**Plasmodium vivax and Plasmodium falciparum are Common Malaria Species in Pakistan**

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**Abstract**— The microbes have a diverse nature, it makes human laugh and cry. Some microbes are fruitful for humans while others are harmful. Infectious diseases are a key problem in the modern world. In the last few decades, millions of peoples have died from different diseases, including bacterial, viral, fungal, parasitic, etc. Among these diseases, malaria is one of the major health problems for developing countries including Pakistan. This study was undertaken to provide baseline information about the prevalence of malaria, species distribution and to contribute to the data regarding epidemiology in Pakistan. For a collection of literature, the electronic search engine was used, using different key words i.e. prevalence, species distribution, epidemiology of malaria in Pakistan, etc. The time frame of the obtained articles was from 2000 to 2014. The two species of malaria *Plasmodium vivax* and *Plasmodium falciparum* are common in Pakistan.

**Keywords**: Microbes, Disease, Malaria, Plasmodium vivax, Plasmodium falciparum.

**BACKGROUND**

The microbes have a diverse nature, it makes human laugh and cry. The efforts of human beings were continued with the day after interaction with microbes to control and eradicate the microbes which cause diseases. Some microbes are fruitful for humans others are harmful. Infectious diseases are a key problem for the modern world. The scientist has reached to the moon, and research is still in progress. But still in this modern area, infectious diseases were stolen peace of the world. In the last few decades, millions of peoples are died from different diseases, including bacterial, viral, fungal, parasitic, etc. As compare to developed countries, the ratio of the disease was found high in the undeveloped countries. In tropical countries include Pakistan, the malaria is still a problem. Millions of peoples infected and died from malaria every year. Four main species of Plasmodium which are responsible for causing the malaria disease include *Plasmodium falciparum* (P. falciparum), *Plasmodium malariae* (P. malariae), *Plasmodium ovale* (P. ovale) and *Plasmodium vivax* (P. vivax) (Anwar et al., 1994; Ahmad et al., 2013). This study was undertaken to provide baseline information about the prevalence of malaria, species distribution and to contribute to the data regarding of epidemiology malaria in Pakistan.

**SEARCHING METHOD FOR LITERATURE**

The electronic search engine was used for literature downloading. The main key words used for literature search were the prevalence of malaria in Pakistan, the prevalence of malaria in Khyber Pakhtunkhwa, frequency distribution of malaria, species wise distribution of malaria in Pakistan, etc. The time frame of the obtained articles was from 2000 to 2014.
LITERATURE REVIEW OF MALARIA IN PAKISTAN

In Pakistan, the accurate information about incidence and prevalence of malaria are very necessary to implement an effective malaria control program. It was clear from the available literature that epidemiological data from a different region of the country is insufficient (Khadim, 2002). This study will contribute to the epidemiology of malaria in Pakistan. Hussain et al. (Hussain et al., 2014) conducted an epidemiological study in a local population of Lal Qilla Dir (Lower) and reported 29% positive cases of malaria (97% P. vivax and 3% P. falciparum). No cases of P. malariae, P. ovale and mixed infection (P. vivax and P. falciparum) were recorded. According to Daud et al. (Daud et al., 2014), 83.33% of total suspected cases of malaria were found positive in the general population of Mithakhel District Karak. Yasinzai and Kakarsulemankhel (Yasinzai and Kakarsulemankhel, 2013) notified 38.3% malaria positivity rate at district Panjgur in south-western Pakistan. The ratio of P. vivax was found very high as compared to P. falciparum 79.6% and 20.3% respectively. Khan et al. (Khan et al., 2013a) carried out a study in a general population of Bannu District reported that 27.1% cases were found positive for malaria infection. Species wise analysis shows that high infection rate was observed with P. vivax 22.6%, while the P. falciparum was observed in 3.04% population and mixed infection was recorded in 1.46% cases. No cases of P. malariae and P. ovale were investigated.

Table 1. Prevalence of malaria infection in different locations of Pakistan (2000-2014)

