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A Retrospective Analysis of Dengue Cases in Suriname: Implications for Treatment and Prevention in a Upper Middle Income Country (UMIC)

Diana Hamer[1*], Arti E. R. Jessurun[2], Manodj Hindori[3], John Codrington[4], Jimmy Roosblad[4] and Maureen Lichtveld[1]

[1]Department of Global Environmental Health, Tulane University School of Public Health and Tropical Medicine, New Orleans, LA 70115, USA.
[2]Department of Pediatrics, St. Vincentius Hospital, Paramaribo, Suriname.
[3]St. Vincentius Hospital, Paramaribo, Suriname.
[4]Academic Hospital Laboratory, Academic Hospital of Paramaribo, Paramaribo, Suriname.

Authors' contributions

This work was carried out in collaboration between all authors. Authors DH and ML designed the study and wrote the protocol. Authors JC, AERJ, MH and JR contributed the data used for this study and provided protocol feedback. Author DH did the statistical analysis and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To describe hospitalized dengue cases and characterize the hospitalization length and cost of dengue based on clinical and laboratory classification in a primary hospital in Paramaribo, Suriname.
Study Design: A retrospective study was conducted to identify patients at higher risk of dengue hemorrhagic fever (DHF) and to compare the length and cost of hospitalization by dengue

**Corresponding author: Email: dhamer@tulane.edu;*

classification and dengue severity.
Methodology: We analyzed 2800 dengue cases hospitalized between 2001 to 2012. All dengue cases were spatially visualized using a geographic information system (GIS).Dengue cases were stratified by demographic characteristics and classified as suspected, probable and confirmed. This classification was used to compare length and cost of hospitalization.
Results: The majority of hospitalized dengue cases, 50.1%, were ethnic Hindustani or Javansese (Southeast Asian descent). Dengue was laboratory confirmed in a 188 cases between 2001 and 2012. However, ethnicity is not associated with progression into DHF in hospitalized cases with a confirmed diagnosis of dengue. When comparing length of hospitalization, suspected dengue cases stayed on average longer hospitalized (7.81 days) than probable (6.65 days) and confirmed cases (6.29 days). In contrast, confirmed cases had the highest cost of hospitalization (3100 Surinamese dollars – SRD) compared to suspected (2766 SRD) and confirmed (2157 SRD) cases. Suspected and probable dengue fever cases had longer hospital stays compared to the more severe DHF. There is a difference in the length and cost of hospitalization among suspected, probable and confirmed dengue cases and dengue fever cases have longer hospitalization terms than DHF for suspected and probable cases.
Conclusion: This study contributed to the limited evidence of the demographic characteristics and the economic burden of dengue in Suriname. There is a need to standardize and increase diagnosis capabilities to improve surveillance and treatment of dengue while reducing hospitalization costs in Suriname.

Keywords: Dengue; cost of dengue; Suriname; GIS.

1. INTRODUCTION

Dengue has become hyperendemic in Suriname. The distribution of dengue is heavily influenced by degree of urbanization and meteorological factors. Currently, 2.5 billion people live in endemic regions and an estimated 50 – 390 million dengue infections occur yearly [1,2]. There are four different types of dengue virus (DENV type 1 – 4) capable of causing dengue fever (DF) or the more severe forms of the disease (dengue hemorrhagic fever and dengue shock syndrome – DHF and DSS) in humans [3]. Co-circulation of serotypes within a population increases the risk of a secondary heterologous infection, which is the most important risk factor for DHF and DSS [4]. Furthermore, the dengue serotype [5,6], the sequential order in which different serotypes are encountered within a population [7-9] and the time elapsed between primary and secondary dengue infections[10-12] are associated with increased pathogenicity and the development of DHF and DSS.

