causes of the incidence of malaria.

In this part of the paper we analyze the relationship between the incidence of malaria in the asylum country caused by the displacement of people from the country that suffers the civil war to the asylum country. We argue that while urban areas are mostly free of non-imported malaria, rural areas have some characteristics that make them a very contagious place for non-immune civil population fleeing from civil war or social unrest. We consider civil wars and social conflict as one of the basic reasons behind the observed increase in the incidence of malaria either directly (non-immune refugees get in contact with infected individuals when they flee through rural and rainforest areas to reach a foreign country) or indirectly (civil wars make very difficult or even impossible to keep active control measures against malaria). Notice that if this is the case the problem of a future vaccine against malaria will not only be the economic cost for developing countries of making it available for the population but also the fact that frequent civil wars in underdeveloped and developing countries will make very difficult its administration. In fact it could also become an "arm" for some of the factions involved in a civil war. Therefore, as in the case of control efforts, the effectiveness of an eventual vaccine will depend not only on socioeconomic development and the incentives for vaccine research but also on political stability.

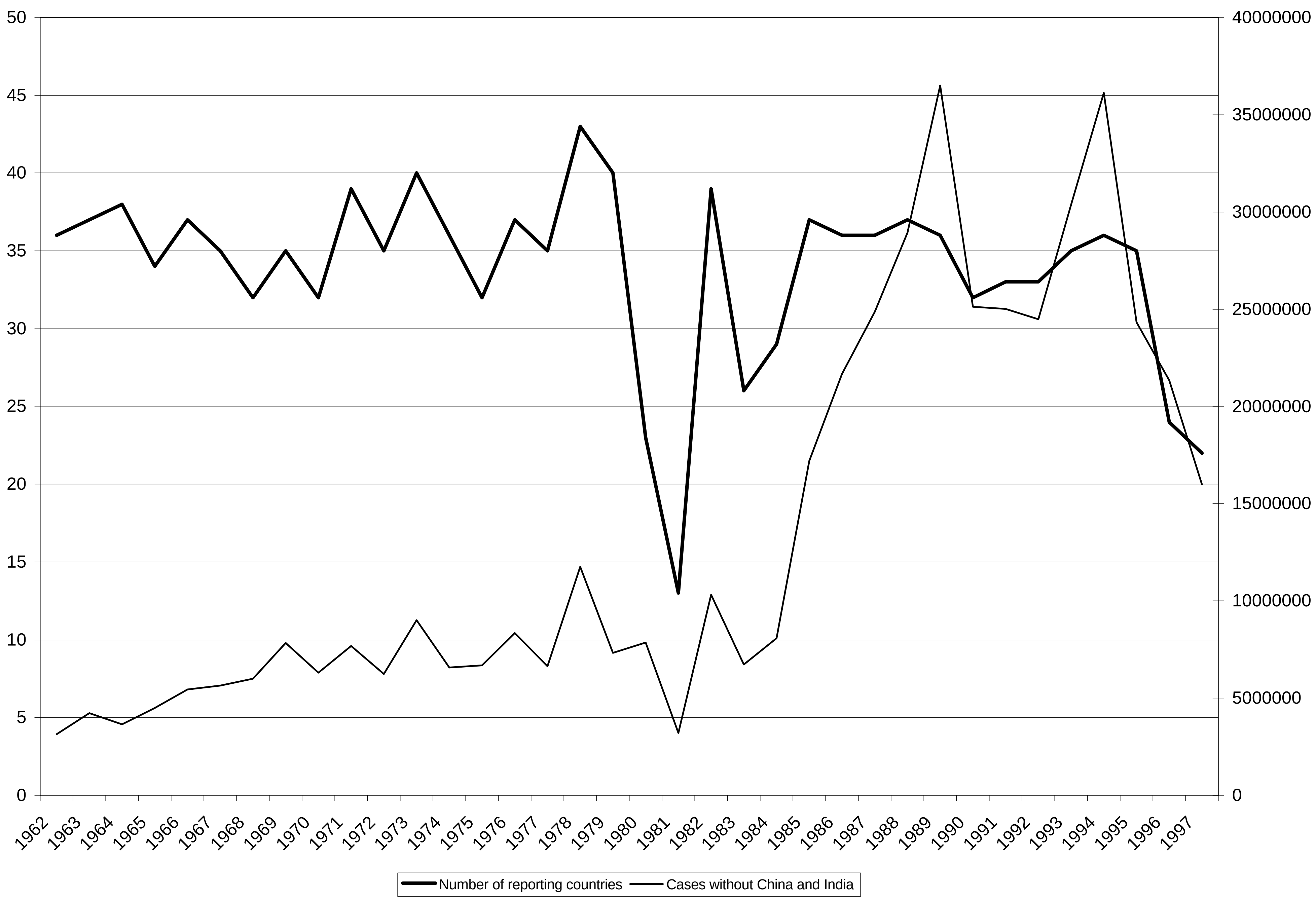
Figure 1 presents a general view of the relationship between the official data on cases of malaria[22] and civil wars. With respect to the total cases of malaria it should be beard in mind that the number of reporting countries varies largely over time. In particular there are two countries that have a determinant influence on the number of cases: China and India. China started to report officially to the World Health Organization (WHO) in 1977. Initially it reported close to four million cases and from 1977 it reported an exponentially decreasing number of cases. India is also a conflictive case in terms of its effect on the total number of cases and it drives the growth of cases during the 1974-77 epidemic period where it accounts for close to 20% of the total cases of malaria in the world. For this reason in Figure 1 we also depict the relationship between the number of civil wars and the cases of malaria in the world without counting India and China. Still after eliminating the influence of India and China there exist the problem of the African region. The countries in this area are known to have irregular reporting, in most of the cases due to the difficulties caused by socio-political conflicts. Figure 2 shows the evolution of the number of cases of malaria, after eliminating China and India, and the number of reporting countries in tropical Africa. It shows how erratic is the evolution of the number of reporting countries in tropical Africa. For this reason we have performed an interpolation procedure[23] to impute the missing data of these countries. The interpolation is performed using the last available data before the missing period and

[22]For a historical and geographical perspective see Hamoudi and Sachs (1999).

