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Exploring Socio-Economic Impact of Dengue Fever in Dhaka City: A Statistical Modeling Approach

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ABSTRACT

There was a sudden increase in dengue affected people in Dhaka city during 2018 and 2019, considering the seriousness of the disease, this study attempted to investigate the socio-economic impact of dengue fever instead of its biological significance. The study considered a primary dataset of 235 affected and 235 unaffected participants from Dhaka city. The impact of dengue infection on the monthly expenditure of the patient was determined by the multiple linear regression models. The impact of Dengue on the human productivity of the respondents was assessed by another multiple linear regression model; the dependent variable *absence* (number of days absent from work) was applied as a proxy for measuring the productivity of the patient. Moreover, an important objective was to find out potential determinants of dengue in Dhaka city. Binary logistic regression applied for detecting the factors which were responsible for occurring dengue disease. The study found no significant association of family cost with dengue incidence but the loss of productivity turned out as statistically significant. People who lived alone were identified to experience the disease more, which might occur due to their insincerity about this disease. So, living alone persons need to increase their consciousness considering the seriousness of this disease. It was highly recommended by respondents to use mosquito repellent and net during sleeping, changing the water regularly from plant container, providing regular mosquito spray, and developing a drainage system in Dhaka city.

Keywords: Socio-economic impact, Productivity, Potential determinants, Risk factors, and Multiple responses.

INTRODUCTION:

Contagious diseases have emerged as a main indicatory factors of poverty and poor health status in developing and under-developed countries (Kumar *et al*., 2007). In 2018 & 2019, dengue viral epidemic in Bangladesh affected the ability and strength of working people to carry on with day to day activities. In many countries, dengue is a public health problems (Okanurak *et al*., 1997). The term "Dengue" was first originated in Zanzibar naming "Denga" during 1870 epidemic (Mahmood & Mahmood, 2011). The dengue virus usually spreads by day biting female *Aedes* mosquitoes, primarily *Aedes aegypti* and *Aedes albopictus* (Sharmin *et al*., 2015). Climate change will increase severity of dengue in the future (Naish *et al*., 2014).

Bangladesh has made a noticeable progress in child mortality and maternity sector by developing primary healthcare access (Das & Horton, 2013). But so far, the overall public healthcare facilities are not standard to the public demand. Since most of the public hospitals

lack medical documentation system and modern diagnostic facilities, continuous surveillance for dengue disease is a vast challenge here (Organization, 2015). In 1964, dengue was first reported in Dhaka, hence named after as "Dacca Fever" (Aziz *et al*., 1967). The fever remained epidemic since then (Ahmed *et al*., 2001).

Dhaka had been experiencing a large-scale dengue outbreak in every year since 2000 (Akram, 2019). The dengue epidemic in 2019 at Dhaka city created serious public health problem, causing significant absence in working place. **Fig 1** shows how dengue emerged on a sudden large scale. The disease caused a huge economic and social burden in the city. In this paper, the socio-economic impact was measured through the number of absent days in working place of the affected people and percentage of monthly family income spend to monthly family expenditure for occurring dengue disease. The significant covariates for occurring this disease were identified and various suggestions for knocking the disease off had been analyzed, discussed and concluding remarks made.

MATERIALS AND METHODS:

Primary data were collected from October 9 to November 20, 2019. For this purpose, a questionnaire was designed and data were collected by direct interview (face-to-face) method. Respondents were conveniently selected from Dhaka city where dengue outbreak had occurred. The study covered 235 dengue affected and 235 unaffected respondents.

The questionnaire involved seven major sections: personal (demographic) information of the respondent's, economic condition, environmental condition, disease incidence, preventive measure, treatment, and suggestions. The variables that were highlighted in this study are: family cost [Percentage of monthly income spent on expenditure], incidence [no, yes], living status [alone, with family, with friends/colleague, others], family size, marital status [single, married, divorced, widowed, separated], economic status [lower class, lower middle, middle, higher middle, higher], absence [number of days absent from work], age [0-15, 15-30, 30-45, 45-60, 60+], gender [male, female, others], treatment cost, education status [illiterate, primary, secondary, higher secondary, graduate], drainage system [bad, medium, good], providing spray by city corporation [no, yes], and area [university area, residential area, slum, crowded area, VIP area, commercial area, industrial area, hostel area, others].