In Suriname, DENV-1 was the first documented serotype introduced in 1978 and subsequently DENV-4 was first reported in 1981 [13]. Shortly upon introduction of a serotype, epidemics of dengue in the local population correlated with rapid increase of DENV lineage numbers [14]. Dispersal histories reconstruction demonstrate the strongest dissemination links of DENV between the Lesser Antilles islands and Suriname [15] suggesting that language and economic relationships influence the diffusion of DENVs [14]. When DENV was first introduced in Suriname in 1980, the general population was immunologically naïve. However, after all four DENV serotypes were introduced, the current population is immunologically sensitized and a higher proportion of the population is more likely to show severe manifestations upon infection with DENV. Due to the endemicity of the DENV, most health care practitioners and physicians are familiar with the symptoms of DF and DHF/DSS. Dengue infections are often asymptomatic or it can present mild symptoms including a high fever, headache, muscle and joint pains, vomiting or rash. This febrile phase can also be accompanied by more severe symptoms such as petechiae, hepatomegaly and a continuous drop of white blood cell count resulting in leukopenia and even shock [2]. Thus, dengue morbidity can come at a significant cost (both directly and indirectly) to the infected person and can exert a high cost on society by exhausting national healthcare capabilities.

During the last confirmed dengue outbreak in 2012 the Surinamese Ministry of Health (MoH) was prompted to open an emergency hospital to accommodate all suspected dengue cases [16]. The result was an unplanned allocation of workforce (heath care practitioners) and workplace (hospital beds, diagnostic capabilities) resources to contain the dengue epidemic at a

significant financial cost. Inadequate surveillance of dengue leads to clinical mismanagement during epidemic and non-epidemic periods. As exemplified in Suriname, during a dengue epidemic cases of dengue become grossly over-reported when diagnostic resources become strained and patients are hospitalized based solely on symptoms in an attempt to curb the epidemic resulting in social disruption, lost tourism and lost work and school productivity. In non-epidemic times, however, dengue is under-reported due to a lack of good surveillance resulting in an underestimation of the burden of disease and limiting effective prevention practices [17]. In an study of the economic burden of dengue in the Americas, the estimated average direct medical cost per dengue case (in 2010 US$) in Suriname was $92 and $463 for ambulatory and hospitalized cases, respectively [18]. These cost are much higher when indirect medical and non-medical cost were included. Addressing the rising direct and indirect cost of dengue in Suriname is a priority exemplified in Selck et al. which classified Suriname in the highest dengue expenditure per thousand population quintile from a 108 country cost analysis [19].

This study describes hospitalized dengue cases in a private hospital in Suriname that adheres to the WHO's 1997 classification of dengue fever (DF), dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS). The objective of this study is to identify patients at higher risk of DHF and or DSS. All case were hospitalized in the Sint Vincentius Ziekenhuis (SVZ – Saint Vincent Hospital), a private hospital located in the capital Paramaribo. The hospital has 186 beds, with 17 specialists and a staff of about 600 from which more than half are nurses. The hospital was founded in 1916. Gradually, SVZ services have expanded with modern clinical facitlities. In 2014, the hospital expanded its services with a new 24-hour emergency unit providing services to a large number of patients in Paramaribo.

We characterized the frequency of hospitalization of suspected, probable and confirmed dengue cases and stratified by demographic characteristics from 2001 to 2012. All cases were spatially distributed using a geographic information system (GIS) to facilitate visualization and analysis. Furthermore, hospitalization and diagnostic practices were used to compare the length and cost of hospitalization by dengue classification. The findings will illustrate the need to improve dengue surveillance, diagnostic and prevention practices in Suriname.

2. METHODOLOGY

This study took place in Paramaribo (5°52'N, 55°10'W), the capital city of Suriname. Paramaribo has a tropical climate defined by a short and a long rainy season (SRS and LRS – from December to January and from April to August, respectively) and a short and long dry season (SDS and LDS – from February to March and September to November, respectively). The Bureau of Public Health (BOG), under the Ministry of Health (MoH), is in charge of vector control and dengue epidemiological surveillance. Suriname has 6 hospitals with a total of 1,687 beds [20]. The MoH subsidizes and coordinates through the BOG 56 Regional Health Service clinics in the coastal region and the Medical Mission clinics in the interior to provide primary care to the poor or near poor [21]. Of the six hospitals, four, two private and two public, are located in Paramaribo [20]. One hospital, Sint Vincentius Hospital (SVZ), was involved in this study.