[23]We use the ipolate function of STATA in order to apply an standard procedure instead of using our own criterion.

Figure 1. Cases of malaria and civil wars.
Source: WHO Weekly Epidemiological Record (1999) and Doyle and Sambanis (2000).

Figura 2: Number of African countries reporting and number of cases.
Source: WHO Weekly Epidemiological Record (1999).



the first available figure once reporting resumes. In this way if the reporting was stopped because of a civil war and the number of malaria cases rise during the war period then the initial figure of the next reporting period would incorporate most the increase in malaria. Figure 3 represents the total cases of malaria obtained using this interpolation and the number of refugees worldwide. The high correlation of these variables is one of the motivations for this research on refugees and the incidence of malaria. Obviously the increase in the incidence of malaria cannot be only the result of "tropical destiny"[24] since this is invariant over time. There must be the combined effect of ecological and non ecological factors what explain this tendency. Among them the interaction of war refugees and tropical location is one of the basic factors.

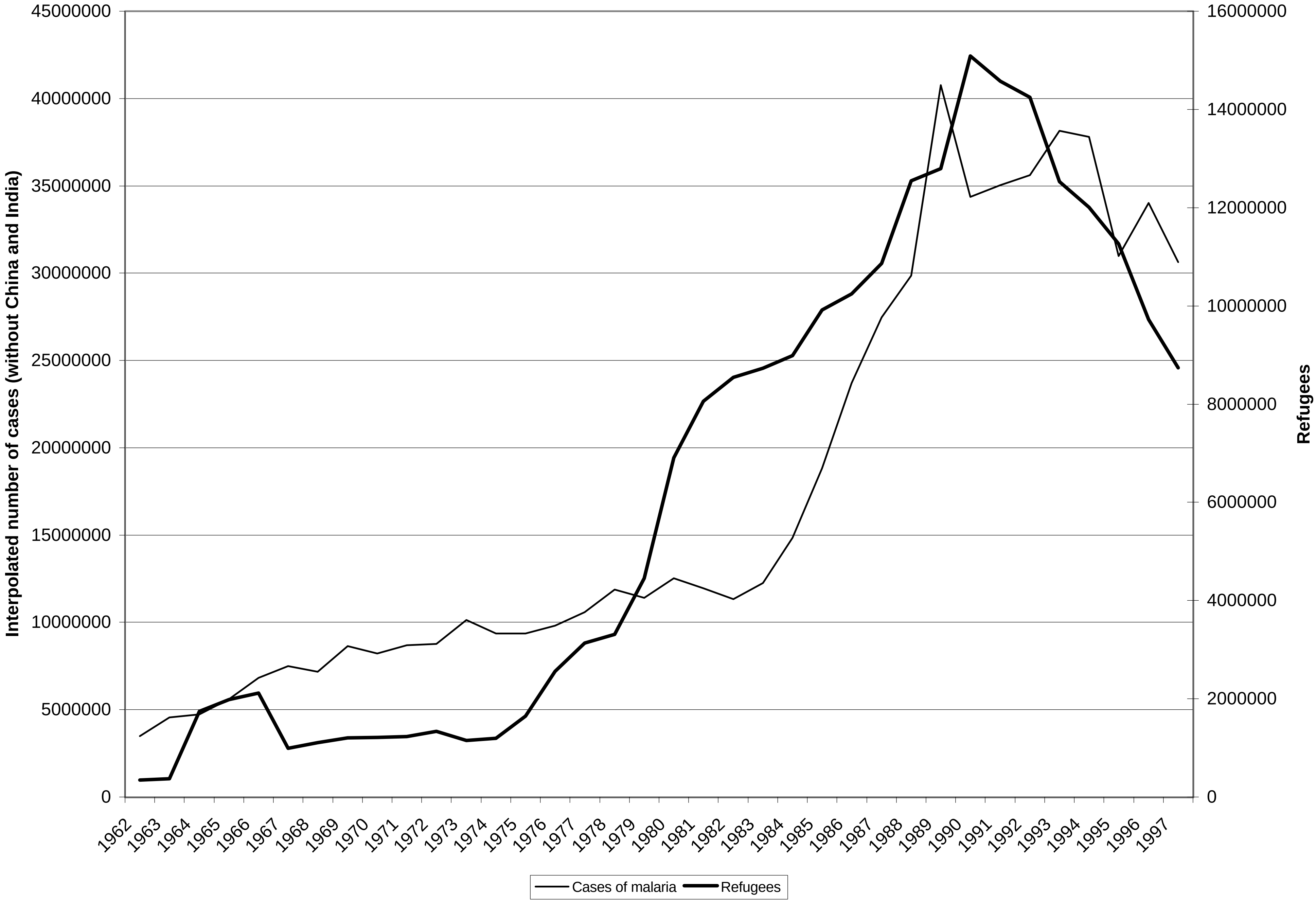
In general malaria transmission depends on the dynamics of the relationship between men, vector, parasite and environment. As we argued in section 2 malaria transmission is not widespread in densely populated urban areas[25].The war leads to movement of people out of the cities. In general the anarchic situation caused by this social unrest and the military importance on paved roads, force people to walk through unfamiliar rural areas, dumps and forests in order to avoid areas of military operations. If the civil war generalizes this movement will end up in migration to a contiguous country as a war refugee. In fact population movement (due to political conflicts or civil wars) is potentially the most important factor in the transmission of malaria (conditional on the dynamics between vector, parasite and environment)[26]. While moving from cities to the borders, if the country has endemic malaria, the probability of getting infected by the malaria parasite increases by the contact with immune rural population and the movement through remote unurbanized areas where

[24] See Bloom and Sachs (1998), Gallup, Sachs and Mellinger (1999) and the controversy between McArthur and Sachs (2001) and Acemoglu, Johnson and Robinson (2001).