Regression analysis is an important statistical method to investigate the relationships that exist between a dependent variable and a set of independent variables (Draper & Smith, 1998; Zeileis & Hothorn, 2002). This widely used analysis examines which factors matter most, which factors can be neglected, and how these factors influence each other (Fahrmeir *et al*., 2013; Montgomery *et al*., 2012). Regression techniques for making predictions is drive by three techniques mostly: type of dependent variables, number of independent variables, and shape of the regression line (Seber & Lee, 2012). However, two widely used regression model, multiple linear regression and binary logistic regression, had been considered here. If independent variable is more than one and dependent variable is continuous type having linear relationship with independent variables and follows some other specific assumptions then multiple linear regression model can assess the impact of independent variables on dependent variable (Nathans *et al*., 2012). For the vector of covariates $\boldsymbol{x}$ and vector of response variable $\boldsymbol{Y}$, the form of the multiple linear regression model in matrix notation becomes (Brown, 2009)

$$\boldsymbol{Y} = \boldsymbol{x}'\boldsymbol{\beta} + \boldsymbol{\epsilon},$$

Where, $\boldsymbol{\beta}$ and $\boldsymbol{\epsilon}$ be the vector of regression coefficient and random error term, respectively. If the response vector $\boldsymbol{Y}$ be of binary type, that is, referring to whether an event of interest has occurred or not, binary logistic regression is used for modeling purpose, which has the following functional form (Sarkar & Midi, 2010).

$$\pi(\boldsymbol{x}) = \frac{e^{\boldsymbol{x}'\boldsymbol{\beta}}}{1 + e^{\boldsymbol{x}'\boldsymbol{\beta}}}$$

Where, $\pi(\boldsymbol{x})$ represents the conditional mean of $\boldsymbol{Y}$ given $\boldsymbol{x}$ i.e., $E(\boldsymbol{Y}|\,\boldsymbol{x})$. In both models, the unknown parameters ($\boldsymbol{\beta}$) are estimated by the method of maximum likelihood estimation (Albert & Anderson, 1984; Myung, 2003). Here, the former model applied for relating family cost and productivity to dengue incidence, while the factors for occurring dengue disease

was identified by the later model. Also, multiple response analysis had been incorporated to assess various suggestions from patients.

Model 1

The impact of dengue infection on the monthly expenditure of the patient was determined by the first model (multiple linear regression models). In this model, dependent variable *family cost* [percentage of monthly income spent on expenditure] was used as a proxy for measuring monthly expenditure of the patient. The main independent variable was dengue *incidence* and related covariates were also considered. The model had the form as –

$$\begin{aligned} family\ cost_i = {} & \beta_0 + \beta_1 incidence_i \\ & + \beta_2 living\ status_i \\ & + \beta_3 family\ size_i \\ & + \beta_4 marital\ status_i \\ & + \beta_5 economic\ status_i + \epsilon_i, \\ & i = 1, 2, \cdots, n; \end{aligned}$$

Where, β denotes regression coefficient of the covariates and ϵ_i is the random error term of the i^{th} respondent.

Model 2

The second model was also a multiple linear regression model which determined impact of dengue infection on human productivity. The dependent variable *absence* [number of days absent from work] was used as a proxy for measuring productivity of the patient. The main independent variable was dengue incidence with other related covariates. The model took the form as –

$$\begin{aligned} absence_i = {} & \beta_0 + \beta_1 incidence_i + \beta_2 living\ status_i \\ & + \beta_3 family\ size_i \\ & + \beta_4 marital\ status_i + \beta_5 age_i \\ & + \beta_6 gender_i + \beta_7 treatment\ cost_i \\ & + \epsilon_i, \qquad i = 1, 2, \cdots, n; \end{aligned}$$

Where, β and ϵ_i bear the same meaning as before.

Model 3

Binary logistic regression applied for detecting risk factors of dengue disease. The acting dependent variable dengue *incidence* [whether dengue disease occurred or not], which was of binary type. This variable and related independent variables took the functional form as –

$$\begin{aligned} incidence_i = {} & \beta_0 + \beta_1 gender_i + \beta_2 age_i \\ & + \beta_3 marital\ status_i \\ & + \beta_4 education\ status_i \\ & + \beta_5 living\ status_i \\ & + \beta_6 drainage\ system_i \\ & + \beta_7 providing\ spray_i + \beta_8 area_i \\ & + \beta_9 + \epsilon_i, \qquad i = 1, 2, \cdots, n; \end{aligned}$$

Where, β and ϵ_i bear the same meaning as before.

