TÜRK
TARIM ve DOĞA BİLİMLERİ
DERGİSİ

TURKISH
JOURNAL of AGRICULTURAL
and NATURAL SCIENCES

www.turkjans.com

Indigenous knowledge about mosquito and its management in Punjab, Pakistan

Waqar JALEEL, Shafqat SAEED, Muhammad Nadir NAQQASH, Qamar SAEED*, Naeem IQBAL
Department of Entomology, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University, Multan, Pakistan
*Corresponding author: saeedqamar@gmail.com

Received: 11.02.2014 Received in Revised Form: 06.01.2015 Accepted: 07.01.2015

Abstract

The *Plasmodium* spp. are responsible for causing a severe disease, commonly known as malaria, in tropical regions of the world. Malaria is the second largest disease in Pakistan as about one million people are affected by malaria. Study planned as questionnaire was developed for collecting basic information and knowledge, attributes and management practices of people about malaria and its vector. Data showed that 43.00% houses had standing nearby and 41.20% houses have poor sanitary conditions in their vicinities so a large fraction i.e. 42.00% people were affected by at least once in their life due to the fact that mosquito breeds in standing water and 86.50% people have mosquito problem in their houses. As malaria is a national problem so majority of people knew that mosquito is responsible for transmission of malaria and its season of prevalence. Most of surveyed people were also well familiar with the casual organism of malaria and its symptoms. Frequently adapted method for control of mosquito is fumigation and a larger fraction of surveyed people consider malaria a severe disease so they consult doctor in case of emergency. Survey data showed that people of Southern Punjab need better control measures for control mosquitoes and malaria.

Key words: Mosquito, Malaria, *Plasmodium spp*, Southern Punjab

Introduction

Malaria caused by *Plasmodium* spp. is progressively becoming a severe problem in most of the tropical countries of the world (Winstanley, 2004). According to the report i.e. World Malaria Report (WMR) made by the World Health Organization (WHO), about 216 million cases of malaria took place in 2010 which resulted in 655,000 malaria deaths (WHO, 2011). Malaria is present as an endemic disease in more than 109 countries (WHO, 2010). Malaria is the second largest disease in Pakistan (HIMS, 2006). The plains of the Punjab are low-lying, wet and often inundated. Malaria in the Punjab is seasonal and unstable, with epidemics recurring at about 8-year intervals (Christophers, 1911; Yacob and Swaroop, 1946). Heavy rainfall in the monsoon season has been implicated as a possible explanation for the variation in malaria transmission from year to year (Yacob and Swaroop, 1946). The periodicity of malaria epidemics has more recently been linked to cyclical climate patterns, notably the El Niño phenomenon actually El Nitro is band which responsible for change in environment and this cycle promotes rain and creates puddles which promotes malaria disease (Bouma and van der Kaay, 1996). The last great epidemic in the Pakistani Punjab dates back to 1972 (Zulueta et al., 1980). In Pakistan, each year an estimated million episodes of malaria infection occur (Yasinzai & Kakarsulemankhel, 2009). The situation today is much improved and malaria has lower public health significance. However there still are substantial variations in the epidemiology of malaria between different districts of the Punjab (Donnelly et al., 1997a).

Vectors play an important role in transmission of vector borne diseases (Tyagi et al., 1995; Akhtar & McMichael, 1996; Tyagi & Chaudhary, 1997). Malaria is transmitted throughout the world by *Anopheles* vector mosquitoes (Sinka et al., 2012). In Pakistan, 23 species of *Anopheles* are known as carriers of malaria; out of these two species, *A. culicifacies* and *A. stephensi* have attained significant importance as a malarial vector in Pakistan. However *A. culicifacies* is more devastating in rural areas (Covell, 1931; Mahmood et al., 1984; Dash et al. 2006; Dash et al. 2007). These vectors need specific habitats with

surface water for reproduction and moisture for adult mosquitos' survival. The development rate of both the vector and parasite population is influenced by temperature (Ceccato et al*.,* 2005).

Ignoring community's attitudes and knowledge about important diseases like malaria results in failure of disease control programmers (Ibidapo, 2005). Increased health educations, distribution of booklets, calendars, malaria-related posters, pamphlets, etc. are adopted in the context of primary health care approach to make community participation (Bista et al., 2003). The focus of this study was to set up basic information and check community knowledge, behavior and practices of the community about malaria. Educated people are more than 50% of the Pakistan population (Anonymous, 2014a). To explore their knowledge about vector-borne diseases and how they manage them as they try to manage the problems in a wise-manner i.e. scientifically (Hannum & Claudia, 2006). This survey will help us in understanding why public health risks are increasing day by day in the presence of 50% educated people in Pakistan. This contribution will add in socio-demographic information of people of Southern Punjab, Pakistan and prevalence of malaria. But also the status of its vector i.e. mosquitoes in residential areas and how people manage with this problem better way and this survey help in furthers study for development of safely control of mosquitoes and malaria.