Since 2001, SVZ has kept a digital database of all in-patient cases of dengue fever and DHF/DSS. All patients admitted with an initial diagnosis of suspected dengue fever are given a unique reference code. Additionally, demographic information, current address, hospital admission and discharge date, and test results are recorded. An initial dengue diagnosis is based on symptomology following the WHO criteria of two or more of the following: headache, retro-orbital pain, myalgia, arthralgia, rash, hemorrhagic manifestations and/or leucopenia. Blood serum is collected for detection of dengue IgG or IgM antibodies using the QuickTest™ Dengue IgG/IgM Plasma/Serum (Orgenics Ltd.). In 2011, the Academic Hospital Paramaribo (AZP) introduced reverse transcription polymerase chain reaction (RT-PCR) for the detection of the dengue virus.

Blood samples from SVZ suspected dengue cases were analyzed by the AZP laboratory for molecular diagnosis. The Medical Laboratory of AZP is the largest clinical laboratory of the country, conducting hematological, serological, bacteriological and clinical chemistry research. A cross-reference of SVZ patients using name and date of birth was performed to identify RT-PCR results from the AZP laboratory database. For the purpose of this study, a patient was classified

as 'suspected' when the QuickTest™ and RT-PCR were negative. A compatible serology (positive QuickTest™ result) classified the patient as 'probable' and a positive RT-PCR detection of the dengue virus in the serum was used to classify a case as 'confirmed'. Dengue cases for which a diagnostic test was performed but the result was not documented was excluded from our analysis.

From 2001 to 2012, there were a total of 2822 dengue-suspected hospitalization. The addresses of all hospitalized cases (suspected, probable and confirmed) were coded according to the Suriname General Bureau of Statistics (ABS) codebook. Suriname is divided into ten districts. Each district is further divided into resorts (similar to a municipality). Digital maps of the Suriname's districts and resorts were used to incorporate all dengue cases with an identifiable address into a geographic information system (GIS). A cluster analysis using Anselin Local Moran's I was used to identify spatial clustering of dengue cases from 2001-2012 using resorts as the base map. All dengue cases were visualized and cluster analysis was performed using ArcGIS v10.2 (http://www.esri.com).

All hospitalized cases (suspected, probable and confirmed) were stratified according to gender, race, age, death, dengue serotype and season. A chi-square analysis to test for the association between patient demographic characteristics and DHF/DSS was performed using only confirmed cases.

Dengue cases were stratified by year and the percentage of cases tested for dengue (either by QuickTest™ or, since 20111, RT-PCR) was calculated. We counted the amount of hospitalization days for each dengue case and obtained the total and mean yearly length of hospitalization. Furthermore, daily hospitalization costs (not including diagnostic tests or treatment) were used to estimate the total and mean yearly hospitalization cost of dengue cases. The mean length and cost of hospitalization was stratified by case classification. The Kolmogorov-Smirnov and Shapiro-Wilk test determined that the hospitalization length data was not normally distributed ($p<0.0001$). Therefore, the medians and inter-quartile ranges (IQR) were calculated and anon-parametric Kruskal-Wallis test was used to compare the hospital length to the three case classifications with a significance level of ≤0.05. We followed up with a Mann-Whitney test on pairs of groups with a Bonferroni correction. A Furthermore, a Mann-Whitney U-test was used to understand whether suspected, probable or confirmed dengue cases median length and cost of hospitalization differ by severity (dengue fever and DHF/DSS).

3. RESULTS

We performed a retrospective analysis of all dengue cases hospitalized at SVZ from 2001 to 2012. A total of 2822 cases were admitted with an initial diagnosis of dengue fever of which 22 were excluded because there was no documentation of the dengue diagnostic test result. For more than half of all hospitalized cases (1637 or 58.0%) there was no recorded test and 464 cases (16.4%) had a negative QuickTest™ or RT-PCR result. Therefore, 2101 dengue cases (2007 dengue fever and 94 DHF/DSS) were classified as suspected. Of the remaining 25% of cases, 511 (18.10%) were classified as probable and 188 (6.7%) as confirmed (Fig. 1).

Of the 2800 dengue cases, 2477 had an address that was coded and incorporated into ArcGIS (Fig. 2A). The Global Moran's I ($I = 0.809$, $z>1.96$, $P=.05$) indicated spatial autocorrelation of dengue cases from 2001 to 2012. Using the local Moran's I, the resorts of dengue cases admitted to SVZ were Blauwgrond, Munder, Rainville, Welgelegen, Tammenga, Flora and Latour (Fig. 2B). Based on the geographic distribution, the majority of hospitalized cases come from the resort, or a neighboring resort, in which SVZ is located (Blauwgrond).

