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Social and Environmental Determinants of Dengue Infection Risk in North Sumatera Province, Indonesia

[1]Fazidah A. Siregar, [2]Mohamed Rusli Abdullah, [2]Julia Omar, [1]Sori Muda Sarumpaet, [3]Teguh Supriyadi, [4]Tri Makmur and [5]Nurul Huda

[1]Faculty of Public Health, University of Sumatera Utara, Medan, North Sumatera, 20155, Indonesia
[2]School of Medical Science, University Sains Malaysia, Kubang Kerian, 16150, Malaysia
[3]Department of Health, North Sumatera Province, Medan, 20155, Indonesia
[4]Faculty of Medicine, Islamic University of Sumatera Utara, Medan, North Sumatera, Indonesia
[5]Food Technology Program, Universiti Sains Malaysia, Penang, 11800, Malaysia

Corresponding Author: Fazidah A. Siregar, Faculty of Public Health, University of Sumatera Utara, Medan, North Sumatera, 20155, Indonesia

ABSTRACT

The incidence rate of dengue hemorrhagic fever in North Sumatera Province remains high. Socio-demographic and socio-cultural factors, as well as knowledge, attitudes, practices and environmental factors, influence incidence of dengue hemorrhagic fever. For effective control measures, effort should be concentrated on the disease risk factors. The objective of this study was to determine the risk factors for dengue hemorrhagic fever incidence based on their socio-demographic and socio-cultural factors, as well as knowledge, attitudes, practices and environmental factors and to determine whether the characteristics of caregivers influence the risk of dengue hemorrhagic fever. The study was designed as a case cohort study. The total number of study recruits was 682 at a case: sub-cohort ratio of 1:1 and all subjects were selected via purposeful and systematic sampling. Data analysis was performed using simple and multiple logistic regressions with α at 5% to determine the predictors of dengue hemorrhagic fever incidence in North Sumatera Province. The results of the study revealed that history of dengue hemorrhagic fever in the family, travel history of family members, frequency of garbage disposal and source of drinking water were the determinant factors for dengue hemorrhagic fever incidence in North Sumatera Province. Moreover, education and knowledge regarding dengue achieved through the involvement of caregivers played an important role in reducing the incidence of dengue hemorrhagic fever. Based on these findings, it is recommended to enhance health promotion regarding dengue prevention in the community.

Key words: Dengue infection, hemorrhagic fever, social-cultural, case-cohort study, health promotion

INTRODUCTION

Dengue Hemorrhagic Fever (DHF) is recognized in many countries and more than 100 countries are endemic for dengue virus infection (Guzman and Isturiz, 2010; Guzman *et al*., 2010). It is estimated that about 3.6 billion people live in high-risk areas for dengue infection and approximately 230 million dengue fever infections occur worldwide each year (Wilder-Smith *et al*., 2012). Moreover, DHF has become a leading cause of morbidity among children in several countries

in Southeast Asia, with Indonesia ranked second for DHF cases in Asia according to the WHO (MHI., 2010). Based on a 2011 report by the Ministry of Health, North Sumatera Province is ranked at third highest for DHF cases in Indonesia (MHI., 2011).

The factors responsible for DHF incidence are complex. However, factors such as population density, inadequate water supply and waste management, lack of effective control programs, climate change and poor socio-economic status is identified as key determinants for DHF (Guzman and Kouri, 2002; Torres and Castro, 2007).

Several studies investigated the factors involved in DHF incidence. Siqueira *et al*. (2004), found that older age, low education and low income is significantly associated with dengue fever incidence. Phuong *et al*. (2008), found that occupation (farmer), number of children less than 15 years old in households, lack of experience with dengue fever in households, presence of a garden near the house and presence of water containers with mosquito larvae is associated with a higher risk of dengue fever in Vietnam. Other factors that contribute to increase DHF incidence include poor sanitation, housing pattern, poverty, illiteracy, cultural practice and climate.

