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Original Article

Correlation of rainfall and socio-economic with incidence dengue in Jakarta, Indonesia

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ABSTRACT

Objective: This investigation was aimed to determine the correlation of rainfall and socio-economic factors with total patient, incidence rate (IR) and the cost of illness due to DHF in Jakarta. Method: A cross-sectional study was applied in this study by collecting data related to the medical record of DHF patient, rainfall, and socio-economic factors from the Department of Health, Department of Meteorological, Climatological and Geophysics, and Statistics Indonesia, respectively. Societal and payer perspectives were considered in this study. A Spearman non-parametric correlation was performed to determine the correlation of rainfall and socio-economic factors with incidence rate and cost of illness due to DHF. Result: The results showed that rainfall has significant correlations with IR, total patient, and cost of illness from both perspectives. IR also has a significant correlation with the cost of illness from both perspectives. The total population has a significant correlation with IR and total patient, whereas population density and population growth have insignificant correlations with IR and total patient. In socio-economic variables, the human development index and mean years of schooling have positive significant correlations with the total patient, while the poverty rate has a negative significant correlation. Annual expenditure per capita and GDP have a significant correlation with IR and the total patient. Conclusion: Rainfall has a significant correlation with IR, total patient, and cost of illness from both perspectives. The total population, expenditure per capita and GDP have a significant correlations with total patient and IR.

Keywords: dengue virus, cost analysis, societal perspective, payer perspective

Introduction

The social and economic burden of mosquito-borne viral infection is widely alarming, and the proven global impact of these diseases [1, 2]. The observation of dengue epidemiology highlights the need to strengthen control of the emerging virus [3]. In Indonesia, the number of DHF was estimated to be 100,347 cases with incidence rate (IR) of 39.9 per 100,000 population and case fatality rate (CFR) of 0.9%, as reported in 2014 [4]. As the capital of Indonesia and the most density province, the number of DHF in Jakarta was estimated to be 8,786 cases with IR of 83.34 per 100,000 population and CFR of 0.22% [4, 5].

The epidemiological factors spreading of DHF virus are strongly correlated with socio-economic, climate and behavior factors, such as high population mobility and changes in climate, population density, and population distribution [6]. Climate change, which might lead to alterations in rainfall, temperature, humidity, and air direction has been reported to have a strong correlation with disease factors such as Aedes mosquitoes and malaria anopheles [7-13]. Several studies also mentioned that socio-economic factors (*e.g.,* population density, poverty, and environment of society) can have an impact on the spreading of DHF virus [14-16]. In many cases, socio-economic factors that are related to behavior and lifestyle have a direct effect on the incidence of dengue disease [17-26]. Furthermore, it has been reported that dengue disease is influenced by multiple sectors such as political, economic, social, and medical sectors [24]. In addition to this complex situation, many published studies

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confirmed that dengue disease has yielded a high economic burden in many countries [27-30].

As the capital of Indonesia, the human development index (HDI) in Jakarta has been reported to be the highest value in Indonesia compared to other provinces. However, HDI is an important indicator for measuring the quality of life and opportunities of the population in accessing and obtaining income, health, education, etc. [31]. In particular, Jakarta is considered to be a province with the highest gross domestic product (GDP) and the lowest poverty rate in Indonesia [32, 33]. Considering several facts on epidemiological, socio-economic, climate, and behavior factors, it is necessary to conduct a study to determine the correlation of rainfall and socio-economic factors with incidence rate and cost of illness due to DHF in Jakarta.