Dengue cases by classification were further stratified by gender, race, age, serotype and season (Table 1). The majority of hospitalizations due to dengue fever occurred in ethnic Hindustani or Javanese, in adults, and during the LDS. Furthermore, since the implementation of RT-PCR dengue diagnosis in 2011 only serotypes 2, 3, and 4 have been detected in hospitalized cases. Only 38 deaths in patients hospitalized with an initial diagnosis of dengue fever were recorded between 2001 and 2012, with none of the deaths having been had a positive laboratory confirmed dengue diagnostic. Dengue infections can manifest with non-specific symptoms making clinical diagnosis unreliable. Furthermore, rapid tests vary in their sensitivity and specificity. Therefore, only confirmed cases of dengue were used to compare demographic characteristics by ethnicity and severity (frequency of DF compared to DHF/DSS cases)

(Table 2). In the hospitalized confirmed dengue cases, Chinese males are more frequently hospitalized compared to females. However, no significant association was detected between ethnicity and severity (DHF/DSS) of dengue. Similarly, Chinese adults (>14) are more likely than Chinese children to be hospitalized (p>0.05). Even though when comparing confirmed dengue cases by severity, we observed a statistically higher frequency of children presenting with DHF/DSS compared to adults (*P*=.05). There was no association between season (excluding the LDS for Chi-square analysis) and disease severity (*P*=.05), which indicates that seasonal variations can have an effect on the number of dengue cases (Table 1) but does not influence the progression of severe disease.

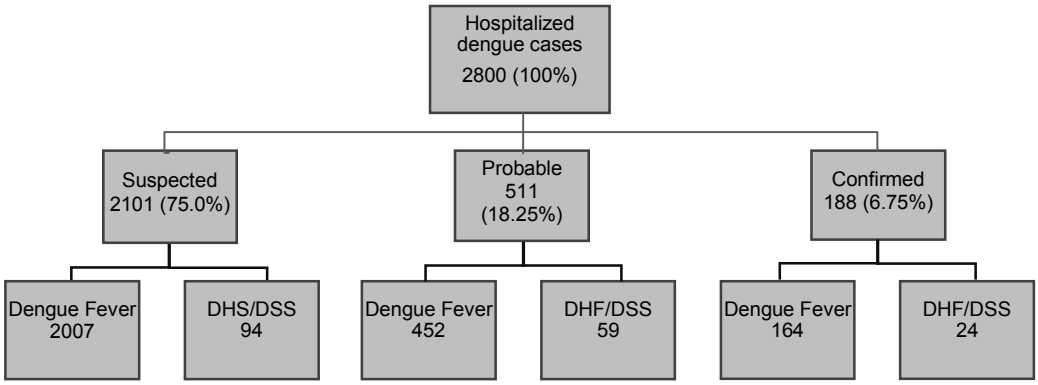

Fig. 1. SVZ hospitalized dengue cases by classification and dengue fever (DF) and dengue hemorrhagic fever/dengue shock syndrome (DHF/DSS) from 2001 to 2012

Table 1. Frequencies of hospitalized cases by demographic and case classification

		Suspected	Probable	Confirmed	Total
Gender	Male	1047	277	114	1438
	Female	1054	234	74	1362
Race	Creole	356	50	22	428
	Hindustani	598	156	48	802
	Javanese	464	102	34	600
	Chinese	218	106	29	353
	European	43	12	6	61
	Indian	34	6	7	47
	Maroon	19	3	2	24
	Other/Unknown*	369	76	40	485
Age	≤14	617	205	61	883
	>14	1484	306	127	1917
Death	No	2069	505	188	2562
	Yes	32	6	0	38
Serotype	2	-	-	170	170
	3	-	-	6	6
	4	-	-	8	8
Season	SRS	351	101	60	512
	SDS	502	68	60	630
	LRS	781	163	62	1006
	LDS	467	179	6	652

**Other/Unknown – includes individuals who self-reported race is not included in the 7 specified, or individuals for which race was not reported, SRS – short rain season, SDS – short dry season, LRS – long rain season, LDS – long dry season*