Socio-economic factors affects the abundance of *Aedes aegypti* mosquitoes and influence disease transmission related to housing with unhygienic living conditions and poor household design. The presence of solid around the household and prolonged storage of water for domestic use can create potential breeding grounds for *Aedes aegypti*, thereby increasing the transmission of dengue infections (Nagao *et al*., 2003; Mondini and Neto, 2007).

Environmental conditions like temperature, humidity and precipitation etc., also play a vital role in the incidence of DHF, as reported by Thammapalo *et al*. (2008) in a study in southern Brazil. Shop-houses, brick houses and houses with poor garbage disposal are at higher risk for contracting DHF. Schmidt *et al*. (2011) examined the association among population density, water supply and dengue risk and argued that risk of dengue is higher in rural areas than in urban settings due to lack of piped water supply. Spiegel *et al*. (2007) investigated the association of social and environmental factors with the presence of *Aedes aegypti* and found a higher risk for DHF due to a lack of preventive measures such as larvicide in water tanks.

Public awareness regarding dengue, perception of the problem and dengue prevention practices are important factors in the epidemiology of dengue. Several studies is investigated the knowledge, attitudes and practices concerning dengue in communities. Shuaib *et al*. (2010) in a study in Jamaica found there was no correlation between knowledge and preventive practices. These findings are similar to those reported by Hairi *et al*. (2003) that found that there was no association between knowledge about dengue and attitude toward *Aedes aegypti* control and concluded that appropriate knowledge does not always lead to effective practices. Al-Dubai *et al*. (2013), in a population in Malaysia, found that knowledge regarding dengue is associated with effective practices for dengue prevention. Similarly, Van Benthem *et al*. (2005) found a correlation between knowledge of dengue and preventive measures.

DHF is a major health problem in North Sumatera Province and despite major prevention efforts, the incidence of DHF remains high. For effective control measures and to reduce the incidence of DHF, efforts should be concentrated on the disease risk factors, particularly those risk factors related to social and environmental conditions. Therefore, the present study was designed to identify the social and environmental determinants of dengue infections.

MATERIALS AND METHODS

The present cohort study was carried out in six districts in North Sumatera Province from December, 2009 to June, 2011. Both DHF cases and the sub-cohort subjects were selected from 3

