Rev Soc Bras Med Trop 51(4):503-507, July-August, 2018
doi: 10.1590/0037-8682-0246-2017

Short Communication

Dengue seroprevalence and its socioeconomic determinants in Faisalabad, Pakistan: a cross-sectional study

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Abstract

Introduction: Socioeconomic disparities in the community make some groups more vulnerable to dengue infection. **Methods:** Fourteen dengue cases (IgM positive) served as index cases for the positive geographic cluster investigations. **Results:** Of 292 individuals, the overall dengue seroprevalence was 22.9% (IgM positive 4.8%; IgG positive 18.1%). The highest (45%) seroprevalence was reported in the most socioeconomically vulnerable lower class, followed by the middle class (39%). Orthogonal comparisons showed that socioeconomic factors play a significant role in the prevalence of dengue. **Conclusions:** An integrated approach is required to control the menace through vector control strategies and improvement of socioeconomic conditions.

Keywords: Dengue. Epidemiology. Geographic clusters. Seroprevalence. Socioeconomic status.

Dengue is an arboviral disease caused by the dengue virus (DENV) belonging to the family *Flaviviridae* and transmitted to humans by *Aedes aegypti* and *Aedes albopictus* mosquitoes[1,2]. The global burden of dengue is estimated to be 390 million cases annually, of which approximately 96 million represent symptomatic dengue infections and 300 million represent subclinical cases[3].

Owing to the subtropical location and favorable climatic conditions of Pakistan, it has been a source of various vector-borne diseases such as malaria, Crimean-Congo hemorrhagic fever, and dengue hemorrhagic fever[4]. Furthermore, natural calamities such as frequent floods with annual recurrence provide suitable conditions for the proliferation of the mosquitoes, which resulted in the worst dengue outbreaks in the past[5]. The rapid geographic expansion of the vector has contributed significantly to the fresh surge in dengue cases from various cities across the country.

Determination of the seroprevalence of dengue antibodies is the first step in determining the magnitude of dengue infections in the community. This is the first study to determine the seroprevalence of dengue infection and the role of socioeconomic factors on the spread of dengue infection in Faisalabad.

This cross-sectional study was conducted in Faisalabad, the third largest City of Pakistan, from September to December 2012. Faisalabad has an arid climate that faces extreme temperatures ranging from up to 50°C in the summer to as low as −1 to −2°C in the winter. However, the decline in the temperature and increase in the humidity in the post-monsoon period (August-December) provide favorable conditions for the proliferation of the dengue vector, accompanied with the emergence of new dengue cases each year.

Fourteen patients with symptomatic dengue fever (positive for anti-dengue IgM) who were living in a 25-km radius from Allied Hospital, Faisalabad, were recruited during their stay in the hospital. Allied Hospital is a public-sector hospital designated as a specialized center for the treatment of dengue. Therefore, the dengue cases around the city were preferentially referred to the hospital for treatment. These patients served as index cases (designated as A to N) for the positive geographic cluster investigations. Each cluster consisted of household contacts (i.e., people living in the same house) of index patients and those living in the neighboring houses on the right, left, front, and back sides of the index house. Demographics, traveling history in the last month, previous history of dengue infection, sewage type, and data related to socioeconomic factors were recorded in the questionnaire. Blood samples were collected in serum-separating tubes from all the participants for analysis of anti-dengue immunoglobulin M (IgM) and immunoglobulin G (IgG) by using

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Received 10 June 2017
Accepted 25 January 2018

enzyme-linked immunosorbent assay (ELISA). The samples were tested for the antibodies by using an indirect antibody enzyme immunoassay (EIA) kit (Human GmbH) as per the manufacturer's instructions.

The study participants were categorized into different socioeconomic classes (lower, middle, and upper) by using a weighted composite index comprised of various relative and absolute sub-indexes, following the method described in the Pakistan Institute of Development Economics (PIDE) working paper[6]. The composite index comprised of education, income, housing, lifestyle, and occupation sub-indexes. The weights of the sub-indexes were calculated using the principle component analysis method, added up to calculate the total scores for the households. The households were then categorized into different classes according to the total index scores[6].

