SOCIO-DEMOGRAPHIC CHARACTERISTICS AND GEOGRAPHIC DISTRIBUTION OF REPORTED MALARIA CASES IN BANGKA DISTRICT, BABEL ISLAND PROVINCE, INDONESIA DURING 2008-2012

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Abstract. Malaria is a major health problem in many developing countries including Indonesia. The purpose of this study was to investigate the socio-demographic characteristics and geographic distribution of malaria cases in Bangka District, Bangka-Belitung Island Province, Indonesia. Bangka District is a malaria endemic area of Indonesia. We analyzed the epidemiological data of all reported malaria cases during 2008-2012 in Bangka District. Of the 4,756 malaria-confirmed cases reported during the study period, 3,234 (68. 0%) were among persons aged ≥15 years, 1,024 (21.5%) were among persons aged 5-14 years and 498 (10.5%) were among persons aged <5 years. Malaria cases were primarily located along the sea coast and less frequently in inland. Malaria cases were found not only among the local population but also among migrant workers. The monthly incidence of reported malaria cases in the study population ranged from 0.06 to 1.06 per 1,000 person-months. The cases were mostly due to *Plasmodium vivax* (57.1%) followed by *Plasmodium falciparum* (40.2%). *Plasmodium falciparum* was more common among migrant workers while *Plasmodium vivax* was more common among the local population (Odds ratio 1.2; p=0.03). The main transmission vector found in the coastal area was *Anopheles sundaicus*. *An. letifer* and *An. barbirostris* were found inland. We identified "malaria hot-spots" in the study area using a Geographic Information System. The results of this study will contribute to the malaria control program.

Keywords: malaria, transmission, hotspots, climate, migrant workers, GIS, Indonesia

INTRODUCTION

Malaria is an acute parasitic febrile disease caused by five species of the genus *Plasmodium*. There are an estimated 1.2 million annual deaths globally due to malaria (Murray *et al*, 2012). The United Nations Millennium Development Goals prioritize combating malaria among other diseases (Khanum and Singh, 2007; Ross, 2012).

In Indonesia, endemic malaria occurs in 75% of the total districts or cities, and about 45% of the total inhabitants are at

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risk of malaria infection in 2012 (Surya, 2013). Four species of malaria parasites infecting humans have been found in Indonesia: *Plasmodium falciparum, P. vivax, P. malariae,* and *P. ovale* (Elyzar *et al,* 2011). *P. falciparum* accounts for 53% of overall malaria infections, followed by *P. vivax,* while *P. malariae* and *P. ovale* infections are rare (WHO, 2011). At least 24 species of malaria vectors including *Anopheles balabacensis, Farauti* Complex, *An. koliensis, Punctulatus* Complex, *Maculatus* Group, and *Sundaicus* Complex (Sinka *et al,* 2011, 2012) have been found in Indonesia.

The disease burden and distribution of malaria in Indonesia is heterogenous; most malaria cases are found in eastern Indonesia (Elyzar *et al,* 2011). A malaria surveillance system and control program have been present in Indonesia for many years. Indonesia had a 53% decrease in reported confirmed malaria cases from 2005 to 2010 (437,323 cases to 229,819 cases) (MOH, 2013). The annual parasite incidence (API) of malaria in Indonesia declined from 5.0 per 1,000 person-years to 2.0 per 1,000 person-years from 2006 to 2012 (WHO SEARO, 2011; MOH, 2013).

We selected our study site in Bangka District, Bangka Belitung Island Province, because, despite a country wide malarial control program, malaria is still endemic in this district. The Indonesian Ministry of Health reported the API for malaria in the study area decreased from 9.3 (2008) to 1.7 (2012) per 1,000 person-years (MOH, 2013). The factors responsible for this declining trend have yet to be investigated from a public health perspective in order to design and implement a more effective malaria control program. Therefore, our current study aimed to investigate the socio-demographic characteristics and geographical distribution of malaria cases in Bangka District using all the reported malaria cases during 2008-2012. We utilized a Geographic Information System (GIS) to better understand the temporal and spatial transmission of malaria (Moore and Carpenter, 1999; Martinez-Piedra *et al*, 2004).