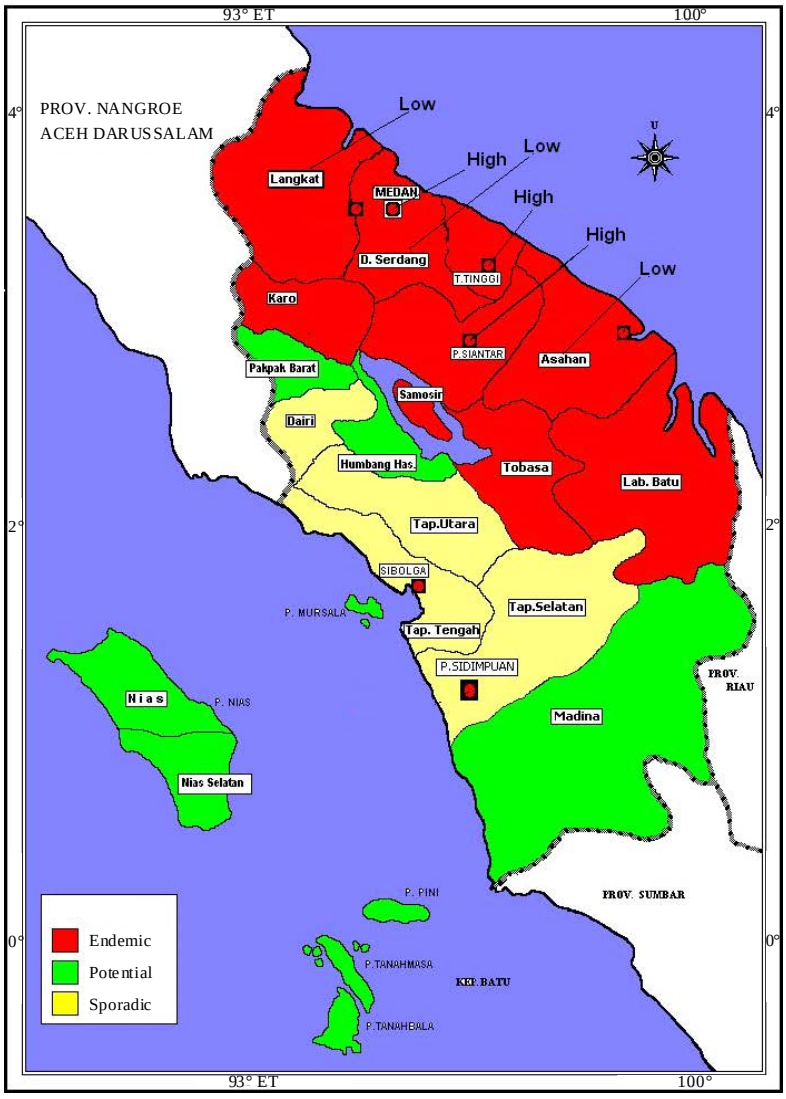

Fig. 1: Subjects location in North Sumatera Province, Indonesia

high-incidence districts and 3 low-incidence districts based on DHF incidence data from 2007. Medan, Pematang Siantar and Tebing Tinggi were selected as the high-incidence districts; Langkat, Asahan and Deli Serdang were selected as the low-incidence districts (Fig. 1).

Cases and sub-cohorts: Cases were patients who had DHF symptoms and were confirmed positive for DHF according to WHO criteria and whenever available, based on the detection of IgG/IgM antibodies in dengue serum with a Panbio Dengue Duo cassette test, Australia. This confirmation test was available for patients admitted to the pediatric infection and medical wards at Dr Pirngadi Hospital. Cases from health facilities in Medan and other districts were ascertained using WHO criteria. The sensitivity and specificity of DHF detection based on IgG/IgM compared to detection according to WHO criteria were evaluated. The subcohort consisted of age-matched

people, who lived close to the residence of our DHF cases and were without any DHF symptoms or history of the disease. Subjects in the subcohort were confirmed DHF free through the detection of IgM and IgM antibodies in blood samples using the Panbio Dengue Duo cassette. For each case of DHF, one age-matched sub-cohort subject was selected. Caregivers were the closest person taking care of the patient and knew the case/sub-cohort the best. Cases were systematically selected from the DHF registry report according to date of admission to the hospital or health facility. The age-matched subcohorts were carefully selected.

Sample size: The sample size for our case cohort study was calculated using the two-proportion formula (Naing, 2006), with an average Odds Ratio (OR) of 1.6. The proportion of poor housing in the subcohort group (p_0) was 0.27 (Spiegel *et al*., 2007), with an allowable error of 5% and a power of study of 80%. Therefore, a total of 341 cases and 341 subcohorts were included in this study. The number of cases and subcohorts for each district was proportionally calculated based on the DHF incidence data from 2007.