Materials and Method

Questionnaire development

A survey questionnaire was developed in Eco-toxicology Laboratory Department of Entomology Bahauddin Zakariya University Multan keeping in view the guidelines of Frary (Frary, 1998).

Areas of Study

Data was collected from different cities of Punjab (Multan,Shujabad, Muzaffargarh, Kot Addu and Bahawalpur), from end of January to April 2013.

Data collection

Total 500 interviews were conducted among people including socio-demographic information of people as gender, ages, area of the house and age of the house, sanitary condition of house and near vicinity. Percent incidence and prevalence of malaria and its vector in Southern Punjab, Pakistan. Find out the information level from educated persons of different disciplines about malaria and its vector and how people manage both disease and the vector.

Data management

For assessment work data was managed for questions like male letter was designed "0" and for female "1". Scale was design from"0" to "4" for categories in each variable. Similarly all questions (categories) of variables were managed by made of scales.

Statistical analysis

The data analysis was done by computing the percentages and frequencies of information provided by the community using SPSS software (Version 10.0 for windows, SPSS Inc., Chicago, USA). Graphs were also drawn about the personal knowledge of educated people of different disciplines about malaria and its vector and how they managed both disease and the vector on statistical software SPSS system (Hosmer and Lemeshow, 2000).

Results

Data about genders, male and female ratio 59.0% and 41.0% respectively was surveyed in Southern Punjab, Pakistan and 78.6% male was surveyed in Muzaffargarh and 47.4% females were interviewed from Multan. Data showed that out of five hundred people 92.4% people are educated. Data showed in Multan, Muzaffargarh and Kot Addu 100% educated people. These people informed familiarity about malaria. 63.8% people were 19-30 years old which was greater percentage among other age groups. In Multan 62.6% people were of 19-30 years old. Data showed about the occupation of people, as students were greater in number that was about 68.6%. In Kot Addu 73.3% students were asked for information about mosquitoes and malaria. Data revealed that people had larger homes in between 6-10 Marla's i. e 42% which were greater percentage among other house area categories and 50% peoples in Muzaffargarh had area of house 6-10 Marla's. Data of house age showed that 51.4% people had 6-20 years old house. In Muzaffargarh 54.3% people possessed old houses between 6-20 years. Data showed peoples who were more in number in Southern Punjab, Pakistan retained well developed house i. e 83% and 94.7% of people in Multan retained cemented houses.

Table 1. Basic information of peoples in five different cities of Punjab, Pakistan