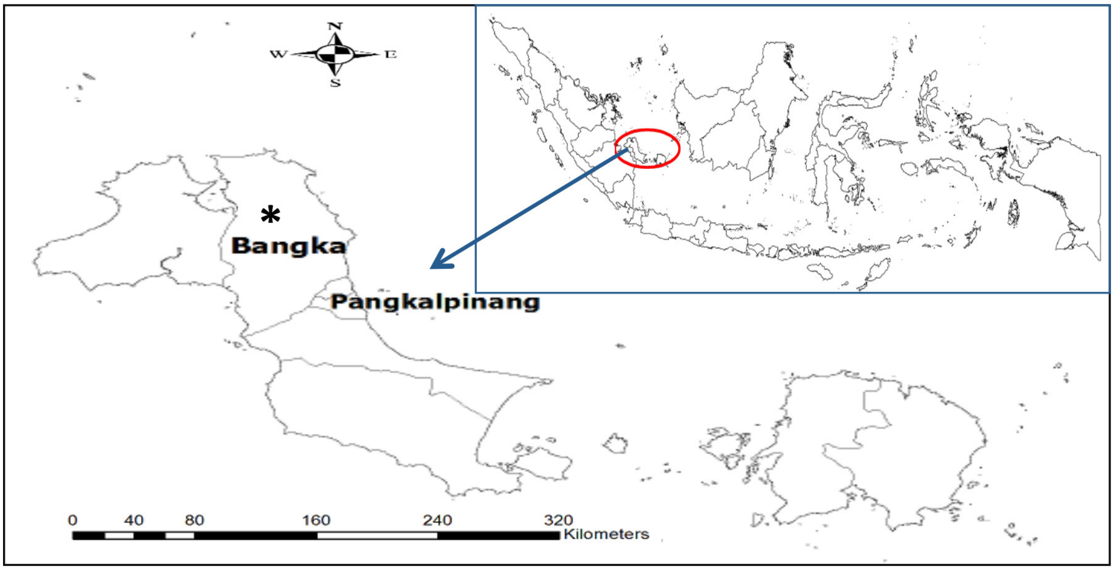
MATERIALS AND METHODS

Study site

Bangka Island is located in the eastern part of Sumatra Island (Fig 1). It has 7 districts. Bangka District consists of 8 sub-districts and 69 villages. According to a 2012 Indonesian national data, the population of the study district was projected as 297,092 (Statistics Indonesia, 2012). Sixty-nine point eight percent of the study district population is aged 15-64 years and 25.9% are aged 0-14 years. Tin mines, agriculture, and fisheries are the major occupations in the study district (Bureau of Statistics, Bangka Distric, 2012). There are large mangrove forests along the coastal region and river sides, and the people working in agriculture and the fisheries are living nearby (Bureau of Statististics, Bangka District, 2012).

Malaria and other data collection

Data about malaria among the inhabitants during 2008-2012 was collected from the records of the Bangka District Health Office reported by all the public health centers. Each public health center consists of 11 primary health centers, 37 assistant primary health centers and 69 public village midwife clinics. Malaria parasites (*P. falciparum, P. vivax* or mixed) were confirmed microscopically or by a malaria rapid diagnostic test (RDT). Malaria cases were categorized by patient resident status (inhabitant or migrant worker), this information was only available for 2011 and 2012. For breeding sites and types of *Anopheles* vectors, data was



Province border

* Bangka District

Fig 1–Bangka District, Bangka Island, Bangka Belitung (BABEL) Island Province, Indonesia.

obtained from a national entomologic survey in Indonesia, conducted every 2 years. Data about the projected population was provided by Bureau of Statistics for Bangka District and the Bangka District Health Office. It was assumed that all residents in Bangka District were at risk for malaria infection. The projected population was therefore used to calculate incidence rate per 1,000 person-years. In malaria surveillance, standardized monitoring indicators, such as annual parasite incidence (API) are widely used. API is a malariometric index to express the number of confirmed malaria cases per 1,000 population per year. Annual malaria incidence (AMI) is another malariometric index, which is calculated as the number of clinical malaria cases per 1,000 population per year. Annual blood examination rate (ABER), which is the number of slides examined per 100 population per year, slide positivity rate (SPR), which is the number of slide positive per 100 slides, and slide falciparum rate (SFR), which is the number of falciparum positive per 100 slides were also calculated.