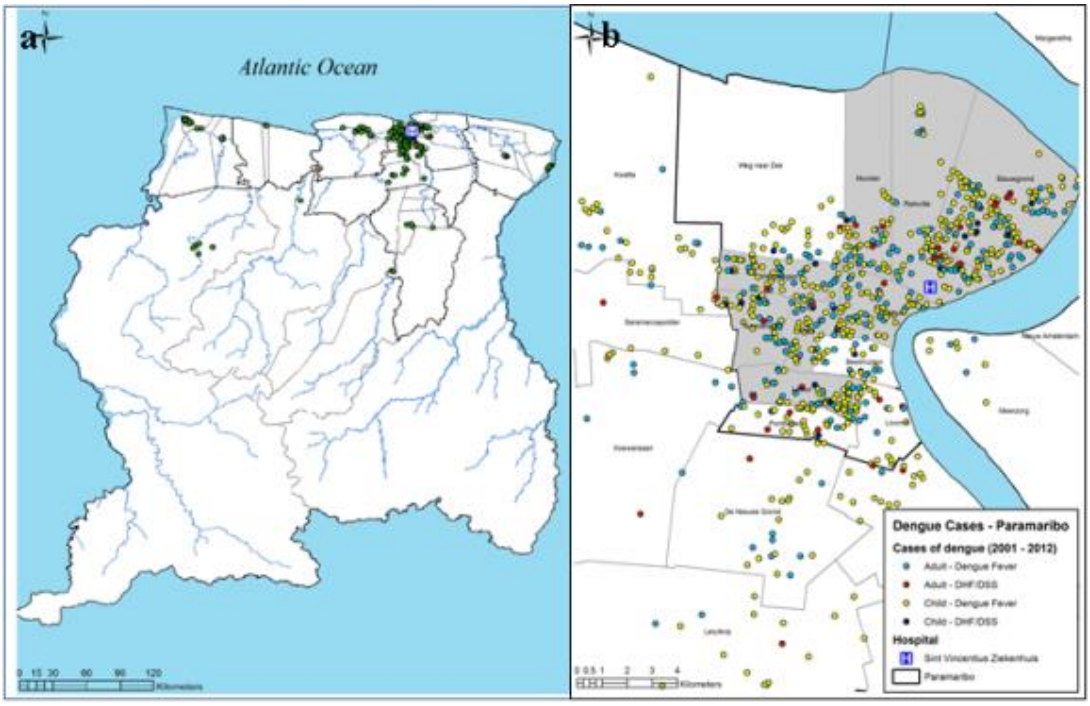

Fig. 2. a) shows the spatial distribution of all hospitalized dengue cases from 2001 to 2012; b) shows the spatial distribution of cases in paramaribo (by age groups and severity) highlighting the resorts with highest case density surrounding the hospital from 2001 to 2012

All cases of dengue were stratified by year. The largest outbreak of dengue fever was recorded in 2005 with an estimated infection of 10% of the population affected by the disease. Between 2005 and 2010, the percentage of hospitalized cases tested for dengue infection increased compared to 2001 – 2004 but remained below 50% except for 2006, the year following the large outbreak. The introduction of RT-PCR diagnosis technology in the AZP laboratory allowed for more dengue diagnostic analysis to be performed and increased the percentage of total (either with QuickTest™ and RT-PCR) cases tested above 50% for 2011 and 2012 (Table 3). However, the total percentage of dengue cases tested remains low at 41%.