[25] In some tropical cities the existence of large slums can facilitate the transmission of malaria. However in that case the living conditions of people in those areas are basically the ones prevalent in rural areas.

[26] See for instance Curtin (1989, 1998) and Cruz Marques (1987).

Figure 3. Refugees and cases of malaria.
Sources: UNHCR and Weekly Epidemiological Record (1999).



the vector is still predominant. The importance of the contact with immune individuals is critical. Repeated infection among individual of rural endemic areas generate an immune response in the host who controls the infection. This fact implies that among rural population the prevalence of malaria could be very high with an small number of reported cases. Even without reinfection the persistence of the malaria parasites could last from two years (*P. falciparum*) to four years (*P. vivax*) up to as many as 50 years (*P. malariae*). However the risk of life threatening malaria is exclusively beard by non-immune populations[27]. Paradoxically in low endemicity areas is where the risk of severe infection is the highest among adult population because they may grow without developing immunity.

Therefore the reasons for migration in this situation are not the usual differences of wages across countries but simply fear of death. The simple theoretical model of section 2 shows that migration will depend on the intensity of the social conflict (measured as the probability of dying if staying), the probability of malaria infection and the distribution of consumption across individuals. Therefore there is always a level of social conflict such that, even if there is malaria in the countryside, people will try to abandon the cities. Whenever the spread of civil war endangers the life of individual, their expected health will decrease and they may optimally decide to migrate even if consumption will decrease by this decision. However, in tropical countries the migration decision will have also a negative effect on expected health given that it increases the probability of getting infected with the malaria parasite because of the contact with the immune population in rural areas where the vector prevails. Once arrived to the asylum country if the migrant has being infected with the malaria parasite she will probably show the symptoms there. This is important because those cases will be counted as diagnosed malaria in the asylum country[28].

[27]Najera et al. (1992).

[28]Additionally the fact that the origen country is in war limits the extent of statistical operations

Moreover the existence of many refugees infected by the malaria parasite in the asylum country increases also the malaria transmission to citizens of the asylum country and the contagion effect among refugees themselves. This will happen if the asylum country has the vector, even though it may not be originally malaria endemic. It could also happen that the refugees come from a non-endemic country into an endemic country and, in that case, it could contract the diseases by contact with immune rural population of the asylum country. In general the concentration of refugees in camps where non-immune and infected individuals live together increases the risk of transmission conditional on the existence of the anopheles mosquito.

4.2 Econometric specification and data sources.

Our basic regression has the following form

$$MAL_{it} = \theta_i + \beta X_{it} + \gamma Z_{it} + u_{it}$$

where MAL is the number of new cases of malaria in the asylum country, X contains the variables related with the refugees and Z includes the variables of the asylum country that may have an effect on the number of cases of malaria. The set of variables to include in the regression follows closely the classification of Najera et al. (1992) on the patterns of malaria. There are basically two groups of patterns: the ecological conditions and the social conditions. Najera et al. (1992) include as ecological conditions the African savannah, the plains and valleys outside of Africa, the highlands, seashore and coastal areas. All these geographical conditions are country specific but time invariant and, therefore, are include in the country specific effect of our regression. The individual effect, θ_i represents also the difference in the reporting practices among countries, if they are stable over time. For instance, it is

and, in particular, the counting of malaria cases. The data shows that the reports of malaria cases mostly stops in countries that suffer a civil war.

well documented that in many African countries the cases of malaria are counted by diagnosed cases opposite to the regular practice of counting clinically diagnosed cases. In addition the WHO points out that in the tropical Africa the cases of malaria may be a small proportion of the actual cases. However the availability of a panel data of countries can control for this effect, even if the reporting in some countries is fragmentary subject to the assumption that the reporting practices do not change too much over time[29].

The social conditions include the agricultural colonization of forest, the migrant agriculture labor force and the displaced population. Among the control methods in these conditions the management of clinical malaria through diagnosis and treatment appears as the first intervention. In addition many of the other control interventions require also the presence of physicians. We proxy the social conditions with data on physicians per thousand population, the percentage of rural population, the extension of land irrigation, and the incidence of civil wars and natural disasters. These variables are grouped in Z. We include the displaced populations, in different versions, in the X variable.

Given our empirical specification we have obtained information on malaria, geography, refugees, internally displaced, civil wars, natural disasters, health variables, agricultural population and land irrigation. In the following pages we discuss the basic sources of data and its characteristics.

Malaria incidence

Data on the number of diagnosed malaria cases come from WHO. From 1982 to 1997 the data is reported in the Weekly Epidemiological Record. From 1962 to 1981 the data was published in the World Health Statistics Annual (1983). The values represent the number of malaria cases reported by countries and WHO regional offices

[29] We use the original data, without the interpolation we considered in section 1 for aggregation purposes, jointly with methods of estimation apropriate for incomplete panel data.

during the period 1962-1997. This is the most reliable information on the malaria incidence even though during the period 1962-1981 there is infrequent reporting by some countries.