| S. No. | Study area                                                   | Prevalence | P. vivax | P. falciparum | Mixed species | References                                      |
|--------|-------------------------------------------------------------|------------|----------|---------------|---------------|-------------------------------------------------|
| 1      | Lal Qilla, District Dir (Lower)                             | 29         | 97       | 3             | -             | Hussain et al., 2014                             |
| 2      | Mithakhel District Karak                                    | 83.33      | -        | -             | -             | Daud et al., 2014                                |
| 3      | District Panjgur                                            | 38.3       | 79.6     | 20.3          | -             | Yasinzai and Kakarsulemankhel, 2013              |
| 4      | Pakistan                                                    | '801       | 76       | 18            | 6             | Khattak et al., 2013                             |
| 5      | Bannu District                                               | 27.1       | 22.6     | 3.04          | 1.46          | Khan et al., 2013a                               |
| 6      | Lal Qilla, District Dir (Lower)                             | 17.32      | 99.47    | 0.53          | -             | Ahmad et al., 2013                               |
| 7      | Khyber Pakhtunkhwa                                          | 1.95       | 0.48     | 1.46          | -             | Khan et al., 2013b                               |
| 8      | Urban and Rural areas of Bannu district                     | 17.35      | 91.53    | 7.47          | -             | Khan et al., 2013c                               |
| 9      | Quetta                                                       | 18.45      | 81.66    | 18.34         | -             | Tareen et al., 2012                              |
| 10     | Bannu District                                               | 3.61       | 3.61     | -             | -             | Awan et al., 2012                                |
| 11     | Children Hospital Chandka Medical College Larkana           | 36.5       | 41.09    | 58.9          | -             | Junejo et al., 2012                              |
| 12     | Shorkot Garrison                                            | 73.5       | 21.5     | 5             | -             | Asif, 2011                                       |
| 13     | Department of Medicine, LUMHS, Jamshoro/Hyderabad           | *200       | 46.5     | 52.5          | -             | Shaikh et al., 2011                              |
| 14     | Liaquat University Hospital Hyderabad, Sindh                 | 89         | 52       | 48            | -             | Uttra et al., 2010                               |
| 15     | District Malaria Control Centre Jacobabad                   | 0.91       | 71.48    | 28.52         | -             | Soomro et al., 2010a                             |
| 16     | Larkano District                                             | 1.68       | 47.15    | 52.85         | -             | Soomro et al., 2010b                             |
| 17     | Department of medicine at Liaquat University Hospital Hyderabad | 81         | 47       | 53            | -             | Devrajani et al., 2009                           |
| No. | Location                          | P. vivax (%) | P. falciparum (%) | Prevalence Rate |
|-----|-----------------------------------|--------------|-------------------|----------------|
| 18  | Central Balochistan District      | 39.04        | 86.2              | 13.7           |
|     | Bolan                             |              |                   | -              |
| 19  | District Ziarat and Sanjavi       | 26.8         | 30.2              | 69.5           |
|     |                                  |              |                   | -              |
| 20  | Sindh province                    | 2.83         | 58.97             | 41.03          |
|     |                                  |              |                   | -              |
| 21  | Barkhan and Kohlu                 | 32.78        | 47.12             | 52.87          |
|     |                                  |              |                   | -              |
| 22  | Zhob district                     | 41.8         | 51.8              | 48.1           |
|     |                                  |              |                   | -              |
| 23  | District Kharan                   | 43.44        | 88.69             | 11.3           |
|     |                                  |              |                   | -              |
| 24  | Harnai, Duki and Sibi             | 34.2         | 57.1              | 42.8           |
|     |                                  |              |                   | -              |
| 25  | CMH Khuzdar                       | 505          | 24                | 69             | 7 |
|     |                                  |              |                   |                |
| 26  | District Dera Murad Jamli         | 40.4         | 71.7              | 28.2           |
|     |                                  |              |                   | -              |
| 27  | Ayub Teaching Hospital Abbotabad   | 7.2          | 72.4              | 24.1           | 3.44 |
|     |                                  |              |                   |                |
| 28  | Qilla-Abdullah                    | -            | 62.2              | 37.7           |
|     |                                  |              |                   | -              |
| 29  | Central area of Balochistan       | 26.64        | 62.5              | 37.5           |
|     |                                  |              |                   | -              |
| 30  | Districts of Sindh                | 2.41         | -                 | -              |
|     |                                  |              |                   |                |
| 31  | Private Clinic at Mansehra        | 96.25        | 92.21             | 7.79           |
|     |                                  |              |                   | -              |
| 32  | Department of Medicine,            | 20           | 40.81             | 58.17          |
|     | Gomal Medical College, D. I. Khan  |              |                   | -              |
|     |                                  |              |                   |                |
| 33  | Balochistan province              | 14.21        | -                 | -              |
|     |                                  |              |                   |                |
| 34  | Balochistan province              | 8.98         | -                 | -              |
|     |                                  |              |                   |                |
| 35  | Quetta                            | 34.85        | 66.87             | 30.72          | 2.39 |
|     |                                  |              |                   |                |
| 36  | Balochistan province              | 9.33         | -                 | -              |
|     |                                  |              |                   |                |
| 37  | Quetta                            | 15.42        | 6.85              | 8.57           |
|     |                                  |              |                   | -              |
| 38  | Rural area of Quetta district     | 16.25        | 5.55              | 10.70          |
|     |                                  |              |                   | -              |
| 39  | Buner                             | 6.86         | 5.78              | 1.08           |
|     |                                  |              |                   | -              |
| 40  | Children Hospital Baqai Medical    | *100         | 35                | 65             |
|     | University                        |              |                   | -              |
| 41  | Combined Military Hospital Zhob   | 11.77        | -                 | -              |
|     |                                  |              |                   |                |
| 42  | Muzaffarabad                      | -            | 6.33              | 0.6            |
|     |                                  |              |                   | -              |
| 43  | Rural Health Centre (RHC), Jhangara| 5.9          | 35                | 65             |
|     |                                  |              |                   | -              |