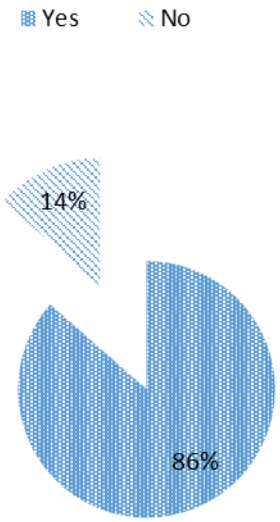
Sr. No	Variables	Category	Multan	Bahawalpur	Shujabad	Muzaffargarh	Kot-Addu	Total
			n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
1	Gender	Male	100 (52.6)	45 (56.3)	61 (61.0)	55 (78.6)	34 (56.7)	295 (59.0)
		Female	90 (47.4)	35 (43.8)	39 (39.0)	15 (21.4)	26 (43.3)	205 (41.0)
2	Education	Yes	190 (100)	67 (83.8)	75 (75.0)	70 (100)	60 (100)	462 (92.4)
		No	0(0)	13 (16.3)	25 (25.0)	0 (0)	0 (0)	38 (7.6)
3	Age	18 years	54 (28.4)	26 (32.5)	7(7.0)	14 (20.0)	0 (0)	101 (20.2)
		19-30years	119 (62.6)	47 (58.8)	69 (69.0)	39 (55.7)	45 (75.0)	319 (63.8)
		31-40years	10 (5.3)	5 (6.3)	5 (5.0)	10 (14.3)	5 (8.3)	35 (7.0)
		< 40 years	7 (3.7)	2 (2.5)	19 (19.0)	7 (10.0)	10 (16.7)	45 (9.0)
4	Occupation	Govt. employ	18 (9.5)	8 (10.0)	7 (7.0)	8 (11.4)	5 (8.3)	46 (9.2)
		Business man	15 (7.9)	6 (7.5)	2 (2.0)	7 (10.0)	4 (6.7)	34 (6.8)
		Farmer	15 (7.9)	4 (5.0)	9 (9.0)	0 (0)	5 (8.3)	33 (6.6)
		Students	129 (67.9)	54 (67.5)	72 (72.0)	44 (62.9)	44 (73.3)	343 (68.6)
		Others	13 (6.8)	8 (10.0)	10 (10.0)	11 (15.7)	2 (3.3)	44 (8.8)
5	Area of House	5 marla	42 (22.1)	23 (28.8)	28 (28.0)	23 (32.9)	19 (31.7)	135 (27.0)
		6-10 marla	79 (41.6)	25 (31.3)	45 (45.0)	35 (50.0)	26 (43.3)	210 (42.0)
		11-20 marla	42 (22.1)	20 (25.0)	19 (19.0)	8 (11.4)	3 (5.0)	92 (18.4)
		< 20 marla	27 (14.2)	12 (15.0)	8 (8.0)	4 (5.7)	12 (20.0)	63 (12.6)
6	Age of House	1-5 years	48(25.3)	19 (23.8)	20 (20.0)	12 (17.1)	10 (16.7)	109 (21.8)
		6-20 years	94 (49.5)	41(51.3)	54 (54.0)	38 (54.3)	30 (50.0)	257 (51.4)
		< 20 years	48 (25.3)	20 (25.0)	26 (26.0)	20 (28.8)	20 (33.3)	134 (26.8)
7	House construction	Kaccha	10 (5.3)	5 (6.3)	43 (43.0)	0 (0)	27 (45.0)	85 (17.0)
		Pakka	180 (94.7)	75 (93.8)	57 (57.0)	70 (70.0)	33 (55.0)	415 (83.0)
8	Standing water	Yes	79 (41.6)	35 (43.8)	44 (44.0)	32 (45.7)	25 (41.7)	215 (43.0)
		No	111 (58.6)	45 (56.3)	56 (56.0)	38 (54.7)	35 (58.3)	285 (57.0)
9	Sanitary condition in House	Poor	22 (11.6)	10 (12.5)	11 (11.0)	4 (5.7)	0 (0)	47(9.4)
		Fair	83 (43.7)	45 (56.3)	50 (50.0)	40 (57.1)	32 (53.3)	250 (50.0)
		Good	75 (39.5)	25 (31.3)	39 (39.0)	26 (37.1)	28 (46.7)	193 (38.6)
		Excellent	10 (5.3)	0 (0)	0 (0)	0 (0)	0 (0)	10 (2.0)
10	Net presence in window	Yes	141 (74.2)	71 (88.8)	84 (84.0)	64 (91.4)	58(96.7)	418 (83.6)
		No	49 (25.8)	9 (11.3)	16 (16.0)	6 (8.6)	2 (3.3)	82 (16.4)
11	Sanitary condition near vicinity	Poor	74 (38.9)	29 (36.3)	41 (41.0)	30 (42.9)	32 (53.3)	206 (41.2)
		Fair	90 (47.4)	50 (62.5)	56 (56.0)	40 (57.1)	28 (46.7)	264 (52.8)
		Good	24 (12.6)	1 (1.3)	3 (3.0)	0 (0)	0 (0)	28 (5.6)
		Excellent	2 (1.1)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.4)
12	Lawn Presence	Yes	64 (33.7)	32 (40.0)	27 (27.0)	21 (30.0)	18 (30.0)	162 (32.4)
		No	126 (66.3)	48 (60.0)	73 (73.0)	49 (70.0)	42 (70.0)	338 (67.6)
13	Duration of irrigation in Lawn	Daily	8 (4.2)	23(28.8)	19 (19.0)	15 (21.4)	11(18.3)	76 (15.2)
		After two days	44 (23.2)	9 (11.3)	8 (8.0)	5 (7.1)	7 (11.7)	73 (14.6)
		Weekly	12 (6.3)	0 (0)	0 (0)	1 (1.4)	0 (0)	13 (2.6)
		Nil	126 (66.3)	48 (60.0)	73 (73.0)	49 (70.0)	42(70.0)	338 (67.6)

*n= Frequency **%= Percentage

Table 2. Information about identification of malaria among people of Punjab, Pakistan