Regarding the total yearly figures the following has to be taken into account: for Africa the figures refer to clinically diagnosed cases (except for the North African countries, Cape Verde, Djibouti, Mauritius, Reunion, Somalia and South Africa). The figures from the other continents represented laboratory confirmed cases, except for China where not all cases are confirmed by laboratory.

In reference to the data from 1982 until 1997 some of the problems with the data are similar: First of all, some countries, especially in Sub-Saharan Africa, report with irregular frequency their cases. Secondly, most countries reports only malaria cases seen by the government health services. Finally, many countries report only laboratory-confirmed cases. We have to take into account that for most countries in Sub-Saharan Africa the figures refer to clinically-diagnosed cases. Figures for the North of Africa and other cases are laboratory -confirmed cases except for China (1982 and 1986) and Papua New Guinea (1994), where not all cases are confirmed by laboratory.

There are 162 countries that have reported cases of malaria from 1962 until 1997. In 27 of those countries the cases of malaria are imported by tourist that travel to tropical countries. Because of the purpose of our study we are not going to consider these cases, that corresponds basically to the OECD countries. Therefore we decide to work with a sample of 135 countries.

Geographical variables

The variable for the tropics comes from the Global Development Network Growth database (GDNG). It considers that a country is tropical if the absolute value of latitude is less than or equal to 23,5 degrees (between the Tropic of Cancer and the

Tropic of Capricorn). Countries in tropical Africa are estimated to account for more than 90% of the total malaria incidence and the great majority of malaria deaths. There are a total of 112 tropical countries. In our sample we have 103 of them.

Natural Disasters:

Data on Natural Disaster comes from the EM-DAT: The OFDA/CRED International Disaster Database[30]. Since 1988 the WHO collaborating Centre for Research on the Epidemiology of Disasters (CRED), has been maintaining an Emergency Events database EM-DAT. EM-DAT was created with the initial support of the WHO and the Belgian Government.

The disasters database contain essential data on the occurrence and effects of mass disasters in the world from 1900 to the present. They define disaster as "a situation or event which overwhelms local capacity, necessitating a request to national or international level for external assistance". The disaster data are sub-divided into three types: natural, technological and conflicts. EMDAT contains essential core data on the occurrence and effects of over 12.500 mass disasters in the world from 1900 to present. The database is compiled from various sources, including UN agencies, non-governmental organizational, insurance companies, research institutes and press agencies. The OFDA/CRED offers information on the occurrence, the number of people injured, killed, homeless and total affected.

There are many different natural disasters included in the data base: drought, earthquake, extreme temperature, flood, slide, volcano, wave/surge, wildfire and windstorm. From all these natural disasters we are interested in the ones that imply mass movements of people. The only situation that can cause mass migration is drought and its main consequence, famine, because the rest of the events considered as natural disasters are expected and last a few days or weeks. After that people starts

[30]EM-DAT: The OFDA/CRED International Disasater Database- www.cred.be/emdat-Universite Catholique de Louvain-Brussels-Belgium.

reconstruction and do not leave the area. However drought has usually a lengthy duration and cannot be handled easily without moving to other areas.

Health data

We also control for the extension of the health system in each country. The health data comes mainly from the World Development Indicators of the World Bank. We consider the number of Hospitals beds per 1000 population and the number of physicians per 1000 population. These two variables are highly correlated. Moreover we would like to consider the access that rural population have to the health system but this information is only available for a few number of countries and only from 1983 until 1993. Data on hospitals beds is available from 1970, and data of physicians is available from 1965. Before 1985, the information on hospitals beds and physicians was basically collected every five years (1965, 1970, 1975, 1980 and 1985). Only for very few countries there are data in the years in between. Information on hospitals beds is even more scarce than information on physicians and that is the reason, together with their high correlation, why we use the proportion of physician per 1000 inhabitants as one of the basic explanatory variables. It is also the case that the number of hospitals beds and the number of physicians do not change much in five years periods. For this reason, and in order to avoid a large reduction of the sample size, we have interpolated the values for the years in between the periods for which we have data.

Land irrigated area and proportion of rural population.

Data on the hectares of land irrigated and the proportion of rural population comes from the World Development Indicators.

5 Empirical results

From the discussion on the econometric specification and the availability of data we consider the period from 1962 until 1997 and the basic regression

$$\begin{aligned} MAL_{it} &= \theta_i + \beta REF_{it} + \gamma_1 RURAL_{it} + \gamma_2 PHYS_{it} + \sum \gamma_{k+2} Z_{it} + u_{it} \\ REF_{it} &= \sum REF_{jt} \;\; for\; j \neq i \end{aligned}$$

where MAL represents the new cases of malaria in the asylum country, REF are the refugees coming from other countries[31], RURAL is the proportion of rural population in the asylum country and PHYS is the number of physician per thousand inhabitants in the asylum country. Among other Z variables, always referred to the asylum country, we include the land irrigated area, natural disasters, civil wars and, in some cases, the percentage of the area of the country which is malaria endemic[32]. We also include a set of year dummy variables to consider possible time effects[33]. In principle a high proportion of physicians should have a negative effect on malaria given that it proxies a good health system and the possibility of improved prevention. The proportion of land irrigated should have a positive effect because of two reasons. First of all the increase of water surfaces favors the proliferation of mosquito larvae. Second this variable is also a proxy for agricultural colonization of new areas. Droughts and civil wars in the asylum country will also favor the displacement of people and, therefore, should increase the incidence of malaria[34] through the relaxation of preventions measures.

[31]The results for the proportion of population infected with respect to total population and refugees per capita are qualitatively the same as the ones that appear in the tables.

[32]In all the regression the variable GDP per capita was included but did not show any significant effect on the cases of malaria. The reason is the inclusion of the proportion of physicians, which also proxies the level of development, and the endogeneity of malaria and GDP per capita.