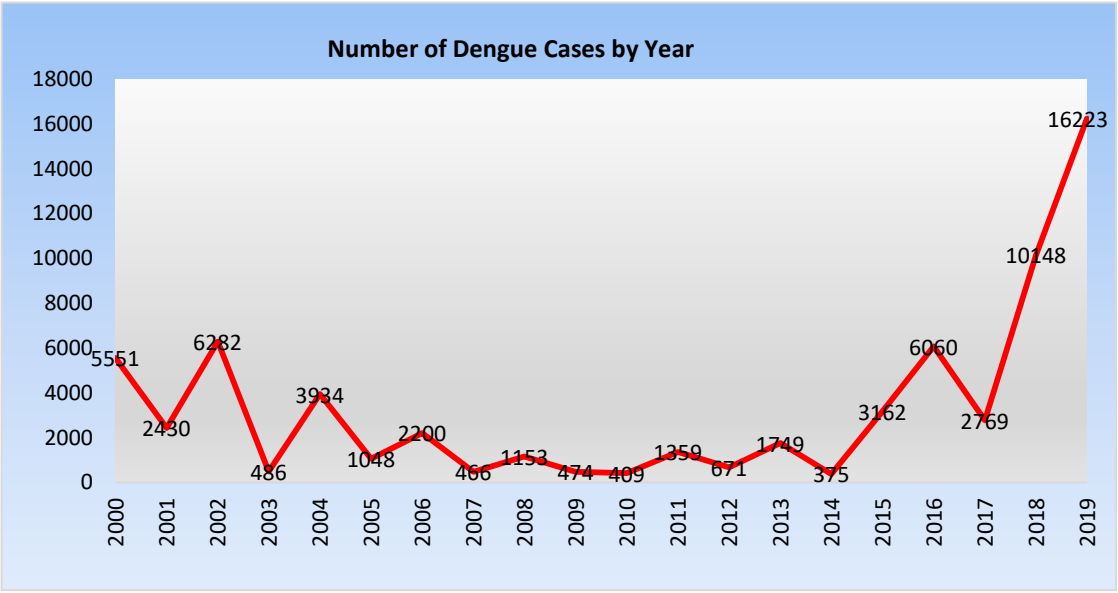

Fig 1: Year wise dengue cases in Dhaka (Data Source: Akram, 2019).

RESULTS AND DISCUSSIONS:

The **Fig 1** is a clear indication of sudden increase of dengue affected people in Dhaka in 2019. Dengue patients increased from 2769 in 2017 to 10148 in 2018, then reached the highest record 16223 in 2019. This study attempted to explore the reasons behind and the impact made in socioeconomic life in Dhaka.

Multiple linear regression and binary logistic regression models had been employed to analyze dengue patients' data. The obtained results were shown in **Table 1**, **Table 2**, and **Table 3**. **Table 1** presented the factors related to family cost.

Table 1: Multiple linear regression model estimates of the selected covariates for family cost in Dhaka city along with standard error (SE) and p-value.

Covariates	Coefficient	SE	p-value
Constant	69.135	4.699	<0.001
Incidence			
no	-	-	-
yes	1.498	1.686	0.375
Living status			
alone	-	-	-
with family	1.925	2.255	0.394
others	-10.565	4.892	0.031
family size	2.363	0.479	<0.001
Marital status			
single	-	-	-
married	4.210	2.063	0.042
divorced	-13.144	5.972	0.028
widowed	7.112	5.187	0.171
Economic status			
lower class	-	-	-
lower middle	-12.615	4.150	0.003
middle	-8.102	3.710	0.029
higher middle	-7.214	4.059	0.076
higher	-15.753	5.437	0.004

The obtained significant variables were living status, family size, marital status and economic status, while incidence was the only covariate that turned out as insignificant at 5% level of significance. Living "with others" decreased the percentage of monthly income spent on expenditure by 10.565 percent compared to living "alone" keeping all other covariates constant. Living with family has no significant effect compared to living alone at 5% significance. Extra one person increasing in number of family member increased the percentage of monthly income spent on expenditure by 2.363 percent. Percentage of monthly income spent on expenditure increased by 4.210 percent and decreased by 13.144 percent in the married and divorced patient groups, respectively, compared to the alone patient group keeping all other independent variables fixed. The lower middle, middle, higher middle, and higher economic class patients had 12.615, 8.102, 7.214, and 15.753 percent less monthly income spent on expenditure than lower economic class patients, respe-ctively. From **Table 2**, it is noticed that the covariates incidence, living status, and treatment cost were significantly affecting productivity, while family size, age, marital status and gender turned out as insignificant at 5% level of significance.

Table 2: Multiple linear regression model estimates of the selected covariates for productivity in Dhaka city along with standard error (SE) and p-value.