Statistical Package for the Social Sciences (SPSS) version 19 was used for data entry and analysis. Disease attack rates in different age groups were calculated by dividing the number of positive cases in a specific group by the total population at risk. The non-parametric Mann-Whitney *U* test was used to calculate the p-value for age; and the χ^2 test, for other categorical variables. Analysis of variance (ANOVA) was used to compare the differences in dengue seropositivity among the various socioeconomic classes. Multiple comparisons were made from the use of orthogonal contrasts to determine the socioeconomic link of acquiring dengue infections. A significance level of 5% was used for analysis.

Sixty families that resided in 54 residential units in 14 index clusters were screened for dengue infection. For this study, 292 subjects (82.2% participation; range, 46.6-100%) were recruited. The study reports an overall seroprevalence of 22.9% (*n*=67) for dengue infection in Faisalabad, the lowest among the previously reported rates in Pakistan. Of the 67 cases, 35 (52.2%) were female and 32 (47.8%) were male. Therefore, this study represents a low level of dengue exposure to the Faisalabad population, which might represent a recent exposure most probably through the travelers coming from dengue endemic areas of the country. In Pakistan, dengue virus transmission was mainly limited to the port City of Karachi until 2011, when Pakistan was hit by devastating floods, which provided breeding sites and favorable environmental conditions for the dengue virus vector. A large dengue epidemic that affected more than 20,000 people occurred in the Northeastern cities of Pakistan, including Faisalabad[5]. Faisalabad, being the third biggest metropolitan city and a lucrative business place, is a source of attraction for the business community and labor workers from all over the country, who might contribute significantly to the dengue transmission cycle. **Table 1** summarizes the major characteristics of each cluster.

Anti-dengue IgM and IgG antibodies were detected in 4.8% (*n*=14) and 18.1% (*n*=53) of the study population, respectively, which are lower than the previously reported rates of 48.66% (*n*=166) and 39.5% (*n*=79), respectively, in Lahore[7]. Similarly, in another study, in the province of Khyber Pakhtunkhawa, the rates were 31.9% and 20.3% (*n*=124), respectively[8].

TABLE 1: Characteristics of each index-cluster and prevalence of dengue cases among household contacts and neighbors of index cases.

Cluster	Cluster size*	Participants	Seropositivity (%)		House size [m² (SD)]	Rooms/house (SD)	Wastewater disposal system
		n (%)	IgM	IgG			
A	24	18 (75.0)	1 (5.5)	4 (22.2)	63.0 (22.6)	3.8 (2.87)	Fields
B	16	11 (68.7)	1 (9.1)	7 (63.6)	52.5 (14.9)	2.0 (2.12)	Sewerage
C	7	5 (71.4)	1 (20.0)	0 (0.0)	105 (0.0)	5.0 (0.00)	Sewerage
D	41	38 (92.6)	1 (2.6)	11 (28.9)	90.3 (15.9)	2.0 (1.73)	Sewerage
E	41	34 (882.9)	1 (2.9)	6 (17.6)	120.7 (43.3)	3.3 (1.50)	Mixed**
F	33	30 (90.9)	1 (3.3)	2 (6.6)	63.0 (14.9)	2.2 (1.64)	Sewerage
G	28	13 (46.4)	1 (7.6)	5 (38.4)	147 (0.0)	8.5 (2.12)	Sewerage
H	19	16 (84.2)	1 (6.2)	4 (25.0)	131.3 (83.0)	3.3 (2.63)	Mixed**
I	29	21 (72.4)	1 (4.7)	7 (33.3)	100.8 (43.0)	2.2 (1.10)	Open sewage drains
J	37	31 (83.7)	1 (3.2)	5 (16.1)	71.4 (18.7)	3.2 (0.84)	Mixed**
K	16	13 (81.3)	1 (7.6)	1 (7.6)	57.8 (10.5)	3.5 (1.29)	Sewerage
L	32	32 (100.0)	1 (3.1)	1 (3.1)	82.0 (27.1)	3.0 (1.00)	Sewerage
M	11	9 (81.8)	1 (11.1)	0 (0.0)	59.5 (13.2)	2.3 (0.82)	Sewerage
N	21	21 (100.0)	1 (4.7)	0 (0.0)	84.0 (14.8)	4.0 (0.00)	Sewerage

IgM: immunoglobulin M; **IgG:** immunoglobulin G; **SD:** standard deviation. *Total population in each cluster, including research participants and those who refused to participate in the study. **Mixed drainage system includes both open and closed sewerage system.