Sr. No	Categories	Variables	Frequency n	Percentage %
1.	Do you know about malaria?	Yes	449	89.8
		No	51	10.2
2.	From where you got the knowledge about malaria.	Doctors	209	41.8
		Television	192	38.4
		Newspapers	41	8.2
		Others	58	11.6
3.	You or any other person in your family attacked by malaria?	Yes	210	42.0
		No	290	58.0
4.	Do you know the causal organism of malaria following of them?	Plasmodium	253	50.6
		Virus	73	14.6
		Bacteria	80	16.0
		Others	94	18.8
5.	Which symptoms observed in case of malaria?	Shivering	53	10.6
		Headache	42	8.4
		Vomiting	74	14.8
		High fever	76	15.2
		All and others	255	51.0
6.	In case of malaria disease which measures adopted	By help of doctors	364	72.8
		Used antibiotics self	43	8.6
		Traditional used	55	11.0
		Others	38	7.6

*n= Frequency **%= Percentage



Mosquito presence

Figure 1. Information by people about mosquito presence in their houses

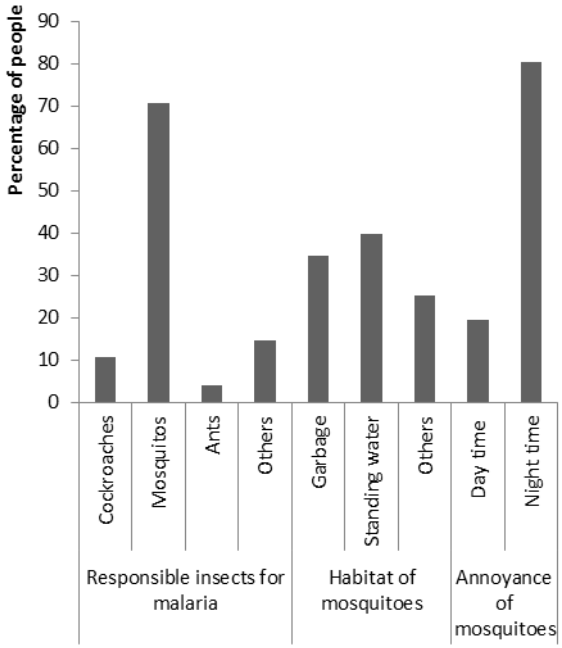


Figure 2. Malaria causing insect, its habitat and peak annoyance time of this insect in Punjab, Pakistan

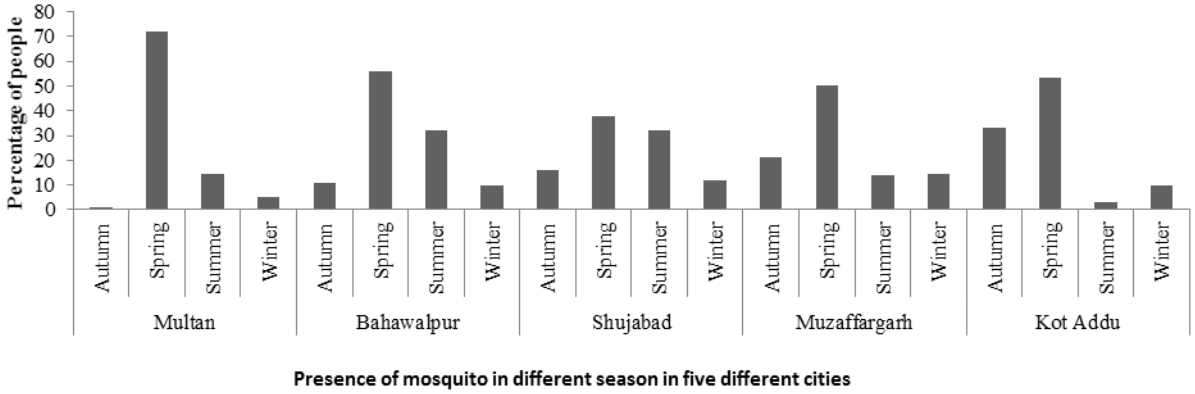


Figure 3. People perception about best season of mosquito in Southern Punjab, Pakistan