Table 3 depicts the total and mean hospitalization length for all dengue cases (suspected, probable and confirmed) between 2001 and 2012. A total of 29,559 hospitalization days were recorded for all 2822 hospitalized cases with a mean of 10.47 days/case. Since 2008, the 'hotel' hospitalization cost has gone up with a total expenditure of 4,525,275.00 Surinamese dollars (SRD) for the 1362 patients admitted into SVZ with an initial dengue diagnosis between 2001 and 2012.On average, each year 3322.52 SRD was spent per patient. These costs, however, do not include nor reflect changes over the years in cost for diagnosis, treatment or medical consults. We calculated the mean and median length and cost of hospitalization for the three dengue classifications. Suspected cases, dengue cases for which there was either no diagnostic test performed or laboratory result came back negative, stayed on average longer hospitalized compared to probable and confirmed cases (Tables 4 & 5). However, confirmed dengue casescost was the highest. This higher cost per confirmed case reflects the higher daily hospital cost in 2011 and 2012, which, coincidentally, corresponds with the introduction of RT-PCR diagnosis that provides a confirmation of a case of dengue. This indicates that the higher cost per confirmed dengue case compared to suspected and probable cases is not related to a longer hospitalization stay but rather to an increase in the daily cost of hospitalization. Furthermore, we observed a significant difference between the length and cost of hospitalization for suspected and probable cases with DF compared to those with DHF (*P*=.05). However, no differences were detected for confirmed dengue cases (Table 6). Such difference could be attributed a change in

the clinical manage of dengue once it has been confirmed by a laboratory test.

4. DISCUSSION

To our knowledge, this is the first study to explore demographic characteristics and hospitalization practices of dengue cases in a hospital in Suriname. Most of the dengue cases (75%) admitted to SVZ did not have a laboratory confirmed dengue diagnosis. Since the DENV was first introduced into the population, the annual number of dengue cases has steadily increased with two of the largest outbreaks, in 2005 and 2012, taking place in the last ten years [16,22,23]. Both outbreaks exhausted national healthcare capabilities and in 2012 even prompted the MoH to open an emergency hospital to treat the high number of dengue cases. This upward trend is of concern. Most of the Surinamese population (70%) lives in an urban area [24]. This urbanization and the climate conditions characteristic of the tropics facilitates and sustains the emergence of DF. Additionally, the effects of climate change could cause more frequent and more severe dengue outbreaks [25-27]. As in Southeast Asia where dengue has been endemic since the 1950s, specific demographic characteristics, such as race [28], gender and age [29,30] are established risk factors in the development of DHF/DSS. Therefore, as the DENV becomes established in Suriname the local population becomes immunologically sensitized changing the dengue disease dynamics. As indicated by the hospitalization information on confirmed dengue cases, children are more likely to present DHF/DSS compared to adults. However, due to the low percentage of cases confirmed by a diagnostic laboratory dengue test, we can only draw limited conclusions about demographic risk factors for severe dengue in the SVZ patient population.

Table 2. Frequencies of hospitalized cases by gender and age stratified by ethnicity and demographic stratified by severity (DF and DHF/DSS)

					Ethnicity		
		N	**Creole**	**Hindustani**	**Javanese**	**Chinese**	**P-value***
Gender	Male	1140	215	413	297	215	0.01
	Female	1062	217	395	309	141	
Age	≤14	655	127	260	193	75	<0.001
	>14	1547	305	548	413	281	
					Severity		
		N	**DF**		**DHF/DSS**		**p-value**
Gender	Male	114	100		14		0.80
	Female	74	64		10		
Race	Creole	22	20		2		0.70
	Hindustani	48	43		5		
	Javanese	34	28		6		
	Chinese	29	26		3		
Age	<14	61	44		17		<0.001
	>14	127	120		7		
Other							
Serotype	1	0	0		0		
	2	170	146		24		-
	3	6	6		0		
	4	8	8		0		
Season	SRS	60	48		12		0.16**
	SDS	60	54		6		
	LRS	62	56		6		
	LDS	6	6		0		

**Chi-square test p<0.05, **LDS not included in Chi-square analysis, DF – dengue fever, DHF/DSS – dengue hemorrhagic fever/dengue shock syndrome, SRS – short rain season, SDS – short dry season, LRS – long rain season, LDS – long dry season*

Table 3. Frequency of hospitalized cases, dengue diagnostic test, and total and mean hospitalization length and cost stratified by year