Data analysis

The data were then entered into Microsoft Excel 2010 and analyzed using XLstat 2013 (Addinsoft, Paris, France). Descriptive analysis by mapping was used to investigate the spatial patterns of malaria incidence in Bangka District. Malaria, breeding sites and types *of Anopheles* vector data were also displayed on the map. Maps were drawn using Arc GIS Version 10.1 (ESRI, Redlands, CA).

RESULTS

Status of malaria surveillance indicators

Over the five year study period, the mean AMI was estimated to be 51.7 per 1,000 population. The highest AMI was recorded for 2012 with 69.6 cases per 1,000

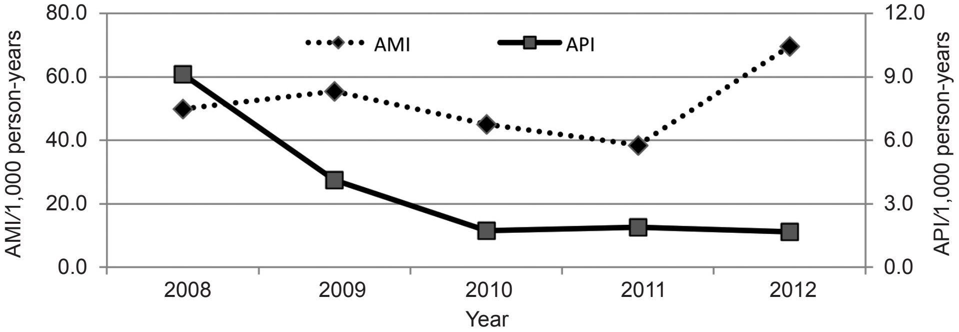


Fig 2–Annual malaria incidence (AMI) and annual parasite incidence (API) in Bangka District, BABEL Island Province, Indonesia, 2008-2012.

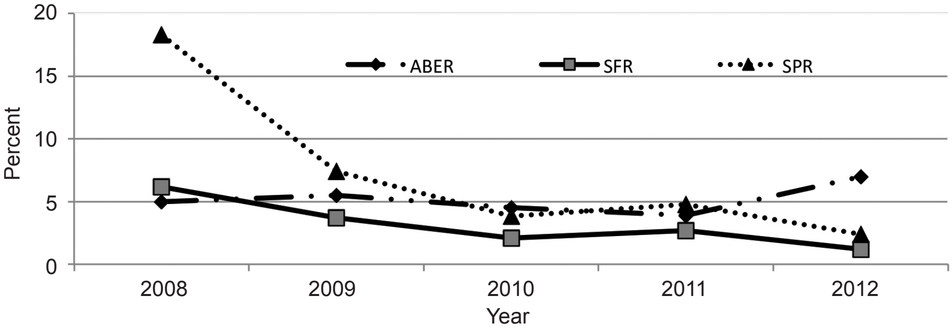


Fig 3–Annual blood examined rate (ABER), slide falciparum rate (SFR), and slide positivity rate (SPR) in Bangka District, BABEL Island Province, Indonesia, 2008-2012.

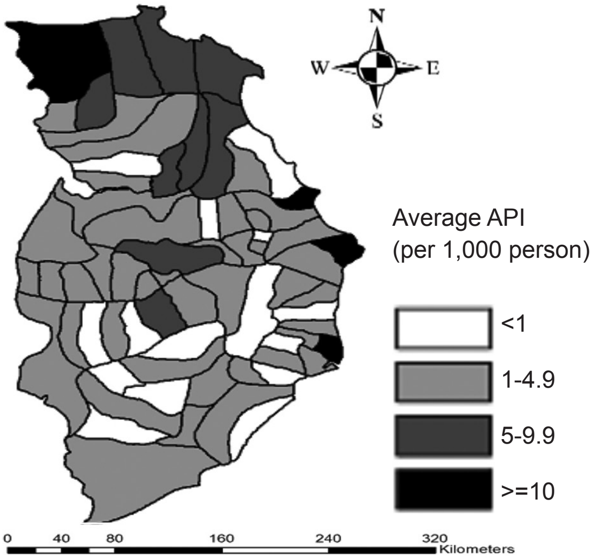


Fig 4–Geographic distribution of mean annual parasite incidence (API) during 2008-2012 among villages in Bangka District, BABEL Island Province, Indonesia.

population, while the lowest API was during the same year with 1.7 per 1,000 (Fig 2). The ABER remained stable at 5% through most of the study period but increased to 7% in 2012. The SFR and SPR both declined from 2008 to 2012. The results imply the smear confirmation of malaria did not change much during the study period and the malaria incidence gradually declined in the district (Fig 3). The geographic distribution of the mean API shows the villages in the coastal areas had high malaria incidence rates (Fig 4).