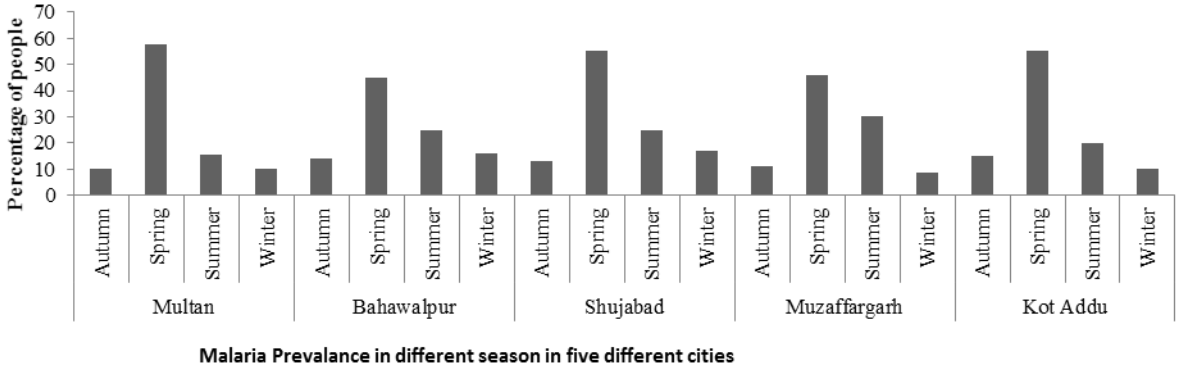


Figure 4. People perception about best season of malaria in Southern Punjab, Pakistan

Data revealed about standing water in house or nearby that is 43% people had source of standing water and in Muzaffargarh 45.7% peoples said that they had source of standing water in house and nearby throughout the year.

The sanitary condition of houses were fair i. e 50% out of 500 people the conditions were quite fair and among cities in Bhawalpur 56.3% house conditions were fair. For control of mosquito and malaria data showed that window net presence in the windows. Houses contained net in their windows i. e 83.6%. In Muzafargarh 91.4% houses had window nets which were greater among others cities of Punjab, Pakistan. The sanitary conditions of vicinity of houses in surveyed cities of Punjab, 52.8% were fair and in Bahawalpur as 62.5% peoples told condition was fair in their vicinity. Lawn presence in houses was importantly related to mosquito development because in lawn water standing place were already developed.

Data showed that 32.4% people had lawns in their houses and this percentage was 40% in Bahawalpur. Duration of irrigation to lawn was another important point so data showed that 15.2% people in Southern Punjab, irrigated their lawn daily and in Muzaffargarh this percentage was 21.4% (Table 1).

Data of survey showed that for the identification of malaria out of 500 people 89.8% people had the malaria in Southern Punjab, Pakistan. Most of people got the knowledge from television i. e 38.4% when they were asked about the source of information they had for the malaria. Data showed that 42% people attacked by malaria in their life. Data showed that 50.6% people knew the casual organism of malaria. 51% people knew most of the symptoms of malaria because of more incidences of malaria among the families and relatives in their life and had exposure to the symptoms of malaria through media but still remaining 49% People did not know the full symptoms of malaria. Best way to deal the malaria was thought to consult a doctor by 72% people of the area (Table 2).

Data about mosquito presence in houses showed that 85.50% people told that mosquito present in their houses (Figure 1). Data survey showed that 70.6% people identify the correct source of malaria spreading insect i. e mosquito for the habitat of mosquito, data showed that 39.8% peoples of Southern Punjab said standing water. For the annoyance of mosquito 80.4% people said night time, 19.6% said day time and 13.2 said other time mean sunshine, dawn and dusk (Figure 2). For problem of mosquito in Multan 72.1% people said in spring (Figure 3). Problem of malaria disease prevalence showed that 57.9% people said in spring (Figure 4). For personally managing mosquitoes 61% peoples used fumigation (Figure 5). Awareness about the control of malaria 28% people said by doctor seminars (Figure 6).