Table 2 summarizes the major characteristics of the study participants who tested positive for anti-dengue antibodies (IgM and IgG) in Faisalabad.

Of the 14 IgM-positive patients, 8 (5.5%) were female and 6 (4.1%) were male. No significant (p=0.68) association was observed between the IgM-positive subjects and sex distribution. The median age was 39.5 years (range, 13–55 years), including 1 child (7.14%; till 15 years) and 13 adults (92.8%). The IgM-positive patients were significantly older (p=0.01) than the IgM-negative participants (21 years). The highest seropositivity (35.7%) was observed between ages 16 and 30 years; however, the incidence rate was highest in the 46- to 60-year age group.

Among the 53 IgG-positive patients, 24 (14.5%) were male and 29 (19.6%) were female. No significant association was observed between their ages and sex distribution (p=0.76). Their median age was 32 years, significantly (p<0.01) higher than that of the IgG-negative patients (21 years). The highest seropositivity (33%) was observed among the 31- to 45-year age group.

Figure 1 illustrates the relationship between the various socioeconomic factors on the seroprevalence of dengue infection in the different households. Dengue seroprevalence was highest (45%) among the most socioeconomically vulnerable lower class, followed by the middle class (39%). The least number of cases was detected from the most socioeconomically privileged upper class (16%). Up to six seropositive cases per household were reported from the target population; therefore, changes in the socioeconomic factors were studied with respect to the increase in the number of cases per household. The ANOVA revealed that the dengue cases were significantly different among the various socioeconomic classes (p<0.01). Furthermore, pairwise comparisons of the different socioeconomic classes showed that the lower class was more vulnerable to dengue infections than the middle class [differences between means, 3.07; 95% confidence interval (95% CI), 2.4-3.7; p<0.01] and upper class (differences between means, 5.3; 95% CI, 4.2-6.4; p<0.01), followed by the middle class in comparison with the upper class (differences between means, 2.3; 95% CI, 1.1-3.5; p<0.01). Moreover, planned comparisons among different socioeconomic classes[6] showed that the upper-lower, middle-lower, and lower-lower classes were more susceptible to dengue infections (p<0.03, p<0.01, and p<0.01, respectively) than the middle and upper classes.

More than 60% of the households in the seronegative group had at least one person who has attended college. By contrast, fewer households with dengue cases (range, 30-50%) had at least one member who attended college (**Figure 1A**). Likewise, persons-per-room increased with the increase in dengue cases (**Figure 1B**). The least number of persons per room (2.2 persons-per-room) was recorded in the seronegative group, which increased successively (up to 5.5 persons-per-room) with the increase in number of dengue cases per household.

Educational level (p=0.45) and household income (p=0.67) were not associated with the frequency of dengue cases. Heads of 80% of the households in the seronegative group had a non-manual occupation in contrast to the households with dengue cases, who were mostly (range, 0-60%) manual labor workers and rickshaw drivers. Moreover, some of the households with a maximum of 3 or 4 cases per household consisted of manual workers only (**Figure 1A**). Moreover, a steady decrease in household income was observed with the increase in the number of dengue cases per household. The highest income [618 United States Dollars (USD)] was recorded in the control group, which decreased successively (up to 43 USD) with the increase in the number of dengue cases (**Figure 1B**).

TABLE 2: Data showing gender- and age-wise distribution of the study participants positive for anti-dengue antibodies.

