The Epidemiology of Dengue Fever in Palau

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Abstract :

***Background:** Dengue fever has been a longstanding problem in Palau, and Public Health programs were implemented in 2001 to conduct surveillance for cases of the disease. Epidemiologic analysis of dengue fever cases in Palau is needed to describe disease occurrence in Palau and to help target prevention and control efforts.*

***Methods:** Case data were collected from the Palau Ministry of Health's Reportable Disease Surveillance System. Descriptive epidemiology was performed on the case data, and spatial analysis was used to assess the distribution of dengue fever cases in Palau.*

***Results:** Between January of 2001 and June of 2006, 676 cases of dengue fever occurred in Palau, and sporadic outbreaks without seasonality were noted. Characteristics of the case population included being male (57.8%), being under the age of 20 (mean age=23.4 years), being Palauan (88.2%), having an indoor occupation (91.7%), and having no history of travel outside of Palau during the estimated exposure period (96.3%). Most cases also lived in urban areas of Palau (92.0%), and the disease rate was significantly higher in urban areas compared to rural areas (3941.8 versus 1175.7 cases per 100,000, respectively for the 5.4-year study period; p=0.0007).*

***Conclusion:** This study supports the idea that dengue fever is still endemic in Palau. Control and prevention measures should be continued, and targeted toward urban areas and populations at increased risk of this disease.*

Introduction

For the past several decades, dengue fever has been increasing in incidence and in geographic distribution globally. The increase in incidence of dengue fever has been attributed to unprecedented population growth, urbanization, lack of vector control, increased air travel, and inadequate public health and sanitation infrastructure[1].

Urbanization in tropical and subtropical regions seems to have had the greatest impact on the amplification of dengue fever in a given country, and travel seems to be the major factor in the geographical spread of dengue fever[2].

Several studies suggest that environmental factors, specifically increased temperature and rainfall, have been found to correlate with the increase in incidence of dengue fever by way of increasing the vector populations in non-epidemic periods in some regions[3,4,] however, this correlation was not demonstrated in a more extensive study by Hay *et al.*, and population dynamics were postulated to be a stronger explanation of dengue fever transmission in interepidemic periods[5].

This study will evaluate the epidemiology of dengue fever in Palau, a small island country in the Western Caroline Islands with a population of approximately 20,000 people. Two-thirds of the country's population lives in its capitol, Koror, which is a cluster of small islands south of the large island of Babeldaob. The majority of the rural population lives on Babeldaob, and a small proportion of the population lives on other islands to the north of Babledaob or to the southwest of Koror and Babeldaob. Historically, Palau has been endemic with dengue fever, and in 2001, improved lab testing and reporting of cases was implemented. Dengue fever is a significant cause of morbidity in Palau. The Palau Ministry of Health has also implemented environmental programs in an attempt to manage the presence of this disease. These programs include monitoring the presence of the necessary mosquito species that serve as vectors for dengue fever and also eliminating potential mosquito breeding sites. Serotype monitoring in this region has shown that DEN-4 has had a longstanding presence, but DEN-2 and DEN-4 were both detected in Palau in 2007. DEN-2 had not been documented in the region since 1999[6]. Very little epidemiological information is known about the occurrence of dengue fever in Palau, and this study will be the first of its kind on cases occurring in Palau.

This study has several objectives. The first objective is to perform descriptive epidemiology on the case data using age, sex, ethnicity, and occupational environment. The timing of the occurrence of these cases will also be examined. The second study objective is to examine demographic differences in the case populations when comparing the urban cases with the rural cases. The third study objective is to evaluate the geographic distribution of these cases in Palau by state; cases that occurred in Koror will also be evaluated at the hamlet level.

The final study objective is to gather epidemiological information to either support or reject the hypothesis that dengue fever is endemic in Palau.

Methods

This study analyzed surveillance data for dengue fever cases in Palau, as collected by the Belau National Hospital, Palau's only hospital, and the Palau Ministry of Health's Division of Environmental Health.

Data was compiled for this study from paper surveillance records and files reported in the Palau Ministry of Health's Reportable Disease Surveillance System. Data of reported dengue fever cases from January 2001 to May 2006 was used. Case reports were completed by patient interview, and collected information on age, sex, ethnicity, occupation, date of onset, date of lab tests, case status, state and hamlet of residence in Palau, date of admission, recent travel, and if the case had ill contacts. Missing information was gathered from medical and public health records at Belau National Hospital. All identifying data was removed. The collection of case reports were compiled into a database for analysis of the variables of interest.

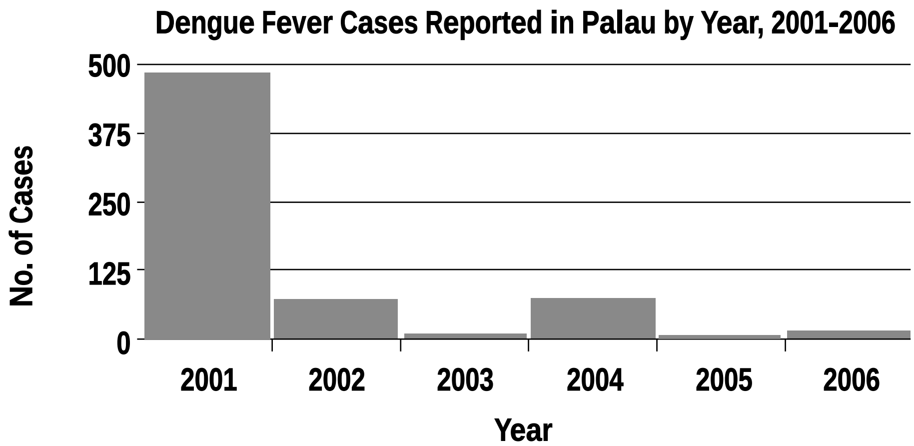
Descriptive epidemiology was performed on demographic case data, and analytic epidemiology was performed to assess any difference in urban versus rural occurrence of disease. The statistical analyses were performed with SASv8 software (SAS Institute, Inc., Cary, NC). ArcGISv9 (ESRI, Redlands, CA) was used to visualize the spatial distributions of risk for dengue fever by Palau state and Koror hamlet. Urban areas were defined as the states of Koror or Airai and all other states were considered to be rural. Where possible, occupational environments were classified as either indoor or outdoor based on the nature of the jobs.

Population statistics were provided by the Office of Planning and Statistics of the Republic of Palau and used for denominator data in computing risks by region, and determining the age distribution. Data from the 2000 and 2005 censuses were used to compute a midpoint for many of the denominators.

Results

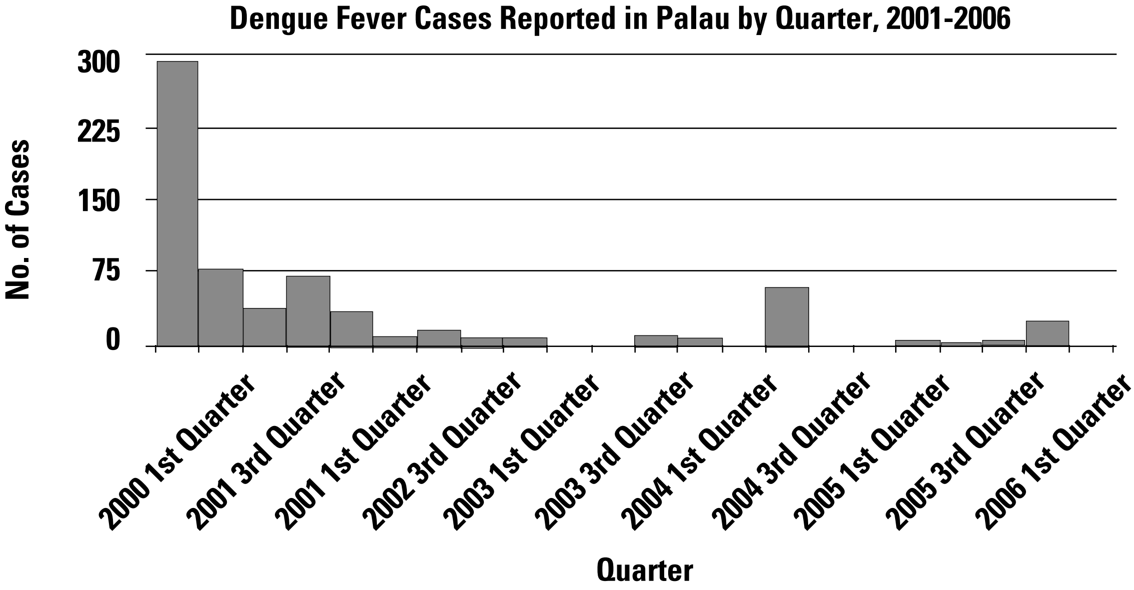
Between January of 2001 and May of 2006, 676 cases of dengue fever were reported (Figures 1 and 2). Outbreaks of dengue fever were known to have occurred in 2000 and 2001, and also July to August of 2004. No seasonality is evident in the quarterly data.

Figure 1:



Time Curve of Dengue Fever Cases Reported in Palau by Year from January, 2001 to June 2006

Figure 2: Time Curve of Dengue Fever Cases Reported in Palau by Quarter from January, 2001 to June 2006.



Descriptive epidemiology of the case population revealed that the majority of cases were male (382 of 661, 57.8%; gender unknown for 15 cases). The mean age of cases was 23.4 years old and the median was 19 years old. Ages of these cases had a range of 96 years, from 3 months to 96 years of age. In examining age-specific risk, the computed rates showed that children and adolescents were at the greatest risk for contracting dengue fever (Table 1).

Table 1: Age Categories of Dengue Fever Cases Reported in Palau, 2001-2006, and Age-Specific Risks

Age Group	No.	%	Midpoint from Census Data*	Age-Specific Risk (per 100,000)
0 - 9	158	23.90	2,946	5363.2
10 - 19	179	27.08	3,157	5670.8
20 - 29	117	17.70	3,051	3835.4
30 - 39	93	14.07	3,941	2360.1
40 - 49	60	9.08	3,172	1891.6
50 - 59	27	4.08	1,682	1605.7
60+	27	4.08	1,571	1718.7

*Midpoint estimates were computed from census data from 2000 and 2005. These numbers were used to compute age-specific risks.
**Age unknown for 15 cases.

In examining ethnicity, the majority of cases with known ethnicity were Palauan (582 of 660, 88.2%, ethnicity unknown for 16 cases), followed by Filipino (31, 4.7%), Chinese (13, 2.0%), and Bangladeshi (10, 1.5%) (Table 2).

Table 2: Ethnicities of Dengue Fever Cases Reported in Palau, 2001-2006

Ethnicity	#	%
Palauan	582	88.2
Filipino	31	4.7
Chinese	13	2.0
Bangladeshi	10	1.5
Other	24	3.6

*Ethnicity unknown for 16 cases.

Occupation data was classified into indoor versus outdoor occupation categories, but this data was either missing or could not be classified for 301 cases. Of those that could be classified, 344 (91.7%) had indoor occupations and only 31 (8.3%) had outdoor occupations.

During case interviews, cases were questioned on travel during their calculated exposure period. This data was not recorded for 434 cases, which creates an insufficient sample size for adequately evaluating travel exposure. However, for those with useable data, 233 of 242 cases (96.3%) had not travelled outside of Palau.

Cases were categorized into urban or rural areas of residence, with the states Koror and Airai being considered the only urban areas in Palau. With this information, it was found that 606 (92.0%) cases lived in urban areas and only 53 (8.0%) lived in rural areas. For 16 cases, such data was either missing, or the case was from another country.

Analytic epidemiology was used to examine the relationship between rural residence versus urban residence among dengue fever cases. No significant trend in gender distribution was detected for urban versus rural cases (OR=0.80, 95% CI 0.45 – 1.41). There was no significant age difference between urban and rural patients (urban mean age: 23.1 years, rural mean age: 26.8 years; F-value: 1.49, F p-value: 0.0332, unpooled T-value: 1.25, T p-value: 0.1394). The relationship between ethnicity and urban versus rural residence was evaluated, and found that non-Palauan cases are not significantly more likely to be from rural areas than Palauan cases (OR=1.84, 95% CI 0.88 – 3.83). However, Filipino cases were significantly more likely to be from rural areas than urban areas compared to Palauan cases (OR=3.65, 95% CI 1.49 – 8.95).

The spatial occurrence of dengue fever cases was examined. The crude risk of dengue fever for Palau is 3315.4 (95% CI 3062.5 – 3568.4) cases per 100,000 for the 5.4-year surveillance period (average annual risk of 612.0 cases per 100,000). The summary disease risk for Palau's urban states is 3941.8 (95% CI 3628.2 – 4255.4) cases per 100,000 for the 5.4-year surveillance period (average annual risk of 727.7 cases per 100,000) and the summary disease risk for Palau's rural states is 1175.7 (95% CI 859.2 – 1492.2) cases per 100,000 for the 5.4-year surveillance period (average annual risk of 217.0 cases per 100,000) (Table 3 and Figure 3). There was no significant difference between the un weighted means for the urban and rural Palauan states (F-value=43.1, F p-value=0.24, pooled T-value= -4.29, p=0.0007). Table 4 and Figure 4 provides disease risk for the 5.4-year study period by hamlet in Koror, Palau's capitol city, where 504 cases of dengue fever were reported.

Table 3: Number and Percent of Dengue Fever Cases, Population, and Disease Risk for Palau States, 2001-2006

State	No. of Cases	% of Cases	2005 Population	Risk (per 100,000)	Lower 95% CI for Risk	Upper 95% CI for Risk	Urban/ Rural
Aimeliik	10	1.52	270	3703.7	1408.1	5999.3	Rural
Airai	103	15.61	2723	3782.6	3052.1	4513.1	Urban
Anguar	1	0.15	320	312.5	-300.0	925.0	Rural
Hatohobei	0	0	44	0.0	0.0	0.0	Rural
Kayangel	0	0	188	0.0	0.0	0.0	Rural
Koror	504	76.36	12676	3976.0	3628.9	4323.1	Urban
Melekeok	3	0.45	391	767.3	-101.0	1635.5	Rural
Ngaraard	5	0.76	581	860.6	106.2	1614.9	Rural
Ngardmau	1	0.15	166	602.4	-578.3	1783.1	Rural
Ngatpang	6	0.91	464	1293.1	258.4	2327.8	Rural
Ngchesar	3	0.45	254	1181.1	-155.4	2517.6	Rural
Ngerchelong	6	0.91	488	1229.5	245.7	2213.3	Rural
Ngeremlengui	4	0.61	317	1261.8	25.2	2498.4	Rural
Ngiwal	3	0.45	223	1345.3	-177.0	2867.6	Rural
Peleliu	10	1.52	702	1424.5	541.6	2307.4	Rural
Sonsorol	1	0.15	100	1000.0	-960.0	2960.0	Rural

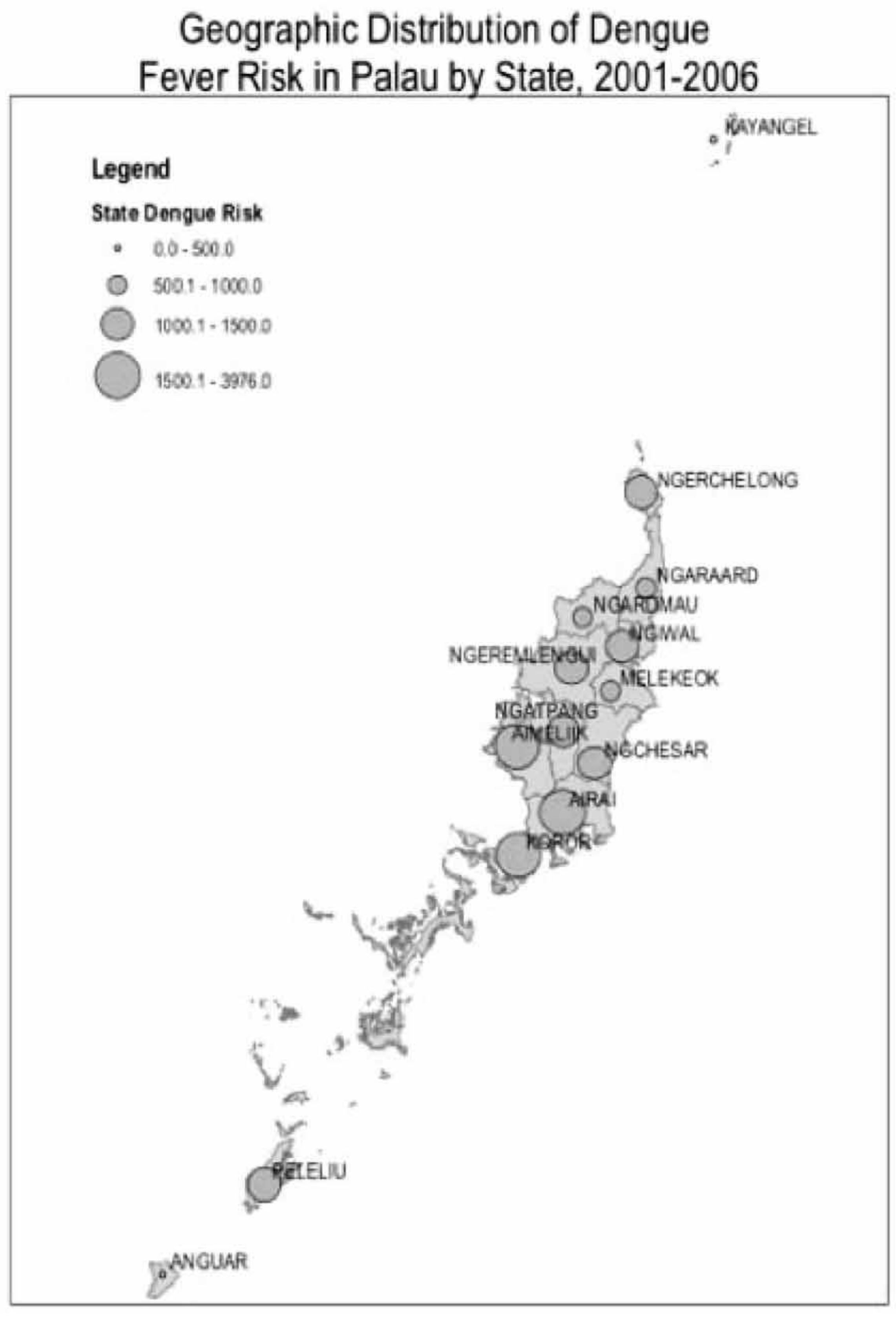
*State unknown for 15, and one case was from another country.

Table 4: Number and Percent of Dengue Fever Cases, Population, and Disease Risk for Koror Hamlets, 2001-2006

Koror Hamlets	No. of Cases	% of Koror Cases	2005 Population	Risk (per 100,000)	Lower 95% CI for Risk	Upper 95% CI for Risk
Dngeronger	24	4.78	275	8727.3	5235.6	12218.9
Eang	16	3.19	353	4532.6	2311.6	6753.5
Idid	30	5.98	722	4155.1	2668.2	5642.0
Ikelau	9	1.79	435	2069.0	717.2	3420.7
Iyebukel	49	9.76	1065	4600.9	3312.7	5889.2
Madalii	66	13.15	2207	2990.5	2269.0	3712.0
Meketii	26	5.18	505	5148.5	3169.5	7127.5
Meyuns	65	12.95	1153	5637.5	4267.0	7008.0
Ngerbeched	67	13.35	1534	4367.7	3321.8	5413.5
Ngerchemai	71	14.14	1871	3794.8	2912.1	4677.5
Ngerkebesang	13	2.59	427	3044.5	1389.5	4699.5
Ngerkesoaol	25	4.98	933	2679.5	1629.2	3729.9
Ngermid	41	8.17	1196	3428.1	2378.8	4477.4

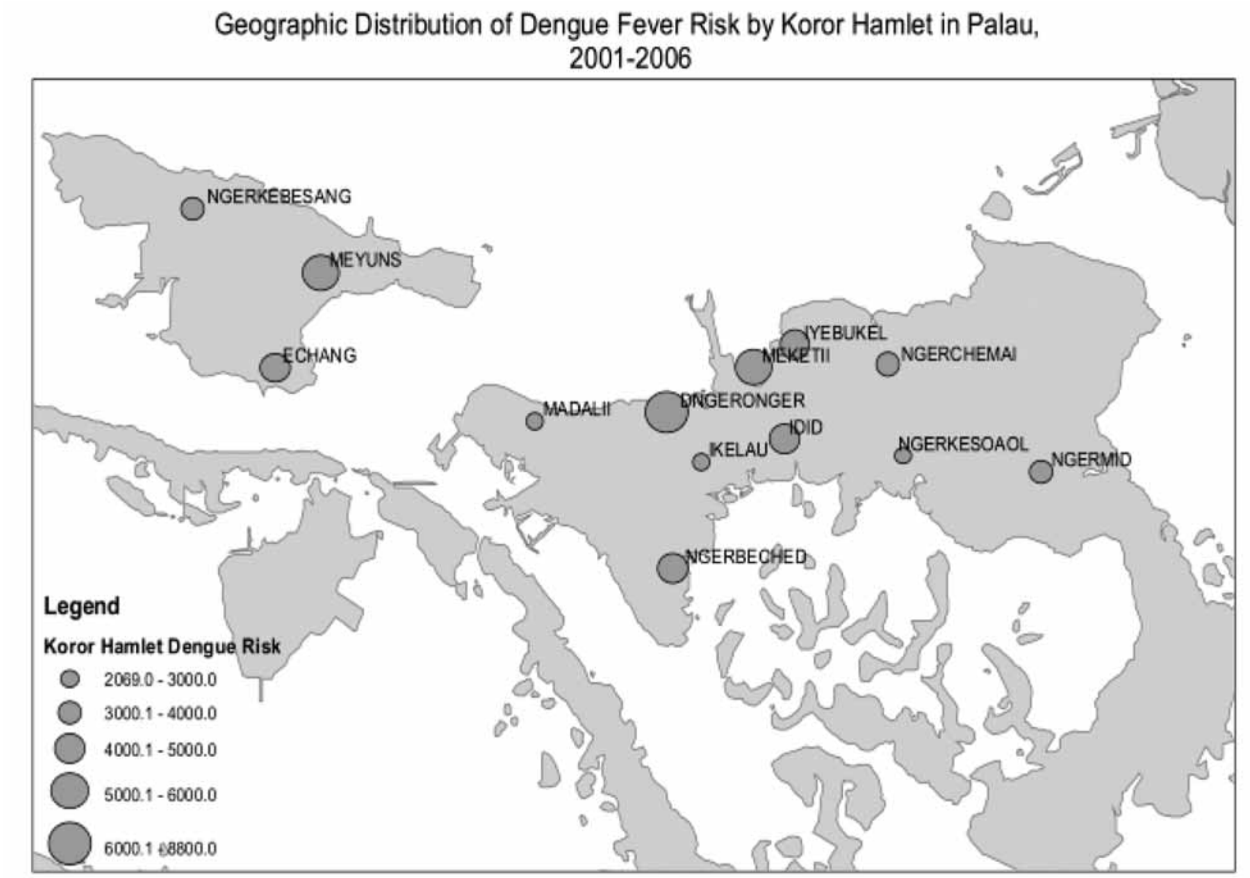