The data was presented in table in the form of percentage. * Represent No. of total studied cases, positive/suspected cases. Prevalence rate of malaria was determined among the enrolled patients. Mixed species (P. vivax and P. falciparum).
A malariometric population survey was conducted by Khattak et al. (Khattak et al., 2013) recorded the high prevalence of P. vivax followed by P. falciparum and mixed infection, 76%, 18% and 6% respectively. A study conducted by Ahmad et al. (Ahmad, 2013) reported 1091 cases of malaria from the general population of Lal Qilla Dir (Lower) in which 17.32% were positive for malaria. Out of positive cases 99.47% were found P. vivax and 0.53% was P. falciparum. No cases with P. malariae, P. ovale and mixed infection were observed. Khan et al. (Khan, 2013b) reported the overall prevalence of malaria was 1.95% among neonates in highly epidemic regions of Khyber Pakhtunkhwa. Out of the total positive cases, P. falciparum and P. vivax were reported 1.46% and 0.48% respectively. Similarly, another study carried out by Khan et al. (Khan et al., 2013c) notified overall malaria prevalence was 17.35%, with high No. of cases of P. vivax 91.53% than P. falciparum 7.47%. A study carried out by Awan et al. (Awan et al., 2012) from March to May 2002, among the student of religious School of Bannu District of Khyber Pakhtunkhwa reported that only 3.61% individuals were found positive for P. vivax. Tareen et al. (Tareen et al., 2012) conducted a study in Quetta investigated 18.45% cases of malaria in the human population. Species wise analysis shows that high infection was caused by P. vivax 81.66% and P. falciparum was 18.34%. No cases with P. malariae, P. ovale and mixed infection were observed. Junejo et al. (Junejo et al., 2012) reported 36.5% positivity rate of malaria at Children hospital Chandka Medical College Larkana from January 2008 to December 2008. Species wise distribution shows that P. falciparum was seen in 58.9% and P. vivax in 41.09. A study conducted by Asif, (Asif, 2011) reported 73.5% cases of P. vivax, 21.5% cases of P. falciparum and 5% cases of mixed infection from Shorkot Garrison. Shaikh et al. (Shaikh et al., 2011) notified maximum No. of cases of P. falciparum than P. vivax 52.5% and 46.5% respectively. According to Uttra et al. (Uttra et al., 2010), 89% were positive for malaria infection. Of the total positive cases, 52% investigated as P. vivax and 48% was identified as P. falciparum. Soomro et al. (Soomro et al., 2010a) conducted a study in District Malarial control Centre Jacobabad, a total of 58,989 blood smears were examined giving overall positivity rate of 0.915 (P. vivax 71.48% and P. falciparum 28.52%). The prevalence of malaria was noticed 1.68% among the febrile patients in District Larkano. P. falciparum and P. vivax were found with a ratio 1.1:1 (Soomro et al., 2010b).

Devrajani et al. (Devrajani et al., 2009) conducted six-month hospital based cross-sectional study reported, 81% were found to be positive for malaria parasite with a high ratio of P. falciparum followed by P. vivax 53% and 47% respectively. Another study was carried out by Yasinizai and Kakarsulemankhel, (Yasinizai and Kakarsulemankhel, 2009a) at Central Balochistan District Bolan observed the ratio of infection with P. vivax were much higher 86.2% than P. falciparum 13.7%. The overall prevalence of malaria infection was 26.8% (P. falciparum 69.5% and P. vivax 30.2%) in District Ziarat and Sanjavi (Yasinizai and Kakarsulemankhel, 2009b). A study conducted by Murtaza et al. (Murtaza et al., 2009) at Sindh province of Pakistan during January 2002 to December 2006. In the study period, a total of 5843626 individuals were examined for the presence of malaria parasites. Of the total studied cases, 2.83% to be positive for malaria (P. vivax 58.97% and P. falciparum 41.03%). In this study, average blood examination rate was 4.46; annual parasite incidence was recorded 1.36.