[33]The results are not affected if we included total population as another explanatory variable.

[34]If the data on internally displaced had a larger temporal and spatial coverage than they have we could have used them instead of the natural disaster and civil war dummies.

Table 2A presents the results of this basic regression using all the observations[35]. The estimators are obtained by using the fixed effects linear panel data estimator[36]. In column (1) we observe that the total number of refugees does not have effect on the malaria cases in the asylum country while the proportion of rural population has a negative effect. When we include the proportion of physicians per inhabitants both take a negative and significant coefficient and the effect of refugees becomes positive and significant. However, the use of the variable physicians reduces the sample from the original 3.214 to only 789 observations. In order to avoid the confusion of the effect of physicians and the effect of the reduction of the sample size we include in (3) the interpolated proportion of physicians[37]. As it is shown in regression (3) the use of this variables does not affect the size or the sign of the effect of the proportion of rural population or physicians and it only transform in non significantly different from zero the coefficient on total refugees. The inclusion of the area of irrigated land, (4), does not alter the results and shows that this variable has a positive and significant effect over the cases of malaria. Finally nothing changes by adding the dummies of drought and civil war in the asylum country and the proportion of malaria endemic land has only a barely significant coefficient.

In table 2B we only work with the sample of tropical asylum countries. We can observe that the sign and significance of the proportion of rural population and physicians is the same as in table 2A but now the refugees arriving into tropical countries have a large impact on malaria. As in table 2A the coefficients for the dummies of drought and civil war in the asylum country as well as the proportion of

[35]The variable physicians has been multiplied by 1000 and, therefore, in the regression we use, in fact, physicians per million inhabitants.

[36]Notice that, in principle, the endogenous variable is positive and discrete (number of cases). Therefore we could use a Poisson regression model or any transformation of this specification that allows for overdispersion. The results are not affected by the choice of a linear panel data estimator versus this alternative specifications.

[37]Notice that this is reasonable since the proportion of physicians evolves very slowly.

Table 2A: Regression results: All refugees (all asylum countries)

Dependent variable: malaria incidence						
Model	1	2	3	4	5	6
REF	0.055	0.189	0.052	0.023	0.019	0.016
	(1.37)	(2.34)	(1.23)	(0.51)	(0.44)	(0.36)
RURAL	-100.91	-224.33	-142.86	-144.09	-146.21	-162.25
	(-7.31)	(-3.72)	(-8.84)	(-8.25)	(-8.34)	(-8.65)
PHYS		-202.49				
		(-2.55)				
IPHYS			-258.24	-317.40	-317.67	-321.33
			(-4.96)	(-5.43)	(-5.43)	(-5.25)
IRRIG				0.040	0.040	0.038
				(4.19)	(4.27)	(3.94)
DR					Yes	Yes
CW					Yes	Yes
MCID						Yes*
R-sq	0.0587	0.0351	0.0494	0.1154	0.1200	0.1242
N	3214	789	3194	2863	2863	2722

The explanatory variables include time dummies.
Numbers in parentheses are t-statistics.
*significant

Table 2B: Regression results: All Refugees (only asylum tropical countries)

Dependent variable: malaria incidence						
Model	1	2	3	4	5	6
REF	0.887	1.448	0.865	0.871	0.875	0.865
	(6.71)	(7.18)	(6.52)	(6.06)	(6.08)	(5.90)
RURAL	-123.45	-121.54	-156.13	-161.03	-163.22	-175.58
	(-7.18)	(-3.35)	(-7.83)	(-7.39)	(-7.46)	(-7.58)
PHYS		-142.53				
		(-1.41)				
IPHYS			-233.43	-249.08	-246.79	-265.29
			(-3.28)	(-3.06)	(-3.03)	(-3.15)
IRRIG				0.004	-0.003	-0.008
				(0.08)	(-0.06)	(-0.15)
DR					Yes	Yes
CW					Yes	Yes
MCID						Yes
R-sq	0.0936	0.1518	0.1221	0.1280	0.1296	0.1269
N	2295	539	2275	1991	1991	1919

The explanatory variables include time dummies.
Numbers in parentheses are t-statistics

land with endemic malaria are not significantly different from 0.

The definition of refugee can also be made more precise in terms of our model. It is reasonable to assume that the refugees from tropical countries would be infected, with higher probability that other refugees, with the malaria parasite. In table 3A we separate the effect of total refugees (REF) from the effect of refugees from tropical countries ($REF1$)

$$
\begin{aligned}
MAL_{it} &= \theta_i + \beta_1 REF_{it} + \beta_2 REF1_{it} + \gamma_1 RURAL_{it} + \gamma_2 PHYS_{it} + \sum \gamma_{k+2} Z_{it} + u_{it} \\
REF1_{it} &= \sum DTROP_j REF_{jt} \;\; for\ j \neq i
\end{aligned}
$$

where $DTROP$ is a dummy variable that takes value 1 if the country j is tropical. The results in table 3A are very similar to table 2A. However now the coefficient for the refugees coming from tropical countries is positive and significantly different from 0. Column (6) points out that for each 1,000 refugees from tropical countries we expect 1,146 new cases of malaria in the asylum country. Table 3B considers the same specification but the sample only includes tropical asylum countries. The results are similar to the ones obtained in table 2A but now, as it should be expected, the coefficient on the refugees coming from tropical countries is larger than before. For each 1,000 refugees from tropical countries we expect to see 1,300 cases of malaria in the asylum tropical countries.