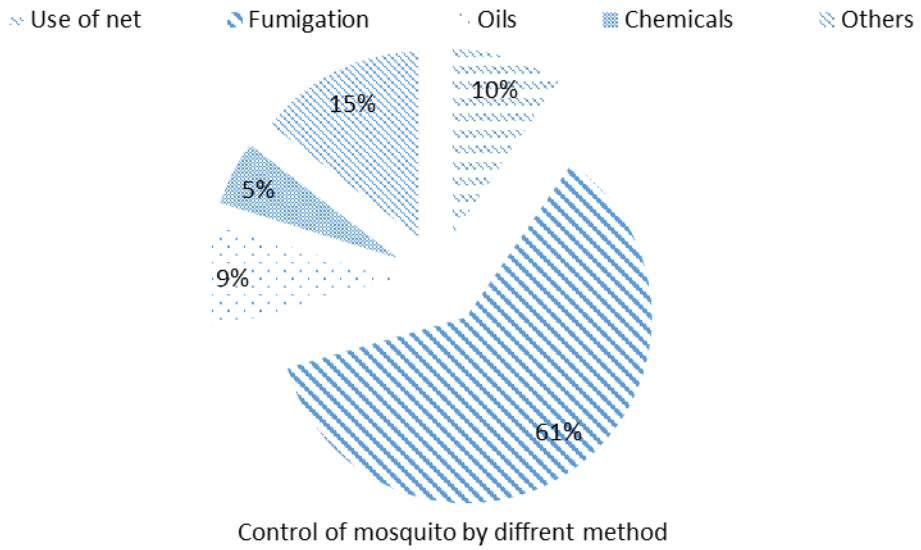


Figure 5. Control adapted for mosquito by people Punjab, Pakistan

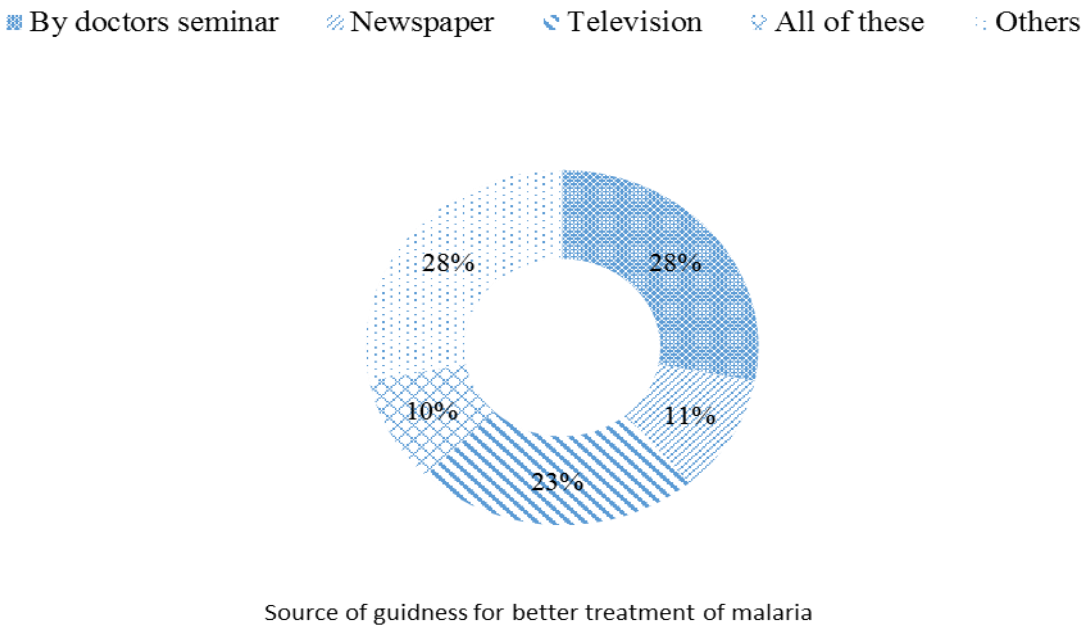


Figure 6. Best source of conveying information/training to peoples from prevention of malaria and mosquito

Discussion

Data of survey contained basic information of people and life style of the people how they manage when they face the problem in their life in Southern Punjab, Pakistan. Data revealed that young educated people were in most in Pakistan (Anonymous, 2014c) as they look every problem in a different and wise way (Hannum & Buchmann, 2006). Area of the house described why lesser number of the houses have good sanitary conditions; larger the area of the house more difficulty in maintaining hygienic conditions and human beings not passed their life peacefully without their house (Onibokun, 1985). Old houses usually were source of favela and mostly living people source of dwellers (Olanrewaju & Akinbamijo, 2002) .Old house were source of living of insect because contained more cracks and crevices for insect multiplication (English, 1987). Data showed that overall 17% house maintenance was poor and in Kot Addu 45% houses were not maintained properly which had evidence of disease because of poor sanitary conditions and poor health maintenance (Martin et al, 1976). Excellent conditions in houses were not enough as some vectors like mosquitos in this case were mobile and could be managed in a clean vicinity because food products spoiled were by these insects (Cloarec et al., 1992; Rivault 1993; WHO, 1997) only a small fraction of house had good sanitary conditions in their vicinities resulting in >95% areas having mosquito infestation and a large percentage of people which had faced malaria at least once in their life. Actually standing water was the main source of mosquito development and great problem of malaria and data showed that 43% of areas of Southern Punjab contained standing water so mosquito caused severe problem in a number of areas. Data showed that in Pakistan great number of people were attacked by malaria mostly children attacked by malaria. Due to malaria destruction 89.8% people identified it because according to United Nation World Health Organization (WHO) Pakistan malaria caused 50,000 deaths of people even in well-established program for control of malaria (IRIN, 2007). Data showed that doctors and media were main source of identification of malaria among people of Southern Punjab. Survey data showed that 50% interviewed people were students so they find the causal organism of malaria. In Pakistan 70.6% people said mosquito were responsible for malaria its mean that greater percentage of peoples was found which they find the vector of plasmodium. Actually female mosquitoes were responsible for malaria disease (Winstanley, 2004). Mosquitoes bite at night time and early in the morning and caused great annoyance (Anonymous, 2014d). The malaria disease occurrence correlated positively with mosquito's development in same season and temperature played main role in spreading of malaria (Craig et al., 1999).