Study instruments: The socio-demographic data and the knowledge, attitudes and practices were collected by interview and recorded using questionnaires administered by the researchers that were developed based on questionnaires published research (Matta *et al*., 2006; Siqueira *et al*., 2004; Van Benthem *et al*., 2002). The socio-demographic factors included age, sex, marital status, ethnicity, education level, occupational status, income, length of stay, number of family members in the house, number of children under 15 years in the house and incidence of DHF in the family. Income evaluation was performed using the minimum wage standard of North Sumatera Province (Siqueira *et al*., 2004). The socio-cultural factors included travel history of family members, hang-drying of clothes, frequency of water container cleaning, frequency of garbage disposal and frequency of cleaning of the refrigerator water tray (Bohra and Andrianasolo, 2001). Knowledge was assessed via twenty questions regarding cause, symptoms, mode of transmission, mosquito bites, breeding sites of mosquitoes, re-infection and practice measures. These questions could be answered with yes (scoring 1 point) and no or do not know (scoring 0 points). Knowledge was classified as good when 80% or more of the answers were correct, moderate, when 60-80% answers were correct and low when less than 60% of the answers were correct (Phuong *et al*., 2008). For attitude, 11 questions were asked regarding the perception of dengue, including the severity of the disease, re-infection, impact of mosquito bites, preventive measures, control of DHF and responsibility. Scoring for positive statements included strongly agree (5 points), agree (4 points), uncertain (3 points), disagree (2 points) and strongly disagree (1 point); scoring for negative statements included strongly agree (1 point), agree (2 points), uncertain (3 points), disagree (4 points) and strongly disagree (5 points). Then, the results were classified using a similar range as for the classification of knowledge. For the factor of practice, 14 preventive measures were assessed with scoring for answers as always (4 points), usually (3 points), sometimes (2 points), seldom (1 point) and never/unavailable (0 points). Then, using a similar range, the results were classified as taking maximal, moderate or minimal preventive measures.

The environmental data include house construction, house style, cleanliness around the house, presence of garbage, source of drinking water, presence of window and door screens, presence of gutters and presence of water containers with larvae were collected by observation using a structured check-list (Siqueira *et al*., 2004; Thammapalo *et al*., 2008; Van Benthem *et al*., 2005).

Statistical analysis: Statistical Package for Social Science (SPSS) program for data analysis (Release 22.0, SPSS Inc. Chicago, Illinois, USA) was used. Data were presented either as frequency distribution, percentages or proportion and were summarized using tables and diagrams. The knowledge, attitude and practice scores were calculated and classified into 3 categories; good (≥80%), moderate (60-79%) and poor (<60%) (Phuong *et al.*, 2008). Simple and multiple logistic regressions were used to analyze the factors associated with DHF incidence. Initially, the data were analyzed using simple logistic regression to select the significant variables with p value less than 0.25. Then, the significant variables were included in a multiple logistic regression for further investigation (Norsa'adah, 2011).

RESULTS

In this study, DHF cases were diagnosed based on the detection of IgG/IgM and according to WHO criteria. However, because not all sites could perform laboratory confirmation, it was necessary to compare the sensitivity of the two methods. Our results showed that the sensitivity of the Panbio Dengue Duo Cassette for diagnosing DHF patients was high (92.1%). Similarly, the positive predictive value of WHO criteria for diagnosing DHF was high (90.6%). Thus, the accuracy of WHO case definition criteria in diagnosing DHF was acceptable (Table 1).

DHF cases were determined by the detection of IgG/IgM in serum, whereas the sub-cohorts were determined by negative IgG/IgM detection in blood samples. To ensure accuracy, it was necessary to compare the sensitivity of the two methods. Our results revealed that whole blood had higher sensitivity than serum in diagnosing DHF. We assumed that the sensitivity of whole blood and fingertip blood was similar (Table 2).

A total of 682 samples were included in this study and consisted of 341 DHF cases and 341 sub-cohorts. The mean (SD) of samples was 18.3 (15.2) years old and most of them were females (57.9%). While of the 682 caregivers the mean (SD) was 38.3 (14.6) years old. The majority of the caregivers were Javanese (49.6%) and female (97.8%). They were married (92.8%), had lived there for more than 5 years (69.1%), had a low level of education (87.5%), were not working (66.0%) and came from households with a monthly income of 2 minimum wages or less (81.8%). Most of the caregivers (85%) had 4 or more family members, with 3 or fewer (90.5%) children under 15 years. Among them, 25.2% had experienced DHF in family (Table 3).