Table 4A includes total refugees and refugees coming from a war ($REF2$). Notice that in principle most of the refugees come from civil wars. However in some occasions the reason is a natural disaster. In this case it is interesting to notice that, while the proportion of rural population and physician in the population continue having the same sign and importance in the explanation of malaria cases in asylum countries, the number of refugees from civil war is not significantly different from 0. However if we constrain the sample to the asylum tropical countries, table 4B, the total number of

Table3A: Regression results: Refugees from tropical countries (all asylum countries)

Dependent variable: malaria incidence						
Model	1	2	3	4	5	6
REF	-0.042	-0.045	-0.045	-0.071	-0.076	-0.078
	(-0.97)	(-0.57)	(-1.04)	(-1.53)	(-1.63)	(-1.63)
REF1	1.176	2.354	1.147	1.146	1.159	1.146
	(8.03)	(9.48)	(7.82)	(7.34)	(7.41)	(7.15)
RURAL	-87.56	-83.26	-127.06	-128.12	-130.67	-145.64
		(-2.87)	(-7.88)	(-7.35)	(-7.47)	(-7.77)
PHYS		-168.19				
		(-2.25)				
IPHYS			-241.25	-297.26	297.15	-299.93
			(-4.68)	(-5.12)	(-5.12)	(-4.94)
IRRIG				0.038	0.039	0.037
				(4.09)	(4.17)	(3.86)
DR					Yes	Yes
CW					Yes	Yes
MCID						Yes*
R-sq	0.1060	0.1646	0.0808	0.1485	0.1533	0.1584
N	3214	789	3194	2863	2863	2722

The explanatory variables include time dummies.
Numbers in parentheses are t-statistics
*significant

Table 3B: Regression results: Refugees from tropical countries (only asylum tropical countries)

Dependent variable: malaria incidence						
Model	1	2	3	4	5	6
REF	-0.071	-0.052	-0.069	-0.067	-0.058	-0.060
	(-0.29)	(-0.16)	(-0.28)	(-0.26)	(-0.22)	(-0.22)
REF1	1.334	2.372	1.303	1.317	1.312	1.299
	(4.57)	(5.82)	(4.46)	(4.20)	(4.18)	(4.06)
RURAL	-117.80	-101.31	-149.17	-153.65	-155.85	-168.00
	(-6.87)	(-2.88)	(-7.53)	(-7.06)	(-7.13)	(-7.26)
PHYS		-115.20				
		(-1.17)				
IPHYS			-223.11	-236.32	-234.11	-249.94
			(-3.15)	(-2.91)	(-2.89)	(-2.97)
IRRIG				0.004	-0.003	-0.008
				(0.07)	(-0.06)	(-0.14)
DR					Yes	Yes
CW					Yes	Yes
MCID						Yes
R-sq	0.1109	0.2139	0.1353	0.1406	0.1427	0.1412
N	2295	539	2275	1991	1991	1919

The explanatory variables include time dummies.
Numbers in parentheses are t-statistics

Table 4A: Regression results: Refugees from civil war (all asylum countries)

Dependent variable: malaria incidence						
Model	1	2	3	4	5	6
REF	-0.212	-0.151	-0.229	-0.255	-0.255	-0.264
	(-1.05)	(-0.56)	(-1.14)	(-1.20)	(-1.19)	(-1.21)
REF2	0.279	0.368	0.290	0.287	0.283	0.289
	(1.37)	(1.31)	(1.43)	(1.34)	(1.32)	(1.32)
RURAL	-101.03	-113.65	-143.12	-144.36	-146.43	-162.52
	(-7.32)	(-3.70)	(-8.86)	(-8.27)	(-8.35)	(-8.66)
PHYS		-202.92				
		(-2.56)				
IPHYS			-259.07	-318.23	-318.51	-322.10
			(-4.98)	(-5.44)	(-5.44)	(-5.26)
IRRIG				0.039	0.040	0.038
				(4.18)	(4.25)	(3.92)
DR					Yes	Yes
CW					Yes	Yes
MCID						Yes*
R-sq	0.0581	0.0352	0.0493	0.1147	0.1193	0.1235
N	3214	789	3194	2863	2863	2722

The explanatory variables include time dummies.
Numbers in parentheses are t-statistics
*significant

Table 4B: : Regression results: Refugees from civil war (only asylum tropical countries)

Dependent variable: malaria incidence						
Model	1	2	3	4	5	6
REF	0.182	0.192	0.158	0.157	0.156	0.150
	(0.82)	(0.72)	(0.71)	(0.66)	(0.65)	(0.61)
REF2	0.938	2.283	0.940	0.954	0.960	0.955
	(3.89)	(6.68)	(3.90)	(3.68)	(3.71)	(3.62)
RURAL	-120.74	-102.83	-153.54	-158.30	-160.46	-172.55
	(-7.04)	(-2.96)	(-7.77)	(-7.28)	(-7.35)	(-7.47)
PHYS		-150.17				
		(-1.55)				
IPHYS			-234.48	-250.12	-247.84	-266.23
			(-3.31)	(-3.08)	(-3.05)	(-3.17)
IRRIG				0.004	-0.003	-0.008
				(0.08)	(-0.07)	(-0.16)
DR					Yes	Yes
CW					Yes	Yes
MCID						Yes
R-sq	0.1093	0.2402	0.1362	0.1407	0.1420	0.1396
N	2294	539	2275	1991	1991	1919

The explanatory variables include time dummies.
Numbers in parentheses are t-statistics

refugees from civil wars has a positive and significant effect as it happen originally with the separation between total refugees in the sample of tropical destination countries.

