Demographic Factors Associated with Dengue in Saint Lucia

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Author's contribution

The study was designed and conducted by Brendan Lee.

Original Research Article

ABSTRACT

Aims: To identify demographic variables associated with dengue in Saint Lucia.
Study Design: Retrospective quasi experimental study of secondary data.
Place and Duration of Study: Data was accessed from the Ministry of Health Saint Lucia, the Saint Lucia Tourism Authority and the Central Statistics Office Saint Lucia, 2011-2017.
Methodology: This study included 1869 cases tested for dengue between 2011 and 2017 identified through regular surveillance in Saint Lucia. There were 1310 confirmed cases, of which 667 were male and 643 were female. Data on education, employment, and unemployment levels, population density, hospital access and tourist arrivals were accessed from local Saint Lucian agencies to determine their relationships with the occurrence of dengue.
Results: The largest prevalence of dengue from the sample was found in the district of Castries (29.6%) and 25% of the cases occurring in the adult group (19-44). It was found that over 40 % of the dengue cases occurred in the population when between 12500 to 14000 persons (medium level) had tertiary education. Logistic regression of the data allowed the demonstration of strong significant relationships between age, the 13-18-year age group (*P*<.001, OR 4.091 [CI 2.628-6.369]) and tertiary education (*P*<.001, OR 4.785 [CI 2.896- 7.905]) and occurrence of dengue.
Conclusion: Age and education, along with other variables such as location, tourist visitor arrival, employment status, and population density were found to be associated with dengue in Saint Lucia. Further research is warranted to better characterize these relationships and understand how they could be used to develop predictive models for use in public health prevention programmes.

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1. INTRODUCTION

Dengue is the most widespread arboviral disease with estimates that 40-60% of the earth's population at risk of developing the disease when exposed to the infected Aedes mosquito vector [1-3]. The greatest burden of the disease is arguably the loss of productivity in days absent from work or school especially to countries where the human resource is the main support of the economy [4,5]. Over 125 countries have been found to experience dengue cases of local origin with many of these countries being endemic and the Caribbean is no exception [6-8]. Saint Lucia, one of the islands of the Eastern Caribbean has not been the recent focus of published research on dengue which reduces the potential of public health agencies to effectively manage the disease and its burden within the country.

Saint Lucia is a small, tropical, English-speaking island in the Eastern Caribbean with a population of approximately 165,000 [9]. The island is volcanic and mountainous, with rain-forests in the interior of the island and most of the heavily populated areas situated in coastal areas around the island [10-12]. These conditions are ideal for mosquito oviposition and proliferation of the various stages of its lifecycles, while the concentration of population in relatively limited centers increases the likelihood of mosquito human interaction and transmission of dengue. There are 11 districts across the island Gros Islet, Castries, Anse la Raye, Canaries, Soufriere, Choiseul, Laborie, Vieux Fort, Micoud, Dennery and Babonneau though for the purpose of this study Babonneau was combined with Castries, since some local agencies record data in that manner creating 10 districts [13]. The capital city is found in Castries and there are three towns, Gros-Islet, Soufriere and Vieux Fort. Tourism has replaced agriculture as the main economic industry on the island with both cruise and stay-over visitor sectors being important to the island [14]. Annually Saint Lucia welcomes over 1 million visitors each serving as a possible source of the introduction of the dengue virus. The population is divided 48.7% and 51.3% male and female respectively; 0-14 years: 20.02% (male 17,006/female 16,027), 15-24 years: 15.37% (male 12,870/female 12,492), 25-54 years: 42.97% (male 34,117/female 36,779), 55-64 years: 9.99% (male 7,608/female 8,881), 65 years and over: 11.65% (male 8,704/female

10,510) [15] . Life expectancy is estimated at 73 years for men and 78 for women and the urban population was calculated at 18.7% in 2018 [16]. There are six hospitals, one polyclinic and 31 health centers on the island (Ministry of Health and Wellness, Saint Lucia, 2018).

Researchers have identified statistically significant relationships between demographic variables such as sex, age, population density [17], place of residence and socioeconomic variables such as economic status, employment, education level, urbanization, and income [1,7,18]. The impact of each of these variables on dengue occurrence and severity has been found to vary across geographic locations and time, and suggestions have been made that the specific local epidemiology should be investigated in an effort to provide applicable data and analysis useful to identified populations [2,4,19-24].