Chemical control of insect-pests is the most common method to control insect pests in Pakistan (Yang et al., 2005). Despite of the fact that educated persons were focused for the study but data shows that only 72.8% people had consulted a doctor when they were suffered from malaria. Survey data showed that there was a strong need to start educating people about vector borne diseases to manage vector borne diseases by national efforts.

Conclusion

People of Southern Punjab contain poor living standard especially poor sanitary condition in their houses and vicinity, due to this mosquito create problem and spread malaria diseases. People of Southern Punjab need to improve their living standard. In Southern Punjab mostly people are educated. They were interested that got better information for eradication of malaria. People of Southern Punjab control mosquito by chemical but still they need safe and proper control measures. In Southern Punjab need training program to educate people about vector borne diseases to manage them.

References

Akhtar, R., McMichael, A.J. 1996. Rainfall and malaria outbreaks in western Rajasthan. *Lancet.* 348:1457–1458.

Anonymous, 2014a. http://x.dawn.com/2013/05/22/literacy-and-pakistan/.

Anonymous, 2014b. http://x.dawn.com/2013/05/22/literacy-and-pakistan/.

Anonymous, 2014c. http://www.tradingeconomics.com/pakistan/literacy-rate-youth-female-percent-of-females-ages-15-24-wb-data.html

Anonymous, 2014d. http//in.answers.yahoo.com/question/index?qid=20060916223148AA 8NDj

Bista, M.B., Banarjee, M.K., Vaidya, R.G., Thakur, G.D. 2005. The annual internal assessment of malaria and kala-azar control activities, 2003. Kathmandu, Nepal: Epidemiology and Disease Control division, *Department of Health Services, Ministry of Health*.

Bouma, M.J., Van der Kaay, H.J. 1996. The El Nin˜ o Southern Oscillation and the historic malaria epidemics on the Indian subcontinent and Sri Lanka: an early warning system for future epidemics? *Tropical Medicine and International Health*, 1: 86– 96.

Ceccato, P., Conno, R.S.J., Jeann, E.I., Thomson, M.C. 2005. Application of geographical information systems and remote sensing technologies for assessing and monitoring malaria risk. *Parassitologia*, 47:81–96.

Christophers, S.R. 1911. Malaria in the Punjab. Scientific Memoirs by the Officers of the medical and sanitary departments of the government of India. New Series no. 46. Government Printing, Calcutta.

Cloarec, A., Rivault, C., Fontaine, F., Leguyader, A. 1992. Cockroaches as carriers of bacteria in multi-family dwellings. *Epidemiological Infection*, 109: 483–490.

Covell, G. 1931. The Present State of the Knowledge Regarding the Transmission of Malaria by different Species of Anopheline Mosquitoes, *Records of the Malaria Survey of India*, 2: 1–48.

Craig, M.H., Snow, R.W., Sueur, D. 1999. A climate-based distribution model of malaria transmission in sub-Saharan Africa. *Parasitol Today.* 15:105–11.

Dash, A.P., Adak, T., Raghavendra, K., Singh, O.P. 2007. The biology and control of malaria vectors in India. *Current Science*, 92:1571–1578.

Dash, A.P., Raghavendra, K., Pillai, M.K.K. 2006. Combating Resistance to Insecticides in Malaria control-Gains Made in India*. Bayer Environmental Science Journal,*18: 30–37.

Donnelly, M.J., Birley, M.H., Konradsen, F. 1997. An investigation of the relationship between depth to groundwater and malaria prevalence, Punjab, Pakistan. International Irrigation Management Institute, *Working Paper Colombo*, Sri Lanka. 40:1–39.