Finally in table 5A we use total refugees and refugees coming from a tropical country that suffers a civil war (REF3). In this case the coefficients of the proportion of rural population and physicians as well as the one on irrigated land have the right sign and they are significantly different from 0. However in this case the coefficient β_2 is positive and significantly different from 0. For each 1,000 refugees coming from tropical countries with civil war there are 1,378 new cases of malaria in the asylum countries. This is the highest estimate of all the different grouping of refugees up to this point. This result is consistent with the interpretation considered above: people that flee from countries with a civil war are forced to walk without much protection through forest and damps where there is the highest probability of getting infected, conditional on ecological conditions. In table 5B we consider only the sample of tropical asylum countries and we find out that the size of this coefficient is only slightly higher than the one in table 5A. For each 1,000 refugees coming from tropical countries with civil war there are 1,406 new cases of malaria in the asylum tropical countries.

As an initial check for the robustness of the estimations tables 6A and 6B present the results of the specification used in table 5A and 5B but using the linear fixed effect panel data estimator on the variables in per capita terms[38]. In table 6A we use total refugees and the refugees coming from a tropical country that suffers a civil war (REF3), and in table 6B we consider only the sample of tropical asylum countries. The results corroborate the significant effect of refugees coming from tropical countries with civil war on the incidence of malaria in the asylum countries.

[38] As before grouped logit estimation leads to results that are qualitatively very similar.

Table5A: Regression results: Refugees from civil war of tropical countries
(all asylum countries)

Dependent variable: malaria incidence						
Model	1	2	3	4	5	6
REF	-0.034	-0.015	-0.038	-0.063	-0.068	-0.070
	(-0.80)	(-0.21)	(-0.88)	(-1.38)	(-1.48)	(-1.49)
REF3	1.408	2.997	1.378	1.382	1.391	1.378
	(9.33)	(11.52)	(9.12)	(8.59)	(8.64)	(8.35)
RURAL	-86.46	-74.31	-125.44	-126.41	-128.91	-143.69
	(-6.31)	(-2.63)	(-7.81)	(-7.28)	(-7.40)	(-7.70)
PHYS		-144.59				
		(-1.99)				
IPHYS			-238.24	-293.46	-293.60	-296.14
			(-4.64)	(-5.08)	(-5.08)	(-4.90)
IRRIG				0.038	0.039	0.037
				(4.04)	(4.14)	(3.83)
DR					Yes	Yes
CW					Yes	Yes
MCID						Yes*
R-sq	0.1234	0.2036	0.0916	0.1587	0.1634	0.1691
N	3214	789	3194	2863	2863	2722

The explanatory variables include time dummies.
Numbers in parentheses are t-statistics
*significant

Table 5B: Regression results: Refugees from civil war of tropical countries
(only asylum tropical countries)

Dependent variable: malaria incidence						
Model	1	2	3	4	5	6
REF	0.113	0.182	0.104	0.106	0.105	0.101
	(0.63)	(0.77)	(0.58)	(0.55)	(0.55)	(0.51)
REF3	1.408	2.888	1.387	1.410	1.417	1.406
	(6.29)	(8.59)	(6.18)	(5.84)	(5.86)	(5.71)
RURAL	-116.12	-90.30	-147.08	-151.26	-153.32	-165.12
	(-6.80)	(-2.66)	(-7.46)	(-6.98)	(-7.04)	(-7.17)
PHYS		-99.92				
		(-1.06)				
IPHYS			-220.32	-234.43	-232.15	-248.22
			(-3.12)	(-2.90)	(-2.87)	(-2.97)
IRRIG				0.006	-0.002	-0.007
				(0.11)	(-0.04)	(-0.13)
DR					Yes	Yes
CW					Yes	Yes
MCID						Yes
R-sq	0.1330	0.2768	0.1544	0.1578	0.1594	0.1584
N	2295	539	2275	1991	1991	1919

The explanatory variables include time dummies.
Numbers in parentheses are t-statistics

Table 6A: Regression results: Refugees from civil war of tropical countries
(all asylum countries). Per capita fixed effects and glogit

Dependent variable: malaria incidence per capita						
Model	1	2	3	4	5	6
CapREF	-0.0189	-0.0027	-0.036	-0.037	-0.0383	-0.031
	(-0.47)	(-0.04)	(-0.89)	(-0.70)	(-0.71)	(-0.58)
CapREF3	0.2300	0.9788	0.2196	0.239	0.2379	0.2267
	(2.75)	(5.61)	(2.63)	(2.75)	(2.73)	(2.66)
RURAL	0.0008	0.0004	0.0006	0.0005	0.0005	0.0005
	(4.38)	(1.43)	(3.46)	(3.10)	(3.11)	(3.06)
PHYS		-0.014				
		(-2.26)				
IPHYS			-0.0265	-0.0258	-0.026	-0.026
			(-6.04)	(-5.71)	(-5.74)	(-5.87)
CapIRRIG				0.0498	0.0453	0.1314
				(0.65)	(0.59)	(1.75)
DR					Yes	Yes
CW					Yes	Yes
MCID						0.0017
						(0.47)
Year	Yes	Yes	Yes	Yes	Yes	Yes
Country						
R-squared	0.1155	0.1236	0.1206	0.1110	0.1161	0.1002
N	3214	789	3194	2863	2863	2722

Numbers in parentheses are t-statistics. *significant

Table 6B: Regression results: Refugees from civil war of tropical countries
(only asylum tropical countries). Per capita fixed effects