Covariates	Coefficient	SE	p-value
constant	2.012	1.731	0.246
Incidence			
no	-	-	-
yes	6.144	0.687	<0.001
Living status			
alone	-	-	-
with family	-1.261	0.757	0.096
others	-1.888	1.590	0.236
family size	0.085	0.161	0.599
Marital status			
single	-	-	-
married	-0.706	0.867	0.415
divorced	-2.124	1.991	0.287
widowed	-0.866	1.912	0.651
Age			
0-15	-	-	-
15-30	0.629	1.312	0.632
30-45	0.691	1.450	0.634
45-60	1.937	1.652	0.242
60+	0.854	2.209	0.699
Gender			
male	-	-	-
female	0.638	0.585	0.276
treatment cost	<0.001	<.001	<.001

Dengue incidence had significant effect on productivity of the patients with p-value less than 0.001. It hampered approximately 6 working days, keeping all other covariates fixed. Living status was significant at 10% significance level. Patients living with family remained 1.261 days less absent from workplace than patients living alone, keeping all other covariates constant. The positive value of the coefficient under treatment cost denoted more absence in workplace with the higher treatment cost. That is, the more a patient had to pay for dengue, the more he remained absent in workings (Shazeed-Ul-Karim, 2019).

The risk factors that are acting behind to occur dengue fever were shown in **Table 3**. The variables living status, drainage system, providing spray, and area were found significant in **Table 3** while gender, age, marital status, and education status were insignificant.

Table 3: Binary logistic regression model estimates of the selected covariates for dengue incidence in Dhaka along with standard error (SE), hazard ratio (HR), and p-value.

Covariates	Coefficient	SE	HR	p-value
constant	0.541	1.207	1.717	0.654
Gender				
male	-	-	-	-
female	0.077	0.227	1.080	0.733
Age				
0-15	-	-	-	-
15-30	0.748	0.985	2.112	0.448
30-45	0.211	0.853	1.235	0.804
45-60	0.405	0.826	1.499	0.624
60+	-0.252	0.846	0.777	0.766
Marital status				
single	-	-	-	-
married	-0.517	0.341	0.596	0.779
widowed	-3.231	1.263	0.040	0.211
Education status				
Illiterate	-	-	-	-
primary	0.442	0.806	1.556	0.583
secondary	0.403	0.618	1.497	0.514
higher	-0.375	0.488	0.688	0.442
graduate	0.232	0.419	1.262	0.579
Living status				
alone	-	-	-	-
with family	-2.048	1.135	0.129	0.071
with friends	-0.954	0.712	0.181	0.385
others	-0.646	0.690	0.349	0.524
Drainage				
bad	-	-	-	-
medium	0.469	0.389	1.598	0.228
good	-2.116	0.677	0.121	0.002
Providing				
no	-	-	-	-
yes	-0.780	0.239	0.459	0.001
Area				
university	-	-	-	-
residential	-1.653	0.611	0.191	0.007
slum	0.309	0.293	1.361	0.298
crowded	0.291	0.417	1.337	0.486
VIP	-2.038	0.711	0.130	0.004
commercial	-1.716	0.702	0.180	0.014
industrial	-1.294	0.846	0.126	0.180
hostel	0.458	0.866	1.581	0.597

The respondents living with family had 2.048 times significantly less odds of occurring dengue disease at 10% significance level than respondents living alone. The respondents provided with good drainage system had experienced 87.9% fewer odds compared to bad drainage system and this is highly significant at 1% level of significance having p-value 0.002. Providing spray in the locality was significant at 1% significance level with p-value 0.001 bringing 54.1% less odds of experiencing dengue disease compared to from not providing spray. The patients belonging to residential, VIP, and commercial area had significantly 1.653, 2.038, and 1.716 times less odds, respectively, of having this disease at 5% level of significance than patients from university area.

Table 4: Multiple response analysis of used preventive approach of the dengue affected respondents in Dhaka city.

Preventive approach	Percentage (%)
Nothing	5.5
Coil	44.1
Aerosol	35.3
Liquid	17.5
Mosquito racket	27.9
Net	57.8

Multiple Response Analysis - Multiple response analysis is an analysis of frequency when more than one response can be obtained from each participant. Multiple responses had been arranged in three portions in this study: preventive approaches of dengue, suggestions about people's steps on prevention of dengue, suggestions about government's steps on prevention of dengue.