Methods

The study was approved by the Independent Ethics Committee of Faculty of Medicine, Padjadjaran University, (65/Un6.C10/PN/2017). Six districts (Central Jakarta, North Jakarta, West Jakarta, South Jakarta, East Jakarta, and Kepulauan Seribu) in Jakarta were considered in this study as the study site. An observational cross-sectional study was conducted to analyze the correlation between rainfall volume and socioeconomic factors with incidence rate and cost of illness due to DHF in Jakarta. Data from January 2015 to December 2016 was taken into account. Data related to total cases or hospitalized patients at all hospitals (public and private hospitals) were obtained from the surveillance section, Department of Health (DoH). The incidence rate was calculated by considering the number of cases and population in each district. Rainfall data, which represented the monthly volume of rainwater (millimeter) in each district, were collected from the Department of Meteorological, Climatological, and Geophysics. Socio-economic data (*e.g.*, population, population density, development growth, poverty rate, HDI, annual expenditure per capita, and GDP) were obtained from Statistics Indonesia. The cost of illness due to DHF was viewed from two perspectives (payer and societal). From the payer perspective, it was based on INA-CBGs tariff by calculating the average cost from all types of treatment classrooms (1, 2 or 3) and hospital (A, B, C, and D) [34, 35]. From a societal perspective, data from a previous study by Najib *et al.* in 2016 was taken into account [36]. Data were analyzed using SPSS 24.0, Microsoft Excel, and Package R. The percentage, mean, SD, highest and lowest scores from each variable were presented in this study. Bivariate correlation analysis of each variable was conducted by using Spearman, a non-parametric correlation.

Results

Total DHF patients in 2015 and 2016, which were considered as patients with a confirmed diagnosis of dengue by physicians during hospitalization with International Classification of Diseases diagnosis (ICD) ICD-10-CM-A91, can be seen in **Tables 1a and 1b**.

Table 1a: Total DHF patients in Jakarta (by month)

Months	Total patient DHF (%)	
	2015	2016
January	443 (8.80)	980 (4.80)
February	528 (10.50)	2,219 (10.87)
March	755 (15.02)	3,089 (15.13)
April	1,006 (20.00)	3,781 (18.51)
May	725 (14.42)	2,162 (10.59)
June	548 (10.90)	1,606 (7.86)
July	331 (6.58)	1,184 (5.80)
August	173 (3.44)	1,233 (6.04)
September	133 (2.65)	1,103 (5.40)
October	116 (2.31)	1,036 (5.07)
November	113 (2.24)	1,153 (5.65)
December	157 (3.12)	877 (4.29)
Total	**5,028**	**20,423**

Table 1b: Total DHF patients in Jakarta (by district)

District	Total patient DHF (%)	
	2015	2016
Central Jakarta	405 (8.05)	1,222 (5.98)
North Jakarta	968 (19.25)	2,821 (13.81)
West Jakarta	1,283 (25.52)	5,563 (27.24)
South Jakarta	1,140 (22.67)	4,378 (21.43)
East Jakarta	1,226 (24.38)	6,429 (31.48)
Kepulauan Seribu	6 (0.12)	10 (0.05)
Total	**5,028**	**20,423**

The result showed that the highest number of DHF patients can be found in April for both years at 1,006 (20%) and 3,781 (18.51%), in 2015 and 2016, respectively. Districts with the highest number of patients were West Jakarta (1,283) and East Jakarta (6,429), in 2015 and 2016, respectively.

We calculated IR of DHF in all districts since the DoH categorized districts based on IR into three categories: (i) high risk district (IR <20 per 100,000 population); (ii) medium risk district (IR: 20-55 per 100,000 population); and (iii) low risk district (IR < 20 per 100,000 population) [6]. The calculation of IR in 2015 and 2016 is shown in **Figure 1a**. Districts with the highest IR were North Jakarta (55.40 per 100,000 population) and East Jakarta (224.22 per 100,000 population) in 2015 and 2016, respectively. Based on the DoH classification, all districts in Jakarta can be categorized as high-risk districts. We also calculated CFR, as shown in **Figure 1b**. East Jakarta was considered to be a district with the highest CFR in 2015 (0.109) and 2016 (0.489).