Table 1: Sensitivity test of panbio dengue duo cassette

	WHO criteria		
Rapid kits	Thrombocyte<100 μL	Thrombocyte≥100 μL	Total
Serology (+)			
Primary	7	1	8
Secondary	51	5	56
Serology (-)	5	1	6
Total	63	7	70

Sensitivity (dengue infection) = 58/63×100% = 92.1%, Positive predictive value = 58/64×100% = 90.6%

Table 2: Sensitivity and specificity test of the IgG/IgM immunology test using whole blood and serology from 29 DHF cases

	Serology			
Whole blood	Primary	Secondary	Negative	Total
Primary	2	0	0	2
Secondary	0	23	0	23
Negative	0	3	1	4
Total	2	26	1	29

Sensitivity of whole blood (primary): 2/2×100% = 100%, Sensitivity of whole blood (secondary): 23/26×100% = 88.5%, Specificity of whole blood: 1/1×100% = 100%

Table 3: Socio-demographic characteristics of the respondents/caregivers (n = 682)

Characteristics	No.	%
Age of sample	18.3	15.2
Sex of caregivers		
Male	287	42.1
Female	395	57.9
Age of caregivers	38.3	14.6[a]
Sex of caregivers		
Male	15	2.2
Female	667	97.8
Ethnicity		
Javanese	338	49.6
Batakish	166	24.3
Mandailing	65	9.5
Minangnese	43	6.3
Malaya	41	6.0
Others	29	4.3
Marital status		
Single	21	3.1
Married	633	92.8
Divorced	1	0.1
Widow	27	4.0
Occupation		
Government official	45	6.6
Non-government official	26	3.8
Self-employed	118	17.3
Unemployed	13	1.9
Housewife	437	64.1
Other	43	6.3
Occupation		
Working	232	34.0
Not working	450	66.0
Education		
High	85	12.5
Low	597	87.5
Income		
<2 minimum wage	558	81.8
≥2minimum wage	124	18.2
Length of stay		
≤5 years	211	30.9
>5 years	471	69.1
History of DHF in family		
Yes	172	25.2
No	510	74.8
No. of family members		
<4 persons	102	15.0
≥4 persons	580	85.0
No. of children under 15 years old		
≤3 persons	617	90.5
>3 persons	65	9.5

Although travel history contributed to DHF incidence, only 5.4% of caregivers reported family members traveling to other endemic areas. Habits that promote *Aedes aegypti* breeding, such as hang-drying clothes, cleaning water containers, within 5-15 days and garbage disposal within 5-15 days were found to be 67.3, 25.1 and 14.2%, respectively. Most of the subjects had no refrigerator (62.8%); however, some of the refrigerator owners cleaned their refrigerator trays less than once every 2 weeks (16.9%), as seen in Table 4. Despite most of the respondent having good knowledge and attitudes regarding dengue fever, a majority of them did not achieve optimal dengue prevention (Table 5).

Concrete houses with an interconnecting construction style were most common. There were garbage dumps and no animal shelters in most cases. Nearly half of the households used bottled

Table 4: Socio-cultural characteristics of caregivers (n = 682)

Characteristics	No.	%
Travel history of household/family member		
Yes	37	5.4
No	645	94.6
Hanging clothing		
Yes	459	67.3
No	223	32.7
Frequency of cleaning of water container		
Unused	2	0.3
1-4 days	481	70.5
5-15 days	171	25.1
>15 days	28	4.1
Frequency of garbage disposal		
Unused	125	18.3
1-4 days	454	66.6
5-15 days	97	14.2
>15 days	6	0.9
Frequency of cleaning of refrigerator tray		
Unused	428	62.8
1-4 days	38	5.6
5-15 days	101	14.8
>15 days	115	16.9

Table 5: Knowledge, attitudes and practices of caregivers

Characteristics	No.	%
Knowledge		
High	272	39.9
Moderate	247	36.2
Low	163	23.9
Attitude		
Good	251	36.8
Fair	429	62.9
Poor	2	0.3
Practice		
Maximal	25	3.7
Moderate	235	34.5
Minimal	422	61.9

water (48.8%) as their source of drinking water and 30.5% obtained drinking water from piped water supply. Most of the houses did not have screened doors, windows or gutters (Table 6).