Dependent variable: malaria incidence per capita						
Model	1	2	3	4	5	6
CapREF	-0.0147	0.0137	-0.037	-0.0436	-0.044	-0.044
	(-0.31)	(0.16)	(-0.77)	(-0.66)	(-0.67)	(-0.65)
CapREF3	0.2049	0.941	0.1979	0.2261	0.2241	0.223
	(2.15)	(4.48)	(2.08)	(2.24)	(2.22)	(2.16)
RURAL	0.001	0.000	0.0006	0.0005	0.0005	0.0005
	(3.76)	(0.96)	(2.86))	(2.45)	(2.48)	(2.11)
PHYS		-0.022				
		(-2.24)				
IPHYS			-0.039	-0.037	-0.0377	-0.0383
			(-6.42)	(-6.07)	(-6.09)	(-5.94)
CapIRRIG				0.214	0.1958	0.199
				(1.64)	(1.48)	(1.47)
DR					Yes	Yes
CW					Yes	Yes
MCID						0.00013
						(0.03)
Year	Yes	Yes	Yes	Yes	Yes	Yes
Country						
R-squared	0.1331	0.1681	0.1558	0.1313	0.1416	0.1411
N	2295	539	2275	1991	1991	1919

Numbers in parentheses are t-statistics

6 Checking the robustness of the results

The results of the estimations show that the size of the impact of refugees from civil wars on the incidence of malaria in the asylum country depends on the tropical nature of the origin and the asylum country. However, as we argued before, there are problems of irregular and inaccurate reporting on the incidence of malaria in African countries. The problem of irregular reporting is not important because the estimation of incomplete panel data does not present any particular econometric problem. For the available data if the measurement error corresponds to an underestimation[39] of the cases of malaria, it is reasonable to assume that the reporting practices of that particular country are stable over time. The most important difference with respect to reporting cases of malaria between African countries and the rest is the fact that in Africa cases are counted as clinically diagnosed[40] while in other countries they consider confirmed cases (through blood analysis) except for China where not all cases are confirmed by laboratory. Therefore the reporting procedure varies very much over countries, which makes it difficult to estimate the total incidence of malaria worldwide, but we believe that it does not change over time within a country.

It would be a little more problematic if we believe that the intensity of counting cases of malaria in each country is not stable over time. However, if that was the case the proportion of physicians per inhabitant would control for it because the clinically diagnosed cases should be recognized by an specialist. From our estimation it seems that the prevention effect of physicians is larger than the increase in the intensity of counting, if there is any such effect.

Nevertheless, in order to perform some robustness check in this section we compare the results with and without the countries where there may be data problems

[39] Reported cases are believed to represent around 10% of actual cases.

[40] Except for the North African countries, Cape Verde, Mauritius, Reunion, Somalia and South Africa that report laboratory confimed cases.

due to inaccurate reporting. Table 7 presents the basic regression where we already distinguish between refugees coming from a tropical country in war and other refugees coming from a war following the suggestion of the previous section. In column (1) we show that only the refugees coming from a war in a tropical country have effect on the incidence of malaria in the asylum country. The rest of the control variables have the same sign and magnitude as in previous regressions. When we run the regression only for the asylum countries that are tropical the results are basically the same but the coefficient on the number of refugees coming from a war in a tropical countries increases around 15%. Finally column (3) contains the same regression excluding the African countries, China and India. The results show that the only statistically significant coefficient in this case are the ones on refugees coming from wars in tropical countries. As we were expecting the size of the coefficient is much smaller than in the case of tropical countries or all countries including Africa. The fact that there is also a civil war in the asylum country has also a positive and significant effect on the incidence of malaria which is consistent with the practice of concentrating in camps refugees from all countries, including the asylum one.

7 Conclusions

The burden of malaria transmission in the world, specially in underdeveloped countries, is very large in terms of diagnosed cases and deaths. It is estimated that it affects three hundred million people and kills 1.1 million people every year. Many researchers have found that malaria has a very negative effect on development through it effects on productivity (repeated workers absences on the workplace, reduction of geographical job flexibility, etc.). But it is also the case that economic underdevelopment increases malaria incidence. If we do not include GDP per capita or poverty as explanatory variables for malaria incidence, in order to avoid a large endogeneity bias,

Table 7: Analysis of Robustness.

	Dependent variable: Incidence of Malaria		
Model	All countries	Only tropical countries	Without Africa, China, India
REF	0.111	0.218	0.262
	(0.50)	(0.89)	(0.50)
REF3	1.414	1.623	0.340
	(8.29)	(4.48)	(4.03)
REF2	-0.189	-0.314	-0.055
	(-0.84)	(-0.81)	(-1.05)
RURAL	-143.01	-164.51	6.23
	(-7.66)	(-7.14)	(-1.65)
IPHYS	-294.96	-245.28	9.38
	(-4.87)	(-2.93)	(1.02)
IRRIG	0.037	-0.006	0.025
	(3.83)	(-0.12)	(5.85)
DR	Yes	Yes	Yes
CW	Yes	Yes	Yes*
MCID	Yes*	Yes	Yes
R-sq	0.1694	0.1588	0.1724
N	2722	1919	1643

Numbers in parentheses are t-statistics
*significant

then geography is destiny. However there are also social conditions that can favor the spread of malaria and difficult the control tasks. Therefore there are technical factors and social conditions, specially the ones that generate mass migration, which explain the incidence of malaria. Moreover technical factors are affected by social conditions. In fact we could talk about two alternative views of malaria: for some researchers malaria is basically a social disease with socioeconomic causes while for some others malaria is primarily a clinical problem that requires medical research. As the search for a vaccine can last for a long time and the effectiveness of other control measures depend on social conditions it is reasonable to think about policies that may prevent the basic cause of mass migration: civil wars and social conflicts.

We have shown that the size of the refugee population coming from tropical countries with a civil wars have an important contribution to the number of cases of malaria in the asylum countries. Therefore the prevention of civil wars, specially in tropical countries, and the control of its causes is very important for the evolution of the control of malaria. An eventual vaccine, that may still take sometime to become available, will not mean the end of malaria if civil conflicts make impossible its general administration. In the mean time, any effort to reduce the spread of civil wars can help to control, at least partially, the extension of malaria transmission.

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