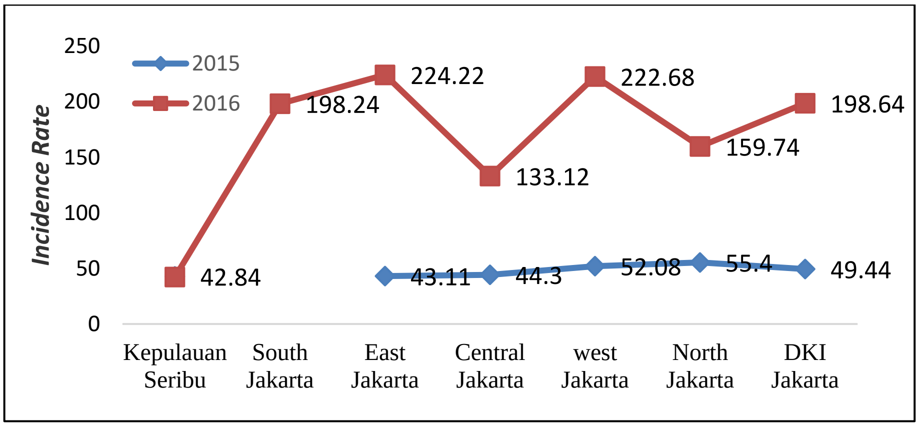

Figure 1a. IR of DHF in all districts in Jakarta

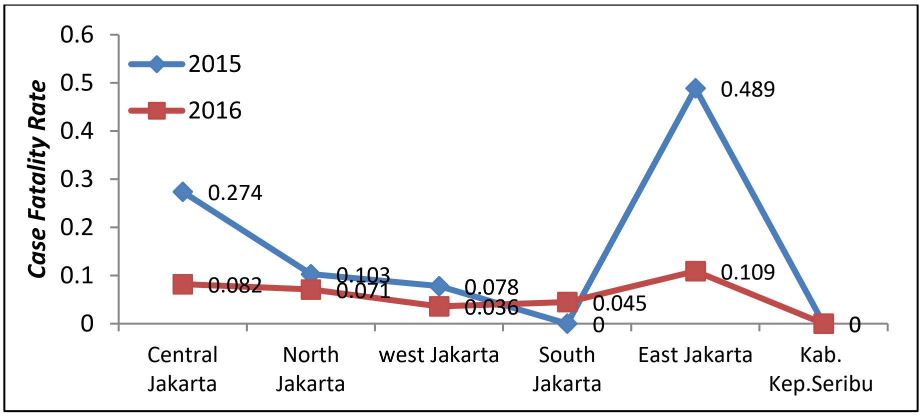

Figure 1b. CFR of DHF in all districts in Jakarta

Regarding the rainfall, the result showed that the highest amount of rainfall can be found in February for both years with 3,105 mm and 2,277 mm in 2015 and 2016, respectively. Districts with the highest amount of rainfall were South Jakarta (1,850 mm) and East Jakarta (2,773 mm), in 2015 and 2016, respectively. Rainfall data from Kepulauan Seribu was not considered due to limited data (see **Table 2**).

Table 2a Total amount of rainfall in Jakarta (by month)

Months	Rainfall (millimeter)	
	2015	2016
January	1,597	717
February	2,229	1,872
March	1,112	790
April	438	739
May	463	672
June	61	712
July	0	753
August	26	955
September	0	1,475
October	0	884
November	371	989
December	797	430
Total	**7,094**	**10,988**

Table 2b Total *amount of rainfall* in Jakarta (by district)

District	Rainfall (millimeter)	
	2015	2016
Central Jakarta	1,458	2,660
North Jakarta	1,125	1,564
West Jakarta	1,255	1,506
South Jakarta	1,850	2,485
East Jakarta	1406	2,773
Total	**7,094**	**10,988**

Demographic and socio-economic situations in all districts in Jakarta are shown in **Table 3**. The results showed that districts with the highest total population and highest population density in both years were in East Jakarta and Central Jakarta. Districts with the highest growth rate population were Kepulauan Seribu and West Jakarta in 2015 and 2016, respectively (see **Table 3a**). The highest HDI, annual expenditure per capita and GDP were found in South Jakarta for both years. While the highest mean years of schooling the lowest poverty rate was found in East Jakarta for both years (see **Table 3b**).