The results of our simple logistic regression revealed the following independent variables with p-values less than 0.25: Income, history of DHF in the family, number of family members, travel history of family members, frequency of garbage disposal, house style, cleanliness around the house, source of drinking water, presence of screened doors and gutters and number of containers containing larvae (Table 7). These significant variables were included in our multiple logistic regression and the forward method revealed four significant variables with p-values less than 0.05. Thus, the risk factors in DHF cases compared to subcohorts were as follows: history of DHF in the family, travel history of family members, frequency of garbage disposal and source of drinking water (Table 8). With the involvement of caregivers, there were six significant variables, including education and knowledge about dengue fever. Thus, education and knowledge play a role in the incidence of DHF (Table 9). This is contradictory as found by Shuaib *et al.* (2010) there was no correlation knowledge and preventive measures.

Table 6: House characteristics and environment

Characteristics	No.	%
House material		
Wood	63	9.2
Brick	212	31.1
Concrete	272	39.9
Mixed	135	19.8
House style		
Independent house	295	43.3
Interconnection house	369	54.1
Slum house	8	1.2
Shop house	9	1.3
Others	1	0.1
Around the house		
Garden	57	8.4
Rice fields	3	0.4
Grass	8	1.2
Others	614	90.0
Animal shelter		
Yes	137	20.1
No	545	79.9
Availability garbage dump		
Yes	477	69.9
No	205	30.1
Cleanliness around the house		
Clean	459	67.3
Not clean	223	32.9
Source of drinking water		
Well	126	18.4
Pump	15	2.2
Pipe	208	30.5
Others	333	48.8
Door screen		
Yes	162	23.8
No	520	76.2
Window screen		
Yes	188	27.6
No	494	72.4
Use of gutters		
Yes	118	17.3
No	564	82.7
No. of positive containers	128	7.0

DISCUSSION

In the present study, history of DHF in the family, travel history of family members, frequency of garbage disposal and source of drinking water are associated with DHF incidence. With the involvement of caregivers, education and knowledge also play a role in the incidence of DHF.

The presence of family members, who suffer from dengue fever increases the probability of dengue infection for other family members. In the current study, the case group included 48.7% cases (significantly higher, $p<0.05$) with a previous history of DHF in the family compared with just 1.8% in the subcohort group. Siqueira *et al.* (2004) also found that a history of DHF in the family was associated with the risk of dengue infection. However, this finding was not consistent with Phuong *et al.* (2008) in Binh Thuan Province, Vietnam, where they did not find an association between a history of DHF in the family and dengue risk infection.

Dengue exposure was associated with traveling. The majority of the dengue infections occur in residents of dengue endemic areas. However, recently, dengue fever was also found among travelers (Freedman *et al.*, 2006). Traveling to endemic areas poses a risk of DHF. In the present

Table 7: Factors associated with DHF incidence in North Sumatera Province in cases and subcohorts according to simple logistic regression

	Cases		Subcohort		Crude		
Variables	No.	%	No.	%	OR	95% CI	p-value of Wald statistics
Income							
>2 minimum wages	74	21.7	50	14.7			
<2 minimum wages	267	78.3	291	85.3	0.62	0.42, 0.92	0.018
History of DHF in family							
No	175	51.3	335	98.2			
Yes	166	48.7	6	1.8	52.96	22.99, 122.04	0.000
No. of family members							
<4 persons	42	12.3	60	17.6			
≥4 persons	299	87.7	281	82.4	1.52	0.99, 2.33	0.054
Travel history of household/family members							
No	311	91.2	334	97.9			
Yes	30	8.8	7	2.1	4.60	1.99, 10.63	0.000
Frequency garbage disposal							
Unused/1-4 days	263	77.1	316	92.7		0.000	
5-15 days	74	21.7	23	6.7	3.87	2.36, 6.35	0.000
>15 days	4	1.2	2	0.6	2.40	0.44, 13.23	0.314
House style							
Independent	162	47.5	133	39.0		0.222	
Interconnected	170	49.8	199	58.4	0.70	0.52, 0.95	0.024
Slum	3	0.9	5	1.4	0.49	0.12, 2.10	0.338
Shop	6	1.8	4	1.2	1.03	0.27, 3.90	0.970
Cleanliness around the house							
Clean	209	61.3	250	73.3			
Not clean	132	38.7	91	26.7	1.74	1.26, 2.40	0.001
Source of drinking water							
Other/bottled water	155	45.5	178	52.2		0.092	
Well	64	18.8	62	18.2	1.19	0.79, 1.79	0.416
Pump	5	1.5	10	2.9	0.57	0.19, 1.72	0.321
Pipe	117	34.2	91	26.7	1.48	1.04, 2.09	0.028
Door screen							
Yes	91	26.7	71	20.8			
No	250	73.3	270	79.2	0.72	0.51, 1.03	0.073
Gutter							
Yes	70	20.5	48	14.1			
No	271	79.5	293	85.9	1.58	1.05, 2.36	0.027
No. of positive containers	75	58.6	53	41.4	1.27	0.95, 1.71	0.110