Of the 4,756 malaria-confirmed cases reported during

Table 1
Demographic characteristics of total malaria cases among inhabitants in Bangka District, BABEL Island Province, Indonesia (N=4,756).

Variable	Categories	No. of cases (%)	*p*-value
Sex	Male	3,041 (63.9)	<0.001
	Female	1,715 (36.1)	
Age	<5 years	498 (10.5)	<0.001
	5-14 years	1,024 (21.5)	
	≥15 years	3,234 (68.0)	

Table 2
Distribution of malaria cases by types of *Plasmodium* among inhabitants, 2008-2012, in Bangka District, BABEL Island Province, Indonesia.

Malaria type	No. of cases (%)					Total
	2008	2009	2010	2011	2012	
P. falciparum	723 (32.1)	487 (48.4)	222 (49.4)	274 (49.6)	208 (42.0)	1,914 (40.2)
P. vivax	1,495 (66.4)	503 (50.0)	207 (46.1)	251 (45.5)	257 (51.9)	2,713 (57.1)
Mixed	35 (1.5)	17 (1.6)	20 (4.5)	27 (4.9)	30 (6.1)	129 (2.7)
Total	2,253 (100)	1,007 (100)	449 (100)	552 (100)	495 (100)	4,756 (100)

the study period, 3,234 (68. 0%) occurred among patients aged ≥15 years, 1,024 (21.5%) occurred among those aged 5-14 years and 498 (10.5%) occurred among those aged <5 years. Males were infected more commonly than females (63.9% *vs* 36.1%, p<0.001) (Table 1). The distrubution of *Plasmodium* infections among confirmed cases are shown in Table 2. The incidence of *P. vivax* was greater than *P. falciparum* (57.1 *vs* 40.2%); 2.7% had mixed malaria infections.

Mapping of malaria cases by *Plasmodium* species and resident status.

We mapped the distribution of malaria cases by resident status among inhabitants and migrant workers during 2011-2012 (Fig 5). Malaria among migrant workers increased during May and October, 2011, and during April and May, 2012. Malaria among inhabitants increased during June, 2011, and January and June, 2012. The geographical distribution of cases of the different types of *Plasmodium* species was varied by the two groups. *P. falciparum* and *P. vivax* were detected in Bangka District (Fig 6). More cases were found in coastal areas. *P. falciparum* was found more commonly among migrant workers and *P. vivax* was found more commonly among inhabitants (Odds ratio 1.2; p=0.03).

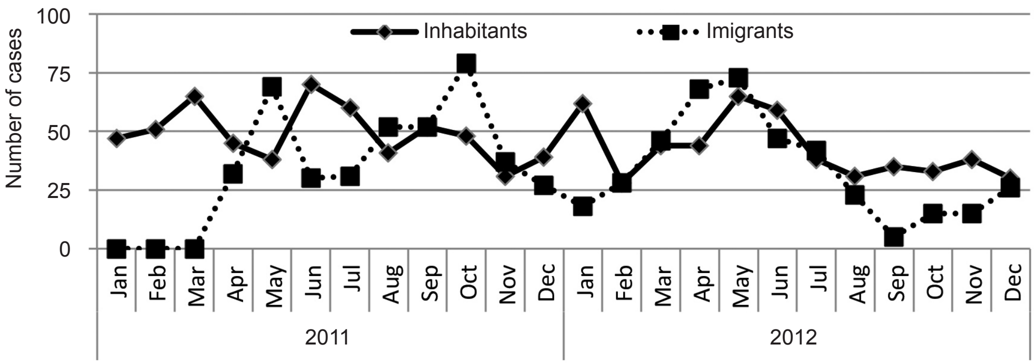


Fig 5–Number of malaria cases by resident status, in Bangka District, BABEL Island Province, Indonesia, 2011-2012.