English, J. 1987. Housing and Health: The relationship between housing conditions and the health of council tenants. Journal of Social Policy, 16:260–262.

Frary, R.B. 1998. A brief guide to questionnaire development.[www.ericae.net/ ft/tamu/vpiques3.htm]. ERICAE.net.

Hannum, E., Claudia, B. 2006. Global Educational Expansion and Socio-Economic Development: An Assessment of Findings from the Social Sciences. In Educating All Children: A Global Agenda, ed. Joel E. Cohen, David E. Bloom, and Martin B.Malin. Cambridge ,MA: The MIT Press.

HMIS, 2007. An Overview: http://www.pakistan.gov.pk/divisions/ContentInfo.jsp?DivID=25& cPath=254_260&ContentID=1635 (accessed on May 16, 2007).

Hosmer, D.W., Lemeshow, S. 2000. Applied Logistic Regression. New York: John Wiley & Sons, Inc. 95.

Ibidapo, C.A. 2005. Perceptions of causes of malaria and treatment seeking behavior of nursing mothers in a rural community. *Australian journal of Rural Health*, 13: 214–8.

IRIN killer number One, 2007. The Fight against malaria. Pakistan: Malaria strategy lagsbehinds global goals. Humanitarian News and Analysis. Un Office for the Coordination of Humanitarian Affairs. pp. 1-3. http:/www.irinnews.org

Mahmood, F.R., Sakai, K., Akhtar, K. 1984. Vector Incrimination Studies and Observation on Species A & B of The Taxon Anopheles culicifacies, *Transactions of the Royal Society of Tropical Medicine and Hygiene,* 78: 607–616.

Martin, A.E., Kaloyanova, F., Maziarka, S. 1976. Housing, the Housing Environment, and Health: An Annotated Bibliography. *Geneva: World Health Organization*, Ministry of Health, Government of Pakistan, National Health Management Information System.

Olanrewaju, D.O., Akinbamijo, O.B. 2002. Environmental Health and Target Audience: A Programmatic Panacea for Poverty Alleviation in Nigerian Cities, *African Journal of Environmental Studies*, 3:2: 82–89.

Onibokun, A.G. 1985. Housing in Nigeria: A Book of Reading. Nigeria: Nigeria Institute of Social and Economic Research (NISER).

Rivault, C., Cloarec, A., Leguyader, A. 1993. Bacterial load of cockroaches in relation to urban environment. *Epidemiological Infection*, 110: 317–25.

Sinka, M.E., Bangs, M.J., Manguin, S. 2012. A global map of dominant malaria vectors. *Parasite Vectors,* 5:69.

Tyagi, B.K., Chaudhary, R.C. 1997. Outbreak of falciparum malaria in the Thar Desert (India), with particular emphasis on physiographic changes brought about by extensive

canalisation and their impact on vector density and dissemination. *Journal of Arid Environments,* 36: 541–555.

Tyagi, B.K., Chaudhary, R.C., Yadav, S.P. 1995. Epidemic malaria in Thar Desert, India. *Lancet*, 346:634–635.

WHO, 1997. Vector control. Method for use by individuals and communities. Geneva: WHO, 288–301.

WHO, 2010. *World malaria report*. India. Available online, http://www.who.int/malaria/publications/country-profiles/profile_ind_en.pdf.

WHO, 2011. "World Malaria Report 2011." World Health Organization, Geneva.

Winstanley, P., Ward, S., Snow, R., Breckenridge, A. 2004. Therapy of falciparum malaria in sub-Saharan Africa: from molecule to policy. *Clinical Microbiology Review,* 17:3: 612–37.

Yacob, M.B.M., Swaroop, S. 1946. Malaria and rainfall in the Punjab. *Journal of Malaria Institute India,* 6: 273–284.

Yang, C., Xu, L., Yang, D. 2005. Effects of nitrogen fertilizer on the Bt protein content in transgenic cotton and nitrogen metabolism mechanism. *Cotton Science*, 17:227–231.

Yasinzai, M.I., Kakarsulemankhel, J.K. 2009. Prevalence of human malaria infection in bordering areas of East Balochistan, adjoining with Punjab: Loralai and Musakhel. *Journal of Pakistan Medical Association*, 59: 132–135.

Zulueta, J., Mujtaba, S.M., Shah, I.H. 1980. Malaria control and long-term periodicity of the disease in Pakistan. *Transactions of the Royal Society of Tropical Medicine and Hygiene,*74: 624–632.