Table 8: Factors associated with DHF incidence in cases and subcohorts in North Sumatera Province according to multiple logistic regression

	Cases		Subcohort		Adjusted		
Variables	No.	%	No.	%	OR	95% CI	p-value
History of DHF in family							
No	175	51.3	335	98.2			
Yes	166	48.7	6	1.8	58.150	24.96, 135.52	0.000
Frequency of garbage disposal							
Unused/1-4 days	263	77.1	316	92.7		0.000	
5-15 days	74	21.7	23	6.7	4.360	2.50, 7.64	0.000
>15 days	4	1.2	2	0.6	2.330	0.32, 16.92	0.403
Travel history of household/family members							
No	311	91.2	334	97.9			
Yes	30	8.8	7	2.1	3.460	1.30, 9.26	0.013
Source of drinking water							
Other/bottled water	155	45.5	178	52.2		0.011	
Well	64	18.8	62	18.2	1.270	0.74, 2.10	0.405
Pump	5	1.5	10	2.9	0.530	0.14, 1.98	0.345
Pipe	117	34.2	91	26.7	1.940	1.27, 2.96	0.002

Forward LR multiple logistic regression was applied. Multi-collinearity was checked and not found. The interaction was found. Hosmer Lemeshow test (p = 0.085), classification table (overall correctly classified percentage = 77.7), area under the ROC curve (80.9%) was applied to check the model fit

Table 9: Factors associated with DHF incidence in cases and subcohorts correspond to characteristics of caregivers in North Sumatera Province according to multiple logistic regression

	Cases		Subcohort		Adjusted		
Variables	No.	%	No.	%	OR	95% CI	p-value
History of DHF in family							
No	175	51.3	335	98.2			
Yes	166	48.7	6	1.8	56.35	23.95, 132.62	0.000
Knowledge about dengue fever							
High	105	30.8	167	49.0	2.0	0.000	
Moderate	122	35.8	125	36.6	5	1.29, 3.25	0.003
Low	114	33.4	49	14.4	4.46	2.59, 7.66	0.000
Travel history of household/family members							
No	311	91.2	334	97.9			
Yes	30	8.8	7	2.1	4.07	1.44, 11.46	0.008
Frequency of garbage disposal							
Unused/1-4 days	263	77.1	316	92.7		0.000	
5-15 days	74	21.7	23	6.7	4.03	2.26, 7.19	0.000
>15 days	4	1.2	2	0.6	2.73	0.73, 20.07	0.323
Education							
High level	53	15.5	32	9.4			
Low level	288	84.5	309	90.6	2.79	1.52, 5.11	0.002
Source of drinking water							
Other/bottled water	155	45.5	178	52.2		0.020	
Well	64	18.8	62	18.2	1.10	0.64, 1.89	0.728
Pump	5	1.5	10	2.9	0.52	0.13, 2.17	0.373
Pipe	117	34.2	91	26.7	1.89	1.21, 2.93	0.005