Table 3a: Demographic situation in all districts in Jakarta

District	Total Population (people)		Population Density (population/ per km²)		Growth Rate population (%)	
	2015	2016	2015	2016	2015	2016
Central Jakarta	914,182	917,753	18,993.11	19,068.23	0.42	0.39
North Jakarta	1,747,315	1,764,614	11,913.83	12,032.01	1.03	0.99
West Jakarta	2,463,560	2,496,002	19,017.92	19,268.20	1.36	1,32
South Jakarta	2,185,711	2,206,731	15,472.17	15,620.67	1.00	0,96
East Jakarta	2,843,816	2,868,910	15,124.15	15,257.72	0.92	0,88
Kepulauan Seribu	23,340	23,616	2,683.96	2,714.48	1.43	1.18

Table 3b: Socio-economic situation in all districts in Jakarta

District	Human Development Index (HDI)		Annual expenditure per capita (IDR)		Mean years of schooling (years)	
	2015	2016	2015	2016	2015	2016
Central Jakarta	79.69	80.22	16,143,000	16,493,000	10.88	11.01
North Jakarta	78.3	78.78	17,205,000	17,418,000	10.05	10.23
West Jakarta	79.72	80.34	19,006,000	19,501,000	10.15	10.36
South Jakarta	83.37	83.94	22,425,000	22,932,000	11.23	11.42
East Jakarta	80.73	81.28	16,455,000	16,733,000	11.32	11.52
Kepulauan Seribu	68.84	69.52	11,433,000	11,608,000	8.04	8.24
District	**Percentage poverty population**		**Total poverty population**		**Gross Domestic Regional Product (IDR)**	
	2015	2016	2015	2016	2015	2016
Central Jakarta	4.16	3.91	3,801,000	3,582,000	485,496,642	532,943,240
North Jakarta	5.91	3.57	10,297,000	9,811,000	378,437,670	412,466,460
West Jakarta	3.64	3.38	8,939,000	8,408,000	328,396,835	359,245,162
South Jakarta	3.41	3.27	7.446,000	7,196,000	443,059,371	485,323,433
East Jakarta	3.24	3.19	9,144,000	9,137,000	345,949,241	380,922,034
Kepulauan Seribu	11.4	12.58	265,000	296,000	6,258,665	6,542,434

The cost of illness due to DHF was estimated from societal and payer perspectives can be found in **Table 4**. According to an investigation conducted by Nadjib *et al.* in 2016 [36], we estimated that the total cost of illness due to DHF from the societal perspective would be IDR 6,962,555 (direct cost: IDR 5,528,269 and indirect cost: IDR 1,434,286). West Jakarta and East Jakarta were considered to be districts with the highest cost of illness from the societal perspective in 2015 and 2016, respectively (see **Table 4a**). From the payer perspective, we calculated that the total cost of illness due to DHF would be IDR 2,416,934 per patient. West Jakarta and East Jakarta were also considered to be districts with the highest cost of illness from a payer perspective in 2015 and 2016, respectively (see **Table 4b**).

Table 4a Cost of illness due to DHF from the societal perspective

District	Cost	Cost of illness (Indonesian Rupiah/IDR)	
		2015	2016
Central Jakarta	Indirect	514,908,791	1,653,732,138
	Direct	1,984,648.463	6,755,544,867
North Jakarta	Indirect	1,388,389,167	3,582,847,252
	Direct	5,351,364,101	15,595,246,002
West Jakarta	Indirect	1,840,189,361	7,978,934,853
	Direct	7,092,768,742	30,758,776,778
South Jakarta	Indirect	1,612,137,852	4,289,950,413
	Direct	6,445,961,304	21,615,520,617
East Jakarta	Indirect	1,758,435,040	9,170,911.057
	Direct	6,777,657,426	35,541,239,473
Kepulauan Seribu	Indirect	8,605,717	14,342,863
	Direct	33,169,621	55,282,687