Table 4 showed that 5.5% patients who were affected by dengue didn't use any approach such as coil, aerosol, liquid, mosquito racket, net, etc. 44.1% patients used coil, 35.3% patients used aerosol, 17.5% of patients used liquid, 27.9% patients used mosquito racket and 57.8% patients used net as a preventive approach to protect from dengue.

Table 5: Multiple response analysis of the suggestions regarding necessary steps that people might take to prevent dengue disease.

Necessary steps	Percentage (%)
No step	7.9
Cover tightly all water containers	33.3
Burring unused tires keeping drain free from blockage	37.5
Keep drain free from blockage	60.8
Changing water regularly in plant container	61.3
Changing water from trays under the fridge	39.9
Destroying unused containers	29.9
Use mosquito repellent and net when sleeping	65.1
Other steps	19.8

It was observed from **Table 5** that 7.9% people had no suggestions, 33.3% people preferred that they could cover tightly all water containers, 37.5% people had opinion that they could burry unused tiers, 60.8% people wanted to keep drain free from blockage, 61.3% people could change water in plant container, 39.9% people preferred to change water in trays under the fridge, 29.9% people could destroy/burn unused containers, 65.1% people also said that they could use mosquito repellent and mosquito net when sleeping and 19.8% of people preferred to take others steps to prevent dengue fever transmission during outbreak.

Table 6: Multiple response analysis of the suggestions regarding necessary steps that government might take to prevent dengue disease.

Necessary steps	Percentage (%)
Repairing open manhole	42.8
Developing drainage system	65.7
Removing blocked water	47.3
Providing regular mosquito	69.4
Keeping the locality clean	41.2

From **Table 6**, 42.8% people were found who thought that government could repair open manhole, 65.7% people wanted that government could develop the drainage system, 47.3% people preferred that government should remove blocked water source, 69.4% people wanted that government should provide regular mosquito spray, and 41.2% people suggested government should keep the locality clean.

This paper primarily measured the impact of dengue both on society and economy. It was observed that dengue had no significant effect on family expenditure. The underlying reason is that the treatment of dengue was not that expensive to affect the total family cost. But, this result contradicted some previous work (Clark *et al*., 2005; Halasa *et al*., 2012; Harving & Ronsholt, 2007). However, dengue fever badly affected the human productivity, which was similar to previous works on this disease (Bhavsar *et al*., 2010; Halasa *et al*., 2012; Serufo *et al*., 1993). Since dengue had no direct economic impact but as it affected productivity, it might affect the national economy indirectly. Again, living status and treatment cost had significant effect on productivity, while living status, marital status, and economic status were significant to the family cost of the respondents.

CONCLUSION AND RECOMMENDATIONS:

A self-collected dataset was analyzed through sophisticated statistical modeling approaches to suspect socio-economic impact of dengue. The analysis found no direct effect of dengue on family cost, but it affected productivity which in terms might affect economy. The analysis revealed that alone living group are in greater risk of dengue (Kularatne, 2015). It might be the case that living alone people didn't take enough protection against mosquito bite, hence experienced the fever. People with bad drainage system experienced dengue disease, which might happen for blocked drains that grew and reserved mosquitos (Singh, 2007). The result expressed that providing mosquito spray decreased dengue incidence which comply with previous literature (Chadee, 2013). The probability of being affected varied significantly by different areas (Pathirana *et al*., 2009). Cleanliness of living areas is a must for preventing the disease which was proven in literature (Pai *et al*., 2006). From the multiple response analysis, it was observed that a few number of respondents used no preventive approach, while majority used mosquito net as preventive approach. Using mosquito net is effective, as this practice was suggested in literature (Nalongsack, Yoshida, Morita, Sosouphanh, & Sakamoto, 2009). The respondents suggested mostly to use mosquito repellent and net, keep drain free from blockage, and regular changing water from plant container. They suggested government to provide mosquito spray and develop drainage system regularly.

Alone living people were more prone to experience the disease, which might occur due to their insincerity about this disease. So, the living alone persons need to increase their consciousness considering the seriousness of this disease. Drainage system is an important issue for a high densely populated capital like Dhaka city. Government should focus to have well developed systems for neat and clean drains in the capital. City Corporation should provide mosquito spray to a regular basis as it had significant influence to decrease dengue incidence. The magnitude of dengue was different at different areas. Respondents highly recommended using mosquito repellent and net during sleeping, changing water regularly from plant container, providing regular mosquito spray and developing drainage system in Dhaka city. People should become conscious enough about the disease remembering all of its hazards.

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CONFLICTS OF INTEREST:

The author declares no conflict of interest.

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