Forward LR multiple logistic regression was applied, Multi-collinearity was checked and not found, Interaction was found, Hosmer Lemeshow test (p = 0.235), classification table (overall correctly classified percentage = 77.6), Area under the ROC curve (85.6%) was applied to check the model fit

study, the proportions of respondents, with a regular travel history in the DHF cases and the subcohort group were 8.8 and 2.1%, respectively and traveling was significantly associated with DHF incidence ($p<0.05$). Da Silva-Nunes *et al.* (2008), found that travel to endemic areas was associated with dengue infection. Pongsumpun and Tang (2005), used a mathematical model to determine the risk of dengue for tourists visiting endemic areas and found a significant association between travel history and dengue incidence ($p<0.05$). Likewise, Lindback *et al.* (2003), investigating 292 people who traveled outside Sweden, found that traveling more than 25 days was a significant factor for dengue fever.

Waste management is associated with dengue transmission as waste, such as plastic bottles and discarded plastic, provides habitats for dengue vector. Poor waste management creates a breeding ground for *Aedes* mosquitoes (Bohra and Andrianasolo, 2001). Thus, waste management has an impact on the presence of *Aedes* mosquitoes and dengue transmission. In this study, a frequency of disposal of garbage of less than once per 7 days was higher in the case group compared with the subcohort group (21.7 versus 6.7%, respectively) and was found to be significantly associated with DHF incidence ($p<0.05$). Similar findings were reported by Cordeiro *et al.* (2011) and Suwannapong *et al.* (2014) in Thailand.

In the case group, 34.2% used piped water as their source of drinking water, whereas in subcohort group, this number was only 26.7%. There was an association between piped water as the source of drinking water and DHF incidence. In reality, even though the respondents were using piped water, the water supply was not regular. Thus, these residents often stored water in water containers, providing breeding places for *Aedes* mosquitoes. Inadequate water supply was associated with the presence of breeding habitats for *Aedes aegypti* (Khan and Hasan, 2011). Spiegel *et al.* (2007) performed a study to determine the association of social and environmental

factors with the presence of *Aedes aegypti* and found that leaky water pipes were associated with an increased risk of infestation. Likewise, Schmidt *et al.* (2011) found that the risk of dengue was higher in rural than in urban areas due to a lack of piped water supply.

Typically, the level of education is linked to knowledge. Therefore, it was assumed that a higher level of education would lead to a greater knowledge of dengue prevention. In this study, both the case and the subcohort groups had low education levels, at 84.5 and 90.6%, respectively. There was significant association between education level and DHF incidence ($p<0.05$). Siqueira *et al.* (2004), in central Brazil, found that low education was significantly associated with dengue infection. Similarly, a cross-sectional study conducted in central Nepal reported that preventive practice was associated with education level (Dhimal *et al.*, 2014). Furthermore, preventive measures are related to knowledge and education level. Lack of knowledge will have an impact on the practice of dengue prevention, as actions based on knowledge are more effective than those without knowledge. In the present study, the caregivers in the case group and the subcohort group (33.4 and 14.4%, respectively) had low levels of knowledge regarding preventive measures. Moreover, there was a correlation between knowledge and practice. This finding was supported by Koenraadt *et al.* (2006) in two districts in Kamphaeng Phet Province, where they found that increasing knowledge improves practices for reducing the number of unprotected containers, thus reducing potential vector breeding grounds.

Overall it can be concluded social and environmental factors play a role in the incidence of DHF. This findings could be used as a recommendation for health organization enhance their public intervention for reducing the incidence of DHF in North Sumatera Province, Indonesia.

CONCLUSION

Our study revealed that history of DHF in family, travel history of family members, frequency of garbage disposal, source of drinking water, education and knowledge play important roles in the incidence of DHF. History of DHF in the family was the greatest risk factor for DHF, followed by knowledge and travel history of family members. For effective control measures to reduce the incidence of DHF, it is important to increase the knowledge of the community regarding dengue prevention. Thus, to reduce and control DHF, health promotion regarding dengue prevention should be enhanced.

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