Table 4b Cost of illness due to DHF from the payer perspective

District	Cost of illness (Indonesian Rupiah/IDR)	
	2015	2016
Central Jakarta	978,858,185	2,368,595,555
North Jakarta	2,339,592,344	6,818,171,491
West Jakarta	3,100,926,609	13,445,405,177
South Jakarta	2,755,305,033	10,581,338,102
East Jakarta	2,963,161,489	14,072,880,077
Kepulauan Seribu	14,501,605	21,752,408

Correlation between rainfall, demographic, socioeconomic with incidence rate, total patient, and cost of illness can be seen in **Table 5**.

The results demonstrated that rainfall has significant correlations with IR, total patient, and cost of illness from both perspectives. In particular, IR also has a significant correlation with the cost of illness from both perspectives. In demographic variables, the total population has a significant correlation with IR and total patient, whereas population density and population growth have insignificant correlations with IR and total patient. In socio-economic variables, HDI and mean years of schooling have positive significant correlations with the total patient, while the poverty rate has a negative significant correlation. Moreover, annual expenditure per capita and GDP have significant correlations with IR and total patient.

Table 5 Correlation of rainfall, demographics, socio-economic with incidence rate and cost of illness

Independent variabel	Dependent variabel	rho *	*p* value
Rainfall	Incidence rate	0.521	0.000**
	Total patient	0.690	0.000**
	Indirect cost societal perspective	0.601	0.000**
	Direct Cost societal perspective	0.587	0.000**
	Direct Cost payer perspective	0.566	0.000**
Incidence rate	Indirect cost societal perspective	0.839	0.000**
	Direct Cost societal perspective	0.842	0.000**
	Direct Cost payer perspective	0.817	0.000**
Total population (people)	Incidence rate	0.594	0.042**
	Total patient	0.860	0.000**
Population density (population/ per km²)	Incidence rate	0.490	0.106
	Total patient	0.510	0.090
Population Growth Rate (%)	Incidence rate	-0.322	0.308
	Total patient	-0.224	0.484
Human Development Index	Incidence rate	0.573	0.051
	Total patient	0.678	0.015**
Expenditure per capita (year) (IDR)	Incidence rate	0.671	0.017**
	Total patient	0.657	0.002**
Mean years of schooling(years)	Incidence rate	0.559	0.059
	Total patient	0.636	0.026**
Percentage poverty population	Incidence rate	-0.636	0.026**
	Total patient	-0.853	0.000**
Total poverty population	Incidence rate	0.434	0.159
	Total patient	0.517	0.085
Gross domestic regional product / GDRP (IDR)	Incidence rate	0.503	0.095
	Total patient	0.443	0.245

* *rho spearman* corellation

** *p* value < 0,005

Discussion

This study confirmed that the highest number of DHF patients can be found in April. Additionally, February and March have been reported to be months with high rainfall that might cause many puddles of water as a breeding site for vectors or mosquitoes in April. However, information on the most endemic time is important for the government on making epidemiological predictions and planning prevention strategies. The results of this study are in line with the result of a previous study, which mentioned that the highest number of dengue cases in Indonesia is usually found in a cycle of January until April. January is considered as the period in which eradication of larvae and source mosquitoes should be done before the transition period [37, 38]. Regarding the IR, the value of IR in Jakarta in 2015 was calculated to be smaller than national value. In 2016, the value increased significantly. This situation is caused by a large number of outbreaks in 2016, as occurred in many countries in the same year. The number of dengue cases in the Region of America has been reported to be more than 2.38 million in 2016, where Brazil alone contributed slightly less than 1.5 million cases, almost three times higher than in 2014-2015. More than 375,000 suspected cases of dengue in the West Pacific Region occurred in 2016, which was much higher than in 2015. The Solomon Islands in 2016 also declared an outbreak with more than 7,000 suspected cases [39, 40].