The difference recognized in the occurrence of dengue between sexes has be related to socioeconomic factors such as employment, where being a housewife, unemployed, below school-age or elderly subject may lead to greater risk of exposure to dengue-infected mosquitoes that typically prefer to rest and feed indoors [25-26]. In other societies a higher risk of dengue is seen among the population of working-age males who are more likely to be exposed outdoors during the active period of the mosquito [27]. Age as a variable has also been found to vary [28], with researchers suggesting that older persons are more likely to have been exposed to circulating dengue viruses leading to their immunity [29,30]. The introduction of a different serotype, especially through visitors to the country may lead to secondary cases of dengue in persons previously infected with a heterologous serotype; or primary cases in younger members of the population if not previously exposed [21,31]. This is a major risk to Saint Lucia which receives visitors from other countries which are also endemic for dengue and could serve as a possible source of introduction of new strains of the virus. Tourism accounts for approximately 65% of the GDP of Saint Lucia with the island welcoming approximately 1 million visitors each year, which underscores the importance of the industry to the island [32,33].

Location or place of residence has also been associated with the occurrence of dengue

through factors such as land use, tree-cover, water supply, population density, housing quality, and access to healthcare [34-36]. Traditionally it was thought that the incidence of dengue was greater in urban areas because of the higher likelihood of high population densities, improper waste management and lower quality of housing in unplanned urban areas, however some studies show that it is possible to have a higher incidence of dengue in rural areas because of factors such as poor water supply leading to inappropriate water storage [37]. In countries like Saint Lucia where there is no nationalized health care and the majority of the population does not have private health insurance, the cost of health care is mainly borne out of pocket and this may also limit access to care especially during outbreaks. The risk of dengue exposure is normally higher in those of lower socio-economic strata because of lower standard of housing or living in an area of poor water supply and waste management, and the lack of knowledge about the disease [1,38-41]. It has been found in some circumstances that knowledge of the disease and preventive measures does not translate into action leading to the occurrence of the dengue across all economic strata which may relate to perception of risk [42].

This study is based upon ecological theory that posits that changes in external factors such as demographics of a population will impact the occurrence of diseases like dengue [43].The author therefore, sought to evaluate the hypothesis that there is a significant relationship between sex, age, geographic location or place of residence, employment status, education, urbanization, hospital access, visitor arrivals and occurrence of dengue in Saint Lucia. This will possibly address the gap in literature on local epidemiology of dengue.

2. METHODOLOGY

The relationship between demographic variables and the occurrence of dengue in Saint Lucia was tested through a retrospective, quasi experimental study using descriptive analysis of the data, bivariate analysis using chi-square tests of independence followed by multivariate logistic regression of secondary data. The significance level for both the chi -squared and logistic regression analysis was set at 0.05. Sample size estimation for this study was determined by power analysis using G*Power 3 (software, http://www.psycho.uni-duesseldorf.de/abteilungen/aap/gpower3/). In

this study, assuming two-tailed, z-test, an alpha level of .05, a power of 0.80 and 0.90, for a logistic regression model, the required sample size using G*Power 3 is 355 (80% power) and 468 (90% power) with a medium effect size of 0.3. The individual level variable sex was measured having two levels male and female, while geographic location or place of residence of each case represented the 10 districts found in Saint Lucia; Anse La Raye, Canaries, Castries, Choiseul, Dennery, Gros-Islet, Laborie, Micoud, Soufriere and Vieux Fort. Age was measured at the individual level according to Medical Subject Headings (MeSH), Infant (age 0-23months), Pre-school child (age 2-5 years), Child (age 6-12 years), Adolescent (age 13-18 years), Adult (age 19-44 years), Middle Aged (age 45-64), Aged (age 65-79 years), Aged 80 and over [44]. A number of data were only available at the population level as collected by the responsible agencies. The subsequent categories were derived based on the range of data for each variable and division into tertiles. Employment was measured at the population level employed and unemployed as separate variables within each district and by year based on the manner of data collection; 3 levels low (≤2500 persons), medium (>2500-5000 persons), high (>5000 persons), Employed, also a population variable on a nominal scale measured at the annual district level with 3 levels, low (0-11000 persons), medium (>11000-22000 persons), high (>22000 persons). Urbanization was based on the population density within the geographic districts of Saint Lucia and measured as a ratio variable as the number of persons per square mile being measured at the population level. The population density variable was divided into three categories low (≤1000 persons/sq. mile), medium (>1000-1500 persons/sq. mile), and high (>1500 persons/sq. mile). Similarly, the population-level variable hospital access was based on the number of health facilities in comparison to population within the ten districts identified in Saint Lucia. The hospital access variable was divided into three categories low (≤3000 persons/health facility), medium (>3000-4500 persons/health facility), and high (>4500 persons/health facility). Visitor arrivals represented the number of visitors entering Saint Lucia either through cruise visitors low (≤30,000 persons/month), medium (>30,000 – 60,000 persons/month), high (>60,000 persons/month) and for stayover visitors low (≤25000 persons/month), medium (>25000-30000 persons/month), high (>30000 persons/month).; both were measured at the population level.

Education represents the highest level of education attained over the categories of no education, primary, secondary, and tertiary level education all measured at the population level. The category of no education was measured at low (≤6000 persons), medium (>6000≤7000 persons) and high (>7000 persons); less than secondary education low(≤61500 persons), medium(>61500-65000 persons), and high (>65000 persons); secondary low (≤58000 persons), medium (>58000-61000 persons) and high (>61000 persons) and tertiary low (≤12500 persons), medium (>12500-14000 persons) and high (>14000 persons). This study design was most practical since large datasets of the relevant information exist, minimizing the study time and eliminating the need to interact directly with patients and included variables at the individual and population levels. These historical data were accessed from the Ministry of Health infectious disease surveillance database, census data from the Central Statistics office and visitor arrival from the Saint Lucia Tourism Authority between May 2018 and September 2019. Employees from each of the agencies mentioned responded to data access requests, providing the required data. The data covered the period from 2011 to 2017. Cases with incomplete records were excluded.

3. RESULTS AND DISCUSSION

During the period of observation for this study in Saint Lucia 1869 cases were investigated for possible dengue infections. Between 2011 and 2017 the population of Saint Lucia steadily increased from 167366 to 177301. The overall number of male cases to female cases were very similar 979 to 890, and occurred in every age group under consideration infant to >80 years. Of the confirmed dengue cases 667 were male and 643 were female. Confirmed cases were reported in each of the 10 districts with the greatest number of confirmed cases occurring in Castries 529 and Gros Islet 239. Over the seven-year period of observation covered in this study the incidence of confirmed dengue cases was on average 1.104 cases/1000 persons, with the highest incidence recorded in 2011, 4.475 cases/1000 persons and 2013, 1.165 cases/1000 persons. On average the highest incidence was found in the age groups from 0-24 years. Table 1. displays the prevalence of dengue across the different variables and their categories. It should be noted that proportion of dengue cases were highest when the level of unemployment was also highest at 30% of sample at level when

more than 5000 persons were unemployed, and lowest when visitors to the island was the lowest with less than 30,000 cruise ship visitors and less than 25,000 stayover visitors at 54% and 30.9% respectively. The highest percentage of dengue cases were found in the adult age group (19-44 years) and the highest proportion of cases occurred in the district of Castries. The differences in the total number of cases for each variable represent missing data.

Table 1 Displays the number/percentage represent cases that occurred under the variables of interest included in this study.

Chi-square analysis of the data indicated that there was a significant relationship between confirmed cases of dengue and all of the variables with the exception of sex and hospital access as indicated in Table 2.

The variables age, no education, secondary education and tertiary education had a strongest association with confirmed dengue cases having a Cramer's V of more than 0.20; the other variables significantly associated with confirmed dengue cases had a weaker relationship with values of Cramer's V less than 0.20 Only cases with complete data sets were included in building logistic regression models which included 1763 cases. A logistic regression model shown in Table 3., of all of the variables under analysis indicated that age, district, cruise visitors and number of employed were significantly associated with confirmed dengue cases at different levels. The adolescent age group 13-18 (*P*<.001, OR 4.336 [CI 2.731-6.885) was most strongly associated with confirmed dengue cases when compared to the reference age group of 0-23 months but there was no proportionate increase or decrease with an increase of age. The district of Laborie was most strongly associated with confirmed dengue cases (*P*=.05, OR 3.211 [CI 1.302-7.918]) when compared to the Anse la Raye reference group. The number of employed persons was also significantly associated with confirmed dengue cases at the medium level >11000-22000 persons (*P*=.05, OR 18.343 [CI 3.323-101.239]) compared to the 0-11000-person reference group. The number of cruise visitors was most strongly associated with confirmed cases of dengue at the medium level >30000-60000 persons (*P*=.05, OR 0.408 [CI 0.221-0.754]) when compared to the 0-30000 reference group though this association was a negative relationship.

Table 1. Distribution of variables within population at the time sample cases occurred, 2011-2017 Saint Lucia

Variable	Dengue Positive		Dengue Negative	
	Count	Percentage	Count	Percentage
Education	**Population Level data**			
No Education				
Low	399	21.30%	226	12.10%
Medium	94	5.00%	97	5.20%
High	817	43.70%	236	12.60%
n=1869	1310		559	
Less than Secondary				
Low	1180	63.10%	426	22.80%
Medium	68	3.60%	65	3.50%
High	62	3.30%	68	3.60%
n=1869	1310		559	
Secondary				
Low	784	41.90%	212	11.30%
Medium	282	15.10%	109	5.80%
High	244	13.10%	238	12.70%
n=1869	1310		559	
Tertiary				
Low	189	10.10%	205	11.00%
Medium	782	41.80%	197	10.50%
High	339	18.10%	157	8.40%
n=1869	1310		559	
Age	**Individual level data**			
Infant (0-23 months)	105	5.70%	98	5.30%
Pre-school Child (2-5 years)	90	4.90%	76	4.10%
Child (6-12 years)	209	11.30%	83	4.50%
Adolescent (13-18 years)	209	11.30%	46	2.50%
Adult (19-44years)	462	25.00%	175	9.50%
Middle Aged (45-64years)	151	8.20%	52	2.80%
Aged (65-79 years)	51	2.80%	18	1.00%
Aged 80 and above	12	0.60%	11	0.60%
n=1848	1289		559	
Cruise Visitors	**Population Level data**			
Low	1006	54.00%	336	18.00%
Medium	27	1.40%	38	2.00%
High	272	14.60%	185	9.90%
n=1864	1305		559	
Stayover Visitors	**Population Level data**			
Low	576	30.90%	169	9.10%
Medium	465	24.90%	248	13.30%
High	264	14.20%	142	7.60%
n=1864	1305		559	
Population Density	**Population Level data**			
Low	636	35.60%	236	13.20%
Medium	82	4.60%	39	2.20%
High	529	29.60%	266	14.90%
n=1788	1247		541	
Unemployed	**Population Level data**			
Low	405	22.70%	149	8.30%
Medium	305	17.10%	113	6.30%
High	537	30.00%	279	15.60%
n=1788	1247		541	
Employed	**Population Level data**			
Low	464	26.00%	197	11.00%

Variable	Dengue Positive		Dengue Negative	
Medium	252	14.10%	72	4.00%
High	531	29.70%	272	15.20%
n=1788	1247		541	
Districts	**Individual level data**			
Laborie	51	2.90%	33	1.80%
Castries	529	29.60%	268	15.00%
Canaries	2	0.10%	5	0.30%
Soufriere	44	2.50%	9	0.50%
Dennery	62	3.50%	35	2.00%
Anse La Raye	239	13.40%	74	4.10%
Gros-Islet	44	2.50%	10	0.60%
Choiseul	82	4.60%	39	2.20%
Vieux Fort	53	3.00%	12	0.70%
Micoud	141	7.90%	56	3.10%
n=1788	1247		541	
Hospital Access	**Population Level data**			
Low	149	8.30%	59	3.30%
Medium	275	15.40%	121	6.80%
High	822	46.00%	361	20.20%
n=1787	1246		541	
Sex	**Individual level data**			
Male	667	35.70%	312	13.20%
Female	643	34.40%	247	16.70%
n=1869				

Table 2. Pearson's chi-square analysis of factors associated with dengue in saint lucia

Variable	Value	df	Significance	Cramer's V
No Education[a]***	79.588	2	0.000	0.206
Less than Secondary Education[b]***	62.696	2	0.000	0.183
Secondary Education[a]***	123.251	2	0.000	0.257
Tertiary Education[a]***	137.419	2	0.000	0.271
Age[a]***	77.057	7	0.000	0.204
Cruise[b]***	64.733	2	0.000	0.186
Stayover[b]***	31.544	2	0.000	0.13
Pop. Density[c]*	8.299	2	0.016	0.068
Unemployed[c]**	11.01	2	0.004	0.078
Employed[c]**	14.952	2	0.001	0.091
District[b]***	33.98	9	0.000	0.138
Hospital Access[d]	0.407	2	0.816	0.015
Sex[d]	3.768	1	0.052	0.045

[a]Strongest significant association on Cramer's V, [b]More moderate significant association on Cramer's V, [c]Weak significant association on Cramer's V, [d] Non-significant result not included in further analysis
p<.05*, p<.01**, p<.001***

A logistic model as reported in Table 4 containing the four variables that had the strongest association with confirmed dengue cases on chi-square analysis based on Cramer's V; age, no education, secondary education and tertiary education, indicated that every level of age was significantly associated with confirmed cases with the exception of the pre-school and 80 year old and over group; and the group with the strongest association was the adolescent age group (*P*<.001, OR 4.091 [CI 2.628- 6.369])

when compared to the infant reference group. The largest no education group > 7000 persons, was found to have a negative significantly associated relationship with confirmed cases (*P*=.05, OR 0.382 [CI 0.170-0.861]) when compared to the reference group 0-6000. Similarly, the largest group of the population with secondary education also had a negative significant relationship with confirmed dengue cases (*P*<.001, OR 0.315 [CI 0.179-0.553)] compared to the reference group

0-58000. When compared to the reference group 0-12500 persons with tertiary education, the fourth variable tertiary education was also found to be significantly associated with confirmed cases (*P*<.001, OR 4.785 [CI 2.896-7.905]).

Table 3. Logistic regression model of predictive factors of dengue in Saint Lucia 2011-2017

		B	S.E.	Wald	df	Sig.	Odds Ratio	95% C.I. for O.R.	
								Lower	Upper
	No Education								
Ref.	Low								
	Medium	20.254	28282.63	0	1	0.999	625157556	0	
	High	19.712	40195.09	0	1	1.000	363644217	0	
	Less than Secondary Education								
Ref.	Low								
	Medium	-0.204	24574.79	0	1	1.000	0.815	0	
	High	19.846	28282.63	0	1	0.999	415777000	0	
	Secondary Education								
Ref.	Low								
	Medium	0.152	24574.79	0	1	1.000	1.164	0	
	High	-0.771	24574.79	0	1	1.000	0.463	0	
	Tertiary Education								
Ref.	Low								
	Medium	1.138	24574.79	0	1	1.000	3.122	0	
	High	20.188	28282.63	0	1	0.999	585389891	0	
	Age								
Ref.	Infant								
	Pre-school Child	0.123	0.234	0.274	1	0.601	1.131	0.714	1.79
	Child**	0.692	0.211	10.771	1	0.001	1.998	1.322	3.021
	Adolescent***	1.467	0.236	38.659	1	0.000	4.336	2.731	6.885
	Adult***	1.156	0.187	38.289	1	0.000	3.176	2.203	4.581
	Middle Aged***	1.305	0.240	29.697	1	0.000	3.689	2.307	5.898
	Aged***	1.259	0.342	13.558	1	0.000	3.523	1.802	6.888
	Aged 80 and above	0.712	0.498	2.044	1	0.153	2.037	0.768	5.405
	Cruise Visitors								
Ref.	Low								
	Medium**	-0.896	0.313	8.172	1	0.004	0.408	0.221	0.754
	High***	-0.534	0.143	13.899	1	0.000	0.586	0.443	0.776
	Stay Over Visitors								
Ref.	Low								
	Medium	-0.161	0.143	1.274	1	0.259	0.851	0.643	1.126
	High	0.081	0.177	0.211	1	0.646	1.084	0.767	1.533
	Population Density								
Ref.	Low								
	Medium*	0.786	0.331	5.638	1	0.018	2.194	1.147	4.196
	High	21.936	28413.6	0.000	1	0.999	3361789819	0.000	
	Unemployed								
Ref.	Low								
	Medium	0.184	0.247	0.555	1	0.456	1.202	0.740	1.953
	High	-0.457	0.646	0.501	1	0.479	0.633	0.178	2.245
	Employed								
Ref.	Low								
	Medium**	2.909	0.872	11.142	1	0.001	18.343	3.323	101.239
	High	1.356	1.312	1.068	1	0.301	3.879	0.297	50.741
	District								
Ref.	Anse La Raye								
	Castries	-22.43	28413.6	0.000	1	0.999	0.000	0.000	

	B	S.E.	Wald	df	Sig.	Odds Ratio	95% C.I. for O.R.	
							Lower	Upper
Canaries	-1.048	0.903	1.345	1	0.246	0.351	0.06	2.061
Choiseul*	1.167	0.460	6.418	1	0.011	3.211	1.302	7.918
Dennery	0.303	0.346	0.770	1	0.380	1.355	0.688	2.668
Gros Islet*	-2.189	0.916	5.714	1	0.017	0.112	0.019	0.674
Laborie**	1.385	0.458	9.129	1	0.003	3.996	1.627	9.815
Soufriere*	0.977	0.427	5.234	1	0.022	2.655	1.150	6.129
Vieux Fort*	0.843	0.344	5.987	1	0.014	2.323	1.183	4.562

*P=.05, **P<.01, ***P<.001

Table 4. Logistic regression model of strong significant demographic predictors of dengue in Saint Lucia 2009-2017

		B	S.E.	Wald	df	Sig.	O.R.	95% C.I. for O.R.	
								Lower	Upper
	No Education								
Ref.	Low								
	Medium	0.138	0.235	0.342	1	0.559	1.147	0.724	1.820
	High*	-0.961	0.414	5.396	1	0.020	0.382	0.170	0.861
	Secondary Education								
Ref.	Low								
	Medium	-0.216	0.369	0.344	1	0.558	0.806	0.391	1.659
	High***	-1.155	0.287	16.175	1	0.000	0.315	0.179	0.553
	Tertiary Education								
Ref.	Low								
	Medium***	1.565	0.256	37.352	1	0.000	4.785	2.896	7.905
	High	0.227	0.273	0.697	1	0.404	1.255	0.736	2.142
	Age								
Ref.	Infant								
	Pre-school Child	0.073	0.223	0.108	1	0.742	1.076	0.695	1.666
	Child**	0.614	0.201	9.307	1	0.002	1.848	1.246	2.743
	Adolescent***	1.409	0.226	38.922	1	0.000	4.091	2.628	6.369
	Adult***	1.069	0.177	36.48	1	0.000	2.914	2.059	4.123
	Middle Aged***	1.294	0.229	32.05	1	0.000	3.648	2.331	5.710
	Aged***	1.199	0.325	13.599	1	0.000	3.316	1.754	6.271
	Aged 80 and above	0.421	0.471	0.796	1	0.372	1.523	0.605	3.837

*P=.05, **P<.01, ***P<.001

Table 5 demonstrated a third regression model including only the variables that were found to have a more moderate relationship with confirmed dengue cases indicated that both cruise tourism and stay over tourism were negatively associated with confirmed cases of dengue for the group >30000-60000 visitors/month (*P*<.001, OR 0.331 [CI 0.188-0.581]) and the group >25000-30000 visitors/month (*P*<.001 OR 0.703 [0.544-0.909]) when compared to the reference groups 0-30000 and 0-25000 visitors/month respectively. The education level less than secondary was found to be negatively associated with confirmed cases most strongly at the level of >65000 persons (*P*<.001, OR 0.330 [CI 0.223 – 0.490]) compared to the reference group 0-61500 persons. The variable district was found to be significantly associated with confirmed cases at multiple levels though without a continually increasing or decreasing pattern across the levels. The level which was most strongly associated with confirmed dengue cases was Laborie (*P*=.05, OR 3.371 [CI 1.459-7.792]) compared to Anse la Raye as the reference group.

Table 5. Logistic regression model of moderately significant demographic predictors of dengue in Saint Lucia 2011-2017

		B	S.E.	Wald	df	Sig.	O.R.	95% C.I. for O.R.	
								Lower	Upper
	Less than Secondary Education								
Reference	Low								
	Medium***	-0.736	0.194	14.382	1	0.000	0.479	0.327	0.701
	High***	-1.108	0.201	30.379	1	0.000	0.330	0.223	0.490
	Cruise Visitors								
Reference	Low								
	Medium***	-1.107	0.287	14.822	1	0.000	0.331	0.188	0.581
	High***	-0.521	0.131	15.770	1	0.000	0.594	0.459	0.768
	Stay Over Visitors								
Reference	Low								
	Medium**	-0.352	0.131	7.243	1	0.007	0.703	0.544	0.909
	High	-0.180	0.155	1.354	1	0.245	0.835	0.616	1.131
	Districts								
Reference	Anse La Raye								
	Castries	0.300	0.242	1.534	1	0.215	1.350	0.840	2.171
	Canaries	-1.309	0.885	2.189	1	0.139	0.270	0.048	1.530
	Choiseul**	1.145	0.437	6.853	1	0.009	3.143	1.333	7.408
	Dennery	0.365	0.320	1.295	1	0.255	1.440	0.768	2.698
	Gros Islet**	0.796	0.268	8.846	1	0.003	2.217	1.312	3.746
	Laborie**	1.215	0.427	8.082	1	0.004	3.371	1.459	7.792
	Micoud	0.562	0.311	3.264	1	0.071	1.754	0.953	3.226
	Soufriere**	1.131	0.400	8.000	1	0.005	3.099	1.415	6.785
	Vieux Fort**	0.732	0.287	6.489	1	0.011	2.080	1.184	3.653

*p<.05, **p<.01, ***p<.001

Table 6. Logistic regression model weak significant demographic predictors of dengue in Saint Lucia 2011-2017

		B	S.E.	Wald	df	Sig.	O.R.	95% C.I. for O.R.	
								Lower	Upper
	Unemployed								
Reference	Low								
	Medium*	-0.395	0.189	4.375	1	0.036	0.674	0.466	0.975
	High*	-1.157	0.567	4.172	1	0.041	0.314	0.104	0.954
	Employed								
Reference	Low								
	Medium**	0.603	0.207	8.471	1	0.004	1.827	1.217	2.741
	High	-0.944	0.988	0.914	1	0.339	0.389	0.056	2.697
	Population Density								
Reference	Low								
	Medium	-0.198	0.218	0.824	1	0.364	0.820	0.535	1.258
	High*	1.786	0.820	4.745	1	0.029	5.966	1.196	29.76

*p<.05, **p<.01

The relationship between the variables with the weakest association with dengue cases was modeled through logistic regression as demonstrated in Table 6. Population density was significantly associated with confirmed dengue cases at the high population density level of >1500 persons/sq. mile (P=.05, OR 5.966 [CI 1.196-29.760]) compared to the reference category 0-1000 persons/sq. Mile. The variable unemployed was found to have a negative significant association with confirmed dengue cases that was highest at the level of >5000 persons (P=.05, OR 0.314 [CI 0.104-0.954]) compared to the reference low unemployment level group of 0-2500 persons. In contrast the variable employed was found to have a positive

significant relationship with confirmed dengue cases at the medium level of >11000-22000 (P=.05, OR 1.827 [1.217-2.741]).

3.1 Discussion

The most significant finding was the positive relationship with dengue and tertiary education, which was also among the strongest relationships between any of the risk factors tested here and dengue. Previously authors have linked increased educational levels to better knowledge of dengue, better health-seeking behavior and better preventive actions resulting in fewer cases occurring within this segment of a population [45,46]. Within the Saint Lucian context, the positive significant relationship with persons with tertiary education may therefore reflect a better knowledge of the clinical signs of the disease and the ability to seek appropriate health-care. Tertiary education also includes students enrolled in the local community colleges and this coincides with the positive relationship with the adolescent group 13-18 years old. Another possible contributing factor to the strong association of tertiary education and dengue cases is this section of the population is more likely to live and work in more densely populated areas such as the city center and therefore come into greater contact with the mosquito vectors, which is supported by the positive associations of population density and employment with confirmed dengue cases [47]. Persons with tertiary education are more likely to have office or indoor jobs which may put them at higher risk of exposure to the indoor dwelling *Aedes aegypti* mosquito and in addition these persons are also more likely to be able to afford healthcare than persons with lower levels of education and consequently higher paying jobs. Having no education, less than a secondary school education or secondary education were found to all be negatively predict confirmed dengue cases in Saint Lucia, and this may be as a result of being uncertain of the clinical signs of the disease therefore increased reporting or seeking medical care for cases that were not dengue. Education has been established by other authors as predictors of the disease and are likewise important in the Saint Lucian context.

Age of persons infected with dengue has been previously established as a significant predictor of dengue within a population, however authors differ on which age groups seem to have the strongest association with dengue [48-52]. In this study the adolescent age group 13-18 had the strongest association with confirmed dengue cases which may be as a result of exposure and lack of immunological protection. The introduction of new serotypes or genotypes of the dengue against which the adolescent age group have no protection may also explain this relationship [53]. The stronger association among this group may also be related to parents ensuring that children that are unwell receive medical care. However, the lack of a discernible pattern of increase or decrease in strength of association between age and dengue cases may reflect the introduction of varying serotypes or genotypes of the virus which would minimize the likelihood of a resistant population. The relationship to dengue occurrence in this group may reflect differences in behavior to other groups, that may put the adolescents at higher risk of dengue. These adolescents may possibly remain indoors for longer periods of time, related to studying and academic work, recreational playing of video games, computer use or sleep [54-56]. A significant relationship was also found to exist across most age groups except the 0-23month and 80+ age groups, which may indicate that dengue impacts a wide cross section of the population, but the greatest strength of association with the adolescent age group suggests that preventive measures should target this age group. The disparity across researches may suggests that there are multiple factors impacting the role of age in the occurrence of dengue in Saint Lucia, including immature immunity in infants, increased risk of exposure based on activity, increased risk of comorbidities with increased age and decreased immunity in geriatric populations.

The negative significant relationships with tourism, may seem counter-intuitive initially, since the influx of persons to a geographical location is often related to the introduction of disease agents, however a number of factors may explain this phenomenon. The highest number of visitor arrivals for both cruise and stayover visitors, occurs mainly during the dryer, cooler parts of the year when mosquito population numbers are apt to be lower, reducing the disease transmission cycle. Additionally, during the busy tourist season, seasonal industry workers are likely to be employed and less likely to take opportunity to seek medical care, therefore potential dengue cases may go unidentified. The increased activity during peak visitor periods may also serve to decrease opportunities for exposure to infected mosquitoes. The increased activity

during peak tourist season, also possibly decreases the amount of time at home for the members of the population employed within the industry and therefore potentially decreases the risk of exposure to the dengue mosquito vector.

Population density was also found to be positively associated with confirmed dengue cases and supports previously established outcomes by other authors, suggesting that the anthropophilic mosquito thrives in areas of dense populations [48,57]. This may be as a result of persons living in surroundings that support mosquito populations with water-holding receptacles, or without appropriate mosquito preventive measures. Unemployment was found to have a negative significant relationship with dengue possibly reflecting unemployed persons, may be less likely to seek medical care for dengue related symptoms because of the costs associated with such care. Employment on the other hand was found to have a positive significant relationship with dengue and an increased risk of exposure to dengue related to employment has been established by other authors with persons working outdoors at higher risk of transmission by A. Albopictus and conversely by A. aegypti indoors [48,58]. This positive relationship with dengue may reflect persons working in areas that exposes them to infected mosquitoes either outdoors or in indoor environments. It is also likely that employed persons are more likely to seek medical care and be diagnosed with dengue than unemployed persons. Dengue preventive plans should take into consideration the associations highlighted here, and include messaging specific to the subsets of the population affected. It would also suggest that greater surveillance or targeted surveillance should seek to determine the true epidemiology of the disease among persons with lower educational levels and the unemployed.

District or the geographical place where persons lived was also found to be significantly associated with confirmed dengue cases with Laborie having the strongest association followed by, Choiseul and Soufriere having the strongest association with dengue when compared to the Anse La Raye as the reference group. The population densities in these districts are low, and this is unlikely to be the explanation for the positive relationship with dengue since increased population density has been established as a risk factor for the disease [59]. The unemployment level in these three districts were the lowest in

Saint Lucia over the period of the study but as previously described unemployment was found to have a negative significant relationship with dengue. The rate of employment in these districts were among the highest across the island during the period of the study, which may mean that the population may have greater resources to seek healthcare increasing detection rates. Employment may also increase the risk of exposure to infected mosquitoes and help explain the strong significant relationship between district and dengue. These communities are also more rural and there is a possibility that there are more suitable environmental conditions to support mosquito populations and also the preventive programs by the Ministry of Health may have less uptake in these regions.

Hospital access was not found to be associated with confirmed dengue cases and this may reflect the fact that the number of health facilities has not changed greatly over the period of the study and also because of the size of the island persons have the ability to visit health facilities outside of their geographic place of residence.

Researchers have found the relationship between dengue and sex has been found to differ with some finding no relationship and others finding either males or females have a stronger relationship to the disease; in this study sex was not associated with dengue in Saint Lucia [53,60,61]. The lack of a difference between genders my indicate equal exposure to mosquito vectors as well as equal access to healthcare on the island.

The analysis of the data demonstrates that most of the demographic variables included are associated with dengue cases in Saint Lucia, which is important in establishing their local relevance. However, further analysis of these variables is necessary to better understand their relationships to dengue. The best model was only able to predict 73.1% of cases and this may be because the majority of variables were measured at the population level and lacked the specificity of individual level data. However, this data does not exist at the individual level and will require additional research to better explain these relationships.

There were a number of limitations with this study, including the limited detail on dengue and dengue suspect cases which did not include the individual's employment status or education level

and limited date of onset information, as well limited information on visitors. With the exception of age, sex, and geographic location, the other variable was measured at the population level and result in a lack of specific detail for individual cases. The operationalization of the variables included in the study may also have led to incorrect outcomes and the continued analysis of the available data and collection of additional more specific data is warranted. Further studies should be conducted to investigate the high association of district with dengue to determine why there is a strong association with Laborie, Choiseul and Soufriere with dengue. Also, the risk factors of age and employment should be further investigated to better understand how these variables are associated with dengue in Saint Lucia. It may be helpful to also conduct a behavior, attitudes and knowledge study within the working population to specifically investigate these phenomena amongst employed persons. The accurate identification of dengue cases due to lack of understanding the disease or lack of economic resources to seek healthcare may also limit the true depiction of the relationship of predictors and dengue in Saint Lucia. The outcomes of this current study may provide additional background that can be used by the Ministry of Education to tailor its preventive program for dengue targeting the age groups and districts identified as being strong risk factors of dengue as well as the employed labor force to reduce the incidence of dengue in Saint Lucia.

Any disease that causes significant morbidity and therefore loss of days at work or at school will have significant social impact on a country; in particular at the lower levels of society that often cannot afford healthcare and the life outcomes of members of this section of the society can be negatively impacted. Dengue affects almost 400 million persons per year, many within the lower economic levels of society because of living conditions that often support mosquito vector populations [1]. The author was able to demonstrate that tertiary education, age, population density, employment, and geographic location are positively associated with dengue cases in Saint Lucia, while education less than tertiary level, visitor arrival, and unemployment was negatively associated. If public health authorities are able to target these sections of the population most at risk, the incidence of dengue might be reduced, minimizing the associated healthcare costs, the days lost at work or school and consequent loss in

productivity. This would minimize the social impact the disease would have in Saint Lucia and indeed possibly in other countries to which dengue maybe exported from Saint Lucia by the movement of infected persons or infected mosquito vectors.

4. CONCLUSION

This study allowed the author to demonstrate that a number of demographic variables of the Saint Lucian population are associated with dengue in the specific local context. However further studies should be conducted to understand these relationships more clearly. While age had a moderate association and positive significant relationship with dengue, the lack of a discernible pattern to this relationship requires additional analysis to determine what is the true relationship in the Saint Lucian context. Similarly, also, education while being associated with dengue, the nature of the relationship is unclear and bears further investigation. These factors will play an important role in the successful design of prevention programs and also the uptake these preventive measures. Dengue remains a public health challenge in, Saint Lucia, the Caribbean and globally, research into risk factors especially at the local level is critical to successful control of this disease.

CONSENT

It is not applicable.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki." Ethical approval was granted from Walden University and the Medical and Dental Saint Lucia Council, Saint Lucia.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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