Year	N	IgG/IgM RT-PCR NEG	IgM/IgG POS	RT-PCR POS	% Tested	Length of stay (days)	Mean length of stay (days/ case)	Hospital cost SVZ (SRD/ day)	Hospital cost (SRD)	Mean hospital cost (SRD/ case)
2001	220	17	6	0	10.5	1775	8.08	-	-	-
2002	197	2	7	0	4.6	1590	8.07	-	-	-
2003	101	4	2	0	5.9	770	7.78	-	-	-
2004	115	10	9	0	16.5	1119	9.73	-	-	-
2005	507	143	236	0	74.7	4278	8.47	-	-	-
2006	198	67	49	0	58.6	1735	8.81	-	-	-
2007	114	43	11	0	47.4	1074	9.50	-	-	-
2008	171	32	28	0	35.1	1431	8.37	275	393525	2301.31
2009	312	20	50	0	22.4	2053	6.58	350	718550	2303.05
2010	189	6	17	0	12.2	1277	6.79	350	446950	2364.81
2011	177	46	45	25	65.5	1129	6.41	450	508050	2870.33
2012	521	74	51	163	55.3	3318	6.37	500	1659000	3184.26
Total	2822	464	511	188	41.2	21550	7.66	-	-	-

IgG/IgM – Immunoglobulin G/Immunoglobulin M, RT-PCR – reverse transcription polymerase chain reaction, NEG – negative, POS – positive, SVZ – SintVincentiusZiekenhuis (saint vincent hospital) SRD – Suriname dollars

Table 4. Length (in days) and cost (in SRD) of hospitalization stratified by dengue classification

	Length of hospitalization (2001-2012)				
	N	**Median (IQR)**	**Mean (STD)**	**Chi-square‡**	**p-value**
Suspected	2094	6 (5-9)	7.81 (5.31)	17.33	<0.001*
Probable	510	6 (5-8)	6.65 (3.55)		
Confirmed	188	6 (5-7)	6.29 (2.81)		
Total	2792	6 (4-8)	7.50 (4.92)		
	Cost of hospitalization (2008-2012)				
Suspected	981	2450 (1650-3150)	2766.33 (1852.17)	66.43	<0.001*
Probable	191	1925 (1400-2500)	2157.59 (1067.85)		
Confirmed	188	3000 (2500-3500)	3100.26 (1395.29)		
Total	1360	2450 (1650-3150)	2724.10 (1720.00)		

‡Kruskal-Wallis H-test, SRD – Surinamese dollars

Table 5. Mann-Whitney U-test of differences in mean rank of hospitalization length and cost by classification

	Length of hospitalization in days/person (2001-2012)				
	N	Mean Rank	Z-score	p-value	Direction
Suspected	2101	1326.42	-3.309	0.001*	S>P
Probable	510	1204.3			
Suspected	2101	1153.5	-2.92	0.003*	S>C
Confirmed	188	1007.84			
Probable	510	352.89	-0.737	0.461	-
Confirmed	188	340.32			
Cost of hospitalization in SRD/person (2008-2012)					
Suspected	981	605.61	-4.38	<0.001*	S>P
Probable	191	488.37			
Suspected	981	559.67	-5.86	<0.001*	S<C
Confirmed	188	717.18			
Probable	191	142.37	-8.55	<0.001*	P<C
Confirmed	188	238.39			

**significance based on bonferroni correction*

Table 6. Mann-Whitney U-test of differences in mean rank hospitalization lenght and costs by classification stratified by severity

	Length of hospitalization in days per person (2001-2012)					
	N	**Mean**	**Mean rank**	**Z-score**	**p-value**	**Direction**
Suspected						
DF	2000	7.88	1058.01	-3.68	<0.001	DF>DHF
DHF	94	6.44	823.98			
Probable						
DF	451	6.88	268.70	-5.63	<0.001	DF>DHF
DHF	59	4.86	154.63			
Confirmed						
DF	164	6.41	97.06	-1.709	0.08	-
DHF	24	5.46	77.00			
Cost of hospitalization in SRD per person (2008-2012)						
Suspected						
DF	2000	2797.30	498.90	-2.93	0.003	DF>DHF
DHF	94	2417.50	401.99			
Probable						
DF	451	2245.86	101.12	2.27	0.023	DF<DHF
DHF	59	1879.34	154.63			
Confirmed						
DF	164	2691.66	97.14	1.755	0.079	-
DHF	24	3100.26	76.46			