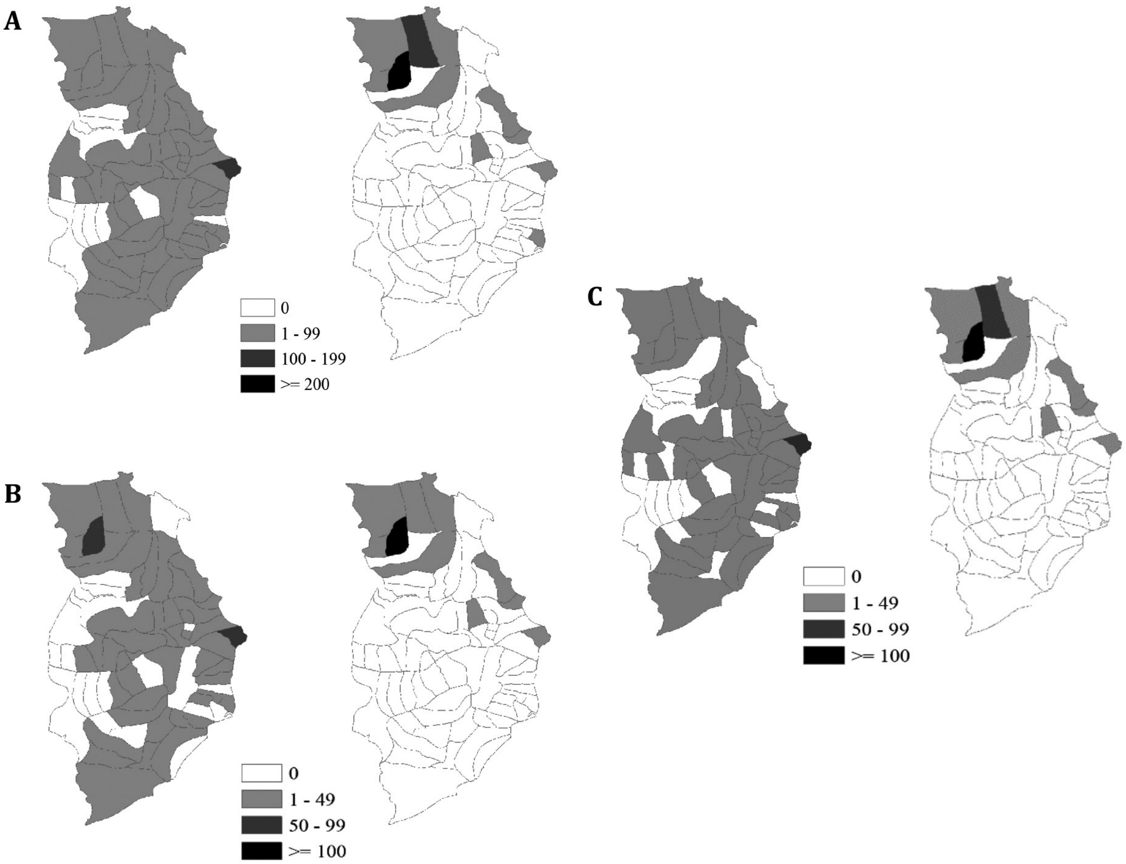


Fig 6–Geographic distribution of cumulative malaria cases from 2011 to 2012 by villages, resident status and types of *Plasmodium* in Bangka District, BABEL Island Province, Indonesia. (A) Overall cases, (B) *P. vivax* cases, and (C) *P. falciparum* cases. Left map is for inhabitant cases and right map for migrant cases.

Table 3
Type of *Plasmodium* species by resident status, in Bangka District, BABEL Island Province, Indonesia, 2011-2012.

Type of *Plasmodium*	Inhabitant	Migrant workers	OR	*p*-value
P. falciparum	482 (46.0%)	407 (50.1%)	Ref	
P. vivax	508 (48.5%)	348 (42.9%)	1.2	0.03
Mixed	57 (5.5%)	57 (7.0%)	NA	NA
Total	1,047 (100%)	812 (100%)		

Breeding site and type of *Anopheles* in Bangka District

During a national entomology survey of Indonesia, 12 *Anopheles* mosquito species were detected in Bangka District. The vector distribution in Bangka District depended on the geographical environments and types of breeding places. The main transmission vector in the coastal area was *Anopheles sundaicus* and in inland were *An. letifer* and *An. barbirostris* (Fig 7).