A study was carried out by Yasinizai and Kakarsulemankhel, (Yasinizai and Kakarsulemankhel, 2008a) in the Barkhan and Kohlu bordering areas of east Balochistan, reported 3340 suspected cases of malaria. Out of total cases, 32.78% were positive for malaria infection (P. falciparum 52.87% and P. vivax 47.12%). The area wise analysis shows that P. falciparum infection was found high in Barkhan area as compare to P. vivax 60.88% and 39.11% respectively. In Kohlu area infection with P. vivax was reported high 58.91% while P. falciparum was 41.08%. No mixed infection and no case of P. malariae and P. ovale were seen. The increase in the P. falciparum and P. vivax infection shows a significant health hazard. However another study was carried out by Yasinizai and Kakarsulemankhel, (Yasinizai and Kakarsulemankhel, 2008b) in Zhob district, investigated high rate of malaria infection 41.8% in a local population of the said area. Species wise distribution shows that 51.8% cases of P. vivax and 48.1% cases of P. falciparum were reported.

Yasinizai and Kakarsulemankhel, (Yasinizai and Kakarsulemankhel, 2008c) reported high rate 43.44% of malaria infection in District Kharan. Of the total positive cases, P. vivax were with the highest ratio 88.69% as compare to P. falciparum 11.30%. However, no mixed infection, P. malariae and P. ovale were not investigated in the current study. Yasinizai and Kakarsulemankhel, (Yasinizai and Kakarsulemankhel...
A study was carried out by Farooq et al. (Farooq et al., no mixed infection was investigated. No cases with P. malariae and P. ovale were seen, and Harnai where the P. vivax was found high in Sibi. shows that P. falciparum wa s reported high in Duki and Sibi. The overall result shows that 52.6% cases of P. vivax and 47.3% cases of P. falciparum were reported from Mastung, while 69.8% P. vivax and 30.1% P. falciparum cases were reported from Khuzdar area of Balochistan.

Nizamani et al. (Nizamani et al., 2006) reported an average slide positivity rate of 2.41% in many districts of Sindh. Infection with P. falciparum was reported 33% in 2004, with increase 37.2% in 2005. Similarly, another study undertaken by Jalal-ud-din et al. (Jalal-ud-din et al., 2006) at a private clinic in Mansehra screened 160 cases of malaria children in which 96.25% to be positive for malaria. They also reported 92.21% cases of P. vivax and only 7.79% cases of P. falciparum. Khan et al. (Khan et al., 2006) reported the overall prevalence of malaria was 20% (P. vivax 40.81% and P. falciparum 58.17%). According to a report of Malaria Control Program Balochistan, (Malaria Control Programme, 2006), high slide positivity rate of malaria infection were observed in Kohlu 42.2% followed by Zhob 29.5%, Mastung 17.5%, Turbat 12.9%, Kharan 7%, Sibi 6.8%, Lasbella 5.7%, Qilla Abdullah 3.8% and Khuzdar 2.5.

In 2005, the high slide positivity rate of malaria infection was recorded from Zhob 32.4% followed by Turbat 13.5%, Kohlu 12.9%, Kharan 10.2%, Sibi 7.5%, Mastung 6.6%, Lasbella 4.7%, Khuzdar 1.5% and Qilla Abdullah 0.5% (Malaria Control Program, 2005). Sheikh et al. (Sheikh et al., 2005) conducted a study in Quetta recorded 34.85% positivity rate, while infection with P. vivax was to be noted high compared to P. falciparum 66.8% and 30.7% respectively. Malaria control program Balochistan, (Malaria Control Programme, 2004) investigated high slide positivity rate of malaria in Zhob 27.2% followed by Turbat 13.5, Kharan 13.3, Kohlu 9.6, Sibi 7.3, Lasbella 5.7, Mastung 5.3, Khuzdar 1.1% and Qilla Abdullah 1%. Form Quetta the prevalence rate of malaria was recorded 15.42% where the P. falciparum cases are high 8.57% compared to P. vivax was 6.85% (Yazinzai and Kakarsulemankhel, 2004).