Characteristics	Participants	IgM positive	p-value	IgG positive	p-value
	n (%)	n (%)		n (%)	
Total participants	292 (82.3)	14 (4.8)	<0.01	53 (18.2)	<0.01
Median age (SD)	21 (17)	39.5 (14.1)	0.01	32 (17.0)	<0.01
Gender distribution					
male	144 (49.3)	8 (5.5)	0.83	24 (14.5)	0.76
female	148 (50.7)	6 (4.1)		29 (19.6)	
Age distribution					
≤15	97 (33.2)	1 (1.0)	0.03	10 (10.3)	<0.01
16–30	94 (32.2)	5 (5.3)		15 (15.9)	
31–45	58 (19.8)	4 (6.9)		18 (33.0)	
46–60	30 (10.3)	4 (13.3)		7 (23.3)	
≥61	13 (4.6)	0 (0.0)		3 (9.7)	

IgM: immunoglobulin M**; IgG:** immunoglobulin G; **SD:** standard deviation.

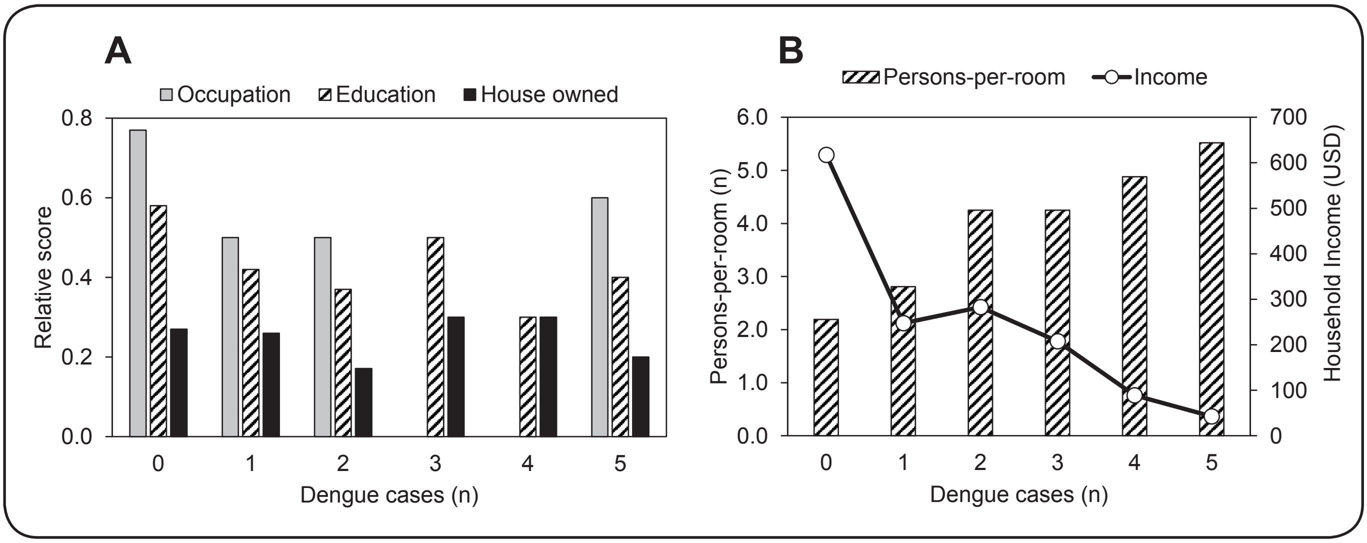

FIGURE 1: Influence of socioeconomic factors on the incidence of dengue infection. A. Relationship between the frequency of dengue cases and socioeconomic factors such as education, house ownership, and occupation. The following factors were quantified as described in the PIDE working paper[6]: education (at least one individual in a household with college education, 1; otherwise, 0), ownership of the house (house owned, 0.3; otherwise, 0), and occupation (if the occupation of the household head is non-manual, 1; otherwise, 0). **B.** Relationship between the frequency of the dengue cases and socioeconomic factors such as persons-per-room and total household income (USD). **PIDE:** Pakistan Institute of Development Economics; **USD:** United States Dollars.