DISCUSSION

In the current study, we analyzed the malaria cases reported through malaria surveillance in Bangka District, Indonesia between January 2008 and December 2012. The API was 1.7%, which is just above the WHO threshold, and the annual SPR was 2.4% in 2012. According to WHO guideline, a SPR less than 5% indicates the area has shifted from a control to an elimination phase (WHO, 2007b; Hay *et al*, 2008, Nájera *et al*, 2011). In our study, the average ABER did not reach the standard of ≤10% set by the WHO (Malaria Foundation International, 2000; Nájera *et al*, 2011). However, other parameters estimated in this study indicate Bangka District may be on it way toward malaria elimination. A previous study (Hay *et al*, 2008) and our study results indicate the current ABER target indicators set up by WHO may need to be reevaluated to validate the effectiveness of a malarial control program. The API declined during our 5-year study. This may be due to implementation of a malaria control program in Indonesia since 2008. The program expanded laboratory testing and enhanced control activities at health facilities, such as procuring long lasting insecticide nets (LLINs) and conducting vector control programs. Malaria transmission is still occurring in the study area. There are two possible reasons for the continuing malaria transmission. First, man-made environmental changes increase the number of mosquito breeding sites, fascilitating malaria transmission (Lazaryan, 2008). Most of the old mines are located along the coastal area in Bangka District; at the mines there are multiple water pits that are potential breeding places for *An. sundaicus.* This is similar to a malaria endemic location on the coast of the Thousand Island District, near to Jakarta, Indonesia (Macquire *et al*, 2005). Second, the ecosystem is well suited to the survival of *An. sundaicus* and other malaria vectors in Bangka District with many breeding sites for this type of *Anopheles* species, and the climate is optimal for vector breeding throughout the year.

In our study, all age groups and both genders of inhabitants were found to be infected with malaria. However, the proportion of malaria cases was low in children < 5 years old and high in adult

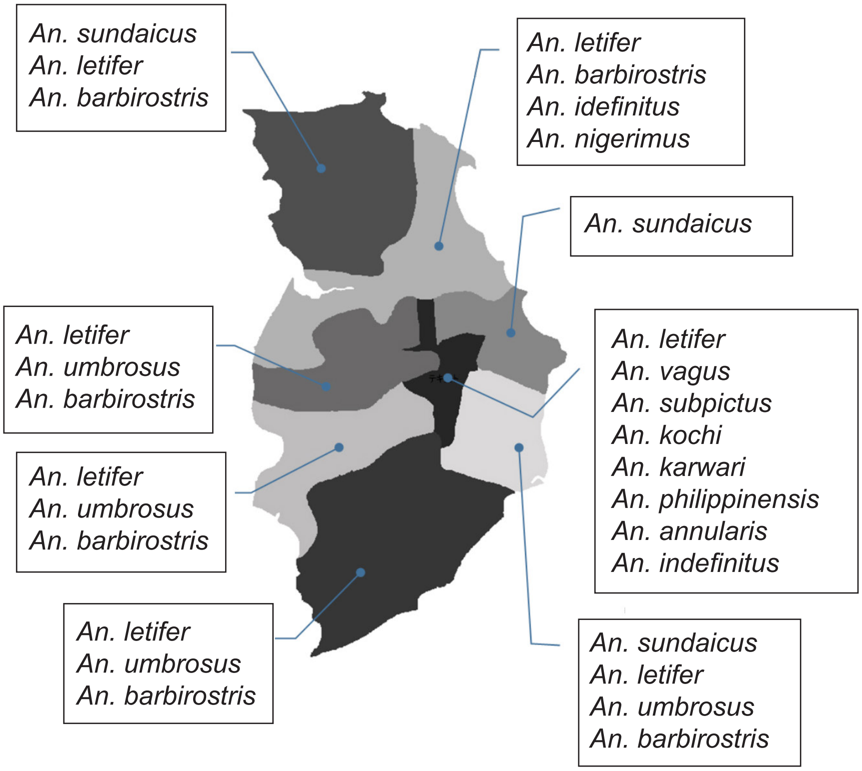


Fig 7–Map of *Anopheles* species detected at the sub-district level in Bangka District, BABEL Islands Province, Indonesia, 2011-2012.

males. There is no clear explanation for these differences. It could be because younger children rarely go outdoors during night time and are more likely to be protected by LLIN (Bekele *et al*, 2013, Mboumba *et al*, 2013). The finding of more male than female cases could be due to greater occupational risk of being exposed by men as they work in mines, fields or forests at peak hours of mosquito biting, or go to endemic locations seeking work (WHO, 2007a). Labor, leisure and sleeping arrangements also vary by gender which could lead to different exposure to mosquitoes among men than women (WHO, 2007b). A study conducted in Kano State, Nigeria found females used bed nets more commonly than males (Garley *et al*, 2013). Age and gender may affect malaria epidemiology rather than the biological variations of the host.