A survey was conducted by Yasinze and Kakarsulemankhel, (Yazinzai and Kakarsulemankhel, 2003) during the period December 2000 to December 2002 at rural area of Quetta district. The overall prevalence was notified to be 16.25%, with more cases of P. falciparum than P. vivax 10.70% and 5.55% respectively. Mohammad and Hussain, (Muhammad and Hussain, 2003) observed 6.86% positive cases of malaria in general population of Buner. P. vivax was notified high 5.78% than P. falciparum 1.08%. Akbar,(Akbar, 2002) reported a high incidence of P. falciparum 65% as compare to P. vivax 35%. Khadim, (Khadim, 2002) reported 11.77% prevalence rate of malaria infection at Combined Military Hospital Zhob. Similarly, Jan and Kiani, (Jan and Kiani, 2001) reported high cases of P. vivax infection as compare to P. falciparum 6.33% and 0.6% respectively from Muzaffarabad. The prevalence of malaria was found to be 5.9% of febrile patients in Jhangerai Sindh with a median age range of 24 months, with 35% cases of P. vivax and 65% of P. falciparum (Hozhabri et al., 2002).
Malaria is considered as the second most frequently recorded disease from a human. In Indo-Pakistan, P. vivax and P. falciparum are common malaria species. Pakistan is the moderately endemic country for malaria. However, the prevalence of malaria was different from province to province and area to area. The province of Punjab which constitutes 52% of the national population, Sindh 25% and Baluchistan 5% population, alternatively contributes less than 10%, about 30% and over 30% cases of malaria respectively (Murtaza et al., 2009).

CONCLUSIONS
It was concluded from the study literature that P. vivax and P. falciparum are common malaria species present in Pakistan. Among the two species, P. vivax was found dominant than P. falciparum. The prevalence of malaria was different from province to province. Preventive measurement, early case detection, proper treatment and awareness regarding disease should be an increase among the local inhabitant of Pakistan to get rid of malaria.

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Competing interests
The authors declare they have no competing interests.

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Problem in the General Population of Bannu District, Khyber Pakhtunkhwa, Pakistan. *Annual Review & Research in Biology* 3(4): 835-845.

Khan, S. N., Ayaz, S., Ali, I., Attaullah, S., Shams, S., Zareen, S., Khan, M. A., Rashid, F and Khan, S. (2013b). Burden of Malaria infection among Neonates in highly epidemic region of Khyber Pakhtunkhwa, Pakistan. *International Journal of Advances in Research & Technology* 2(4): 84-92; ISSN 2278-7763.

Malaria Control Program (MCP). (2004). District-wise epidemiological data of malaria control program, Balochistan, Pakistan.

Malaria Control Program (MCP). (2005). District-wise epidemiological data of malaria control program, Balochistan, Pakistan.

Malaria Control Program (MCP). (2006). District-wise epidemiological data of malaria control program, Balochistan, Pakistan.

Mohammad, N and Hussain, A. (2003). Prevalence of malaria in Pakistan. *International Journal of Advancements in Research & Technology* 2(4): 84-92; ISSN 2278-7763.

Nizamani, A., Kalar, N. A and Khushk, I. A. (2006). Burden of Malaria Control Program (MCP). (2005). Endemicity of malaria in Quetta.

N. A. (2009). Malaria morbidity in Sindh and the Plasmodium species distribution. *Pak J Med Sci* 25(4): 646-649.

Yasinzai, M. I and Kakarsulemankhel, J. K. (2007a). Incidence of human malaria infection in urban areas of district Quetta, Pakistan. *Pak. Armed Forces Med J* 57 (3):276-285.

Yasinzai, M. I and Kakarsulemankhel, J. K. (2009a). Incidence of human malaria infection in Central Balochistan, Pakistan: District Dera Murad Jamali. *Pakistan Journal of Science* 40(3): 67-71.

Yasinzai, M. I and Kakarsulemankhel, J. K. (2009b). Malaria incidence in Central Balochistan, Pakistan: District Dera Murad Jamali. *Pakistan Journal of Science* 60(2): 67-71.

Yasinzai, M. I and Kakarsulemankhel, J. K. (2010). Prevalence of human malaria infection in hottest areas of central Balochistan, Pakistan: Duki, Harnai and Sibi. *Pak. Armed Forces Med J* 58 (3):276-285.

Yasinzai, M. I and Kakarsulemankhel, J. K. (2011). Endemicity of Plasmodium falciparum and Plasmodium vivax in Pakistan. *Pakistan Journal of Science* 36(3): 313-316.

Yasinzai, M. I and Kakarsulemankhel, J. K. (2013). Burden of Malaria control program, Balochistan, Pakistan.

Yasinzai, M. I and Kallar, M. A., Rashid, F and Khan, S. (2013). Burden of Malaria Control Program (MCP). (2005). Epidemicity of malaria in Quetta.

Zareen, S., Zareen, S., Zareen, S., Zareen, S. and Zareen, S. (2010). Malaria infection in Pak-Afghan border area of Pakistan: District Quetta. *Pakistan J. Med Res* 51(1): 41-45.

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