The average annual rainfall rates in Jakarta from this study were estimated to be 1418.8 mm and 2197.6 mm in 2015 and 2016, respectively. This trend is in line with the total number of DHF patients in 2016 that was higher than in 2015. Notably, it has been confirmed in several published studies that climate factors may potentially increase dengue transmission through one variable of the system while simultaneously decrease transmission through other variables [41, 42]. In China, high rainfall caused dengue outbreaks and the climate changes influenced mosquito breeding sites, as reported in 2014 [43].

This study also confirmed that a district with the highest total population was reported to be a district with the highest total patient and IR of DHF. A previous study in Bangkok and Singapore has mentioned that a high-density area is the best place for mosquito breeding that can increase the risk of spread infectious diseases [41]. This result becomes important since in many cases, socio-economic factors have been highlighted to lead to behavior, lifestyle, mobility, and community activities, as reported in a study conducted in Colombia [16]. However, socio-economic and environmental factors can support effectively targeted prevention and measures control [20].

In this study, the cost of disease due to DHF was calculated from societal and payer perspectives. Obviously, the higher total patient was followed by the higher cost of illness from both perspectives in all districts. This study showed that West Jakarta and East Jakarta were districts with the highest cost of illness in 2015 and 2016, respectively. Total costs of illness due to DHF in 2015 in West Jakarta were calculated to be IDR 7,092,768,742 and IDR 3,100,926,610 from societal and payer perspectives, respectively. Total costs of illness in 2016 in East Jakarta were calculated to be IDR 35,541,239,473 and IDR 15,560,222,637 from societal and payer perspectives, respectively. Those numbers explicitly confirmed that DHF in

Jakarta has yielded a high economic burden from both perspectives. The results of this study reconfirmed the results of many previous studies, which highlighted the substantial economic burden due to dengue infection in many countries [44-51]. Specifically, a study conducted in Vietnam reported that the costs of illness due to dengue infection would increase gradually year per year as the consequence of the increasing number of dengue cases in this region [47]. A previous study, which compared the dengue episode and its economic burden in two setting countries in Asia (rich and poorer countries), confirmed that lower dengue episodes in rich countries would give higher economic burden than in poorer countries [50]. The study described that dengue infection would give more economic burden in higher-income regions. As one of the highest-income provinces in Indonesia, our study showed a significant economic burden due to dengue infection in all districts in Jakarta.

This study showed a significant correlation (strongly positive) between rainfall with IR, total patient, and cost of illness from both perspectives. This study can extend the results from two previous studies in Singapore and Bangkok, which mentioned that rainfall can be considered as the most influential factor affecting dengue transmission in these regions [41, 42]. Rainfall also has the potential to increase the relative humidity, which extends mosquitoes life [42]. However, higher dengue transmission would significantly lead to higher epidemiology and economic burden.

In demographic variables, the total population has a significant correlation with IR and total patient. In socio-economic variables, HDI and mean years of schooling have significantly positive correlations with the total patient, while the poverty rate has a significantly negative correlation. Moreover, annual expenditure per capita and GDP have a significant correlation with IR and total patient. A previous study conducted in New Caledonia has reported that demographic and socio-economic importance factors on spreading dengue infection. Specifically, all those variables were strongly correlated with other variables reflecting the different life, socio-economic, and cultural differences in New Caledonia, strongly correlated with the type of housing [26]. However, DHF incidence was ecologically associated with demographic and socio-economic characteristics of the population. Areas with a high proportion of low socio-economic tend to have a high incidence of DHF, as this study also reported.

Conclusion

The results indicated that rainfall has a significant correlation with IR, total patient, and cost of illness from both perspectives. In particular, IR also has a significant correlation with the cost of illness from both perspectives. The total population has a significant correlation with IR and total patient. Annual expenditure per capita and GDP have significant correlations with IR and total patient.

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Conflict of Interest

The authors report no conflicts of interest in this work.

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