A higher incidence of malaria was observed among migrant workers during the last two years of the study. In Indonesia, migrant workers are more likely to work in old mines and live in mining camps in poor sanitary conditions with limited access to health care services. Such conditions may increase the risk of contracting malaria in this population. Migrant workers may also act as vehicles to spread malaria in their homes and neighborhoods (WHO, 2010; Malaria Consortium, 2012). Some may come from malaria non-endemic areas, such as Java Island. Migrants need to be covered by the malaria control program to prevent possible spread of malaria to non-endemic areas; this has been observed in other parts of the world (Konchom *et al,* 2003; Tipmontree *et al,* 2009; Wangroongsarb *et al,* 2011; Tris *et al,* 2012; Wangroongsarb *et al,* 2012).

The incidence of malaria was greater in coastal areas than inland in our study, similar to other studies from Indonesia (Macquire *et al,* 2005; Sudarnika *et al,* 2010). Bangka District has large mangrove forests along the coast and along rivers. *An. sundaicus* which pays a major role in malaria transmission usually breeds in sunlit lagoons, swamps, brackish water and marshes (Dachlan *et al,* 2005; Travellers, 2012). A study done in monsoon areas of Asia found *An. sundaicus* can survive throughout the year, but the peak density is at the beginning of the rainy season due to a low level of salinity in the water used for reproduction by the lervae (Ohta and Kaga, 2012). Our study found a large number of residents live near breeding sites in the coastal area since there are more job opportunities in those areas, such as in agriculture, mining, and road development. Living in the coastal area is a risk factor for contracting malaria in our study. A study done in monsoon areas of Asia found malaria transmission is increasing because of the rapid increase in humans in Anopheles larval habitats (Ohta and Kaga, 2012). Movements of migrant workers working in the mines in the coastal area, spending more time outdoors and the abundance of man-made water pits in abounded mines are risk factors associated with malaria hotspots in our study.

We mapped the geographic distribution of *P. falciparum* and *P. vivax* infections in Bangka District among inhabitants and migrant workers. Several epidemiological studies have found differences in the biological characteristics of *P. vivax* from other species affecting *P. vivax* transmission showing current methods used for preventing and treating infections due to *P. vivax* are inadequate (Galinski and Barnwell, 2008; Carlton *et al,* 2011). Current anti-malaria campaigns focus more on *P. falciparum* than *P. vivax,* which may recall in an increase in *P. vivax* cases (Mendis *et al,* 2001; Mueller *et al,* 2009).

We utilized a GIS to help better understand the geographic distribution, transmission patterns and hotspots for malaria (Moore and Carpenter, 1999). This method has been proven to be a powerful tool for examining spatial patterns and diffusion processes (Martinez-Piedra *et al,* 2004). The GIS is useful for disease monitoring and surveillance (Oppong, 1999). A number of malaria studies using the GIS have been published from different parts of the world (Martin *et al,* 2002; Srivastava *et al,* 2009; Shirayama *et al,* 2009; Fobil *et al,* 2012; Hanafi-Bojd *et al,* 2012; Zhang *et al,* 2012). Malaria hotspots are locations where malaria transmission can persist. Malaria transmission hotspots may play a catalyzing role in stable malaria transmission (Bousema *et al,* 2012). Understanding the spatial distribution of malaria along with identifying geographic risk factors and the population-at-risk are important steps in controlling malaria. The data presented in this paper can help the understanding of malaria in Bangka District from a micro-geographic perspective. The data identify malaria hot-spots in the study area. This can better guide resource allocation toward malaria hotspots and vulnerable groups for health policies and malaria control programs.

In conclusion, the malaria incidence in Bangka District declined during the study period, possibly due to the malaria control program. Malaria risk and transmission are not equally distributed within the population and by area in Bangka District. We identified malaria hotspots for better malaria control. Further studies are needed to evaluate surveillance indicators to identify the variables that contribute to malaria transmission in Bangka District. Migrant workers are an important at risk population and need to be included in malaria prevention strategies.

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