SRD – Surinamese dollars; DF – dengue fever; DHF – dengue hemorrhagic fever

From a health policy perspective, the length and cost of hospitalization analyses in this study highlight the need to increase diagnostic capabilities in this hospital as well as other hospital and clinics in Suriname. The 2005 outbreak increased national awareness of dengue increasing the annual percentage of symptomatic cases tested for the disease. The adoption of RT-PCR technology at the AZP has enabled national diagnostic capabilities allowing both private and public hospitals to confirm a dengue case in a timelier manner. Since the implementation of RT-PCR technology, SVZ has been able to confirm more than 25% of the dengue hospitalized cases and combined with in-house serology test, the laboratory tested cases increased above 50% in 2011 and 2012. The increase in diagnostic capabilities can improve the clinical recognition and treatment of dengue. However, there has been an increased in the mean hospitalization cost per case of dengue even though the length of hospitalization has

decreased mostly due to increasing cost of hospitalizations. The hospitalization cost in this study is a gross underestimation of the cost per case of dengue because we did not include cost of diagnosis, treatment and provider fees. Previous cost studies indicate that due to the care DF and DHF patients require are mostly supportive (intravenous fluids), cost models assume a premium between 20% to 50% above hospitalization cost for developing countries to include all direct medical costs [18,31,32] Furthermore, the burden of dengue is not only measured in direct medical cost (ambulatory and hospitalization cost), but should also include indirect medical costs (any expense related to seeking medical care) and non-medical costs (lost of income, school or job absentee time). Thus, even though the hospitalization cost here presented are an underestimation, they are a partial reflection of the economic burden dengue has on the Surinamese society.

Length and cost of hospitalization differ among suspected, probable and confirmed cases. On average, confirmed dengue cases have the shortest hospitalization length but since confirmation began in 2011, it is possible that the shorter hospitalization terms are due to better clinical practice. Interestingly, when only comparing length of hospitalization by severity of disease, DHF cases have on average a shorter hospitalization term compared to DF for suspected, probable but not confirmed cases. Such discrepancies illustrate the need to implement and standardize diagnostic practices that will enhance clinical management. Moreover, the differentiation between DF and severe dengue (DHF and DSS) has not been precise prompting the WHO to change the classification of dengue to better reflect different levels of severity [22]. The new classification enables an improved standardization of clinical management but its implementation does increase the workload and requires dengue confirmatory tests [33,34].

Standardization of clinical and diagnostic practices of dengue would also strengthen surveillance and research practices in Suriname. As mentioned earlier, patterns of dengue disease differ across geographical regions (Southeast Asia v The Americas), age and race [30,35]. Suriname is a country with a unique ethnic population composed of Hindustani, Javanese, Creole, Maroon, Chinese and Amerindian people. This diverse profile is unlike any other in Latin America presenting the opportunity to examine the relationship between known risk factors, such as race, and severe dengue. Currently, dengue is hyperendemic in Suriname but the disease is relatively new compared to Southeast Asia. Studies have demonstrated that the longer dengue has been endemic in a region the more severe outbreaks become in different age groups with a population [10,11,29] Therefore, enhancing diagnostic practices would strengthen national dengue surveillance, strengthen our understanding of dengue disease pathogenesis and enable the country to inform dengue prevention and control practices based on local research.

There are several limitations to this study associated with the use of retrospective data collected for medical, rather than research, purposes. First, the secondary database utilized did not provide information on patients' comorbidities, symptomology, time of initial onset of symptoms, or course of treatment. We were not able to evaluate additional medical costs, for diagnosis and treatment, nor that patients' indirect and non-medical cost associated with the dengue. Finally, selection bias is possible because our patient population is from only one of the six hospitals in Suriname.

5. CONCLUSION

Since 2001, the majority of cases hospitalized for dengue were people of Southeast Asian descent. However, ethnicity is not associated with DHF in our hospitalized population. Children were more likely to develop DHF compared to adults. Thus, further research is necessary to which demographic characteristics increase the risk of DHF in Suriname. The percentage of hospitalized dengue cases tested using serological diagnosis has increased since 2001. Diagnostic practices were further enhanced by the introduction of RT-PCR technology. There is a need to standardize and increase diagnosis capabilities to improve surveillance and treatment of dengue while reducing hospitalization costs in Suriname.

CONSENT

It is not applicable.

ETHICAL APPROVAL

This study was approved by the Tulane University School of Public Health and Tropical

Medicine Institutional Review Boards and the Ministry of Health Suriname Ethics Board.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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