Other than suitable climatic conditions, one of the reasons for the maintenance of dengue in tropical/subtropical countries of the world is related to socioeconomic factors, which play a pivotal role in the transmission cycle. Lower economic class, exclusively represented by poor infrastructure, higher population density, and lower literacy rates, pose a risk factor in the transmission of dengue infection. Similar observations were also made in the study conducted in Brazil, which demonstrated a high seroprevalence of dengue antibodies in deprived socioeconomic areas as compared with highly privileged areas[9]. Similarly, a recent study conducted in Nouméa, New Caledonia, reported the association of higher incidence of dengue rates with lower socioeconomic status[10]. By contrast, various studies conducted in Pakistan found no statistical association between socioeconomic status and dengue seropositivity[11,12]. However, it is significant to mention here that the results of this study cannot be compared with the previous studies, as most studies involve calculation of middle class solely on the basis of accumulative household income, ignoring other factors such as education, wealth, occupation, and lifestyle.

Another important factor in the transmission of dengue infection in this study was persons-per-room, which indirectly measures host density or overcrowding. The reason lies behind the behavior of the dengue vector, which feeds on several individuals in a given time[2], therefore increasing the risk of transmission of dengue virus to several individuals in households with a higher number of persons per room[13]. Overcrowding is always associated with poverty and lower socioeconomic status, making it an important social predictor of dengue infection[14]. Mondini and Chiaravalloti[15] measured number of residents per house[14] instead of persons-per-room to calculate the effect of population density on dengue transmission. However, persons-per-room was found to be a better measure than residents-per-house, as it ignores the differences in house size; thus, it is a better predictor of density-related transmission of dengue infection.

It is interesting that only a single case of dengue was detected from each of clusters C, M, and N in this study. This phenomenon could be explained by the fact that these clusters represent the socioeconomically privileged upper class. Household members in these clusters were all medical graduates, having the least number (mean, 1.44) of persons per room and the highest household incomes (mean, 450 USD). In addition, active vector control measures in these areas might be another contributing factor that kept the prevalence of dengue cases at the lowest. Previous studies also indicated that the dengue incidence was associated with the lack of knowledge about dengue, its vector, and behavioral practices, which play a significant role in reducing the risk of dengue transmission[16,17]. As most of the houses in Pakistan are self-owned by the people, no clear relationship was found between house size, possession of a house, and number of dengue cases.

Travel to dengue endemic areas is a well-known risk factor in the transmission of dengue infection. Recently, mobile phone-based mobility data also predicted that extensive traveling between the dengue endemic city (Karachi) and other major metropolitan cities (Lahore, Faisalabad, etc.) of Pakistan during this period might have contributed significantly in the introduction of dengue virus into the previously unexposed population[18]. Similarly, in this study, 4 people had traveled to dengue-endemic areas during the outbreak, 3 (75%) of whom were found positive for the dengue infection.

One of the limitation of this study included the recruitment of subjects for cluster investigation from a public-sector hospital, which was designated as a specialized center for dengue treatment in the city. Although the patients were preferentially referred to the study site, but they might belong to the lower/middle income groups and, at a lesser probability, to the higher income groups.

Socioeconomic factors play a pivotal role in the spread of dengue infection in the community. Therefore, an integrated approach is required to control the menace through vector control strategies and improvement of the socioeconomic conditions of the masses.

Ethical considerations

The study protocol was approved by the institutional ethics review board of Punjab Medical College (Ref. No. 318/2012), Faisalabad. Written informed consent was obtained from all the participants or legal guardians in case of minors.

Acknowledgments

We thank Mrs. Ghazala Mohayyuidin Arain for helping in the recruitment of volunteers from the three clusters. We thank Mr. Ahsan Akram and other clinical laboratory personnel of Allied Hospital, Faisalabad, Pakistan, for their contributions, Mr. Liaqat Ali and Mr. Muhammad Afzal for their assistance in the field, and the volunteers for participating in the study.

Conflict of interest

The authors declare that there is no conflict of interest.

Financial support

This work was supported by the Pakistan Health Research Council (www.phrc.org.pk) via grant No. 4-23-9/11/Dengue/RDC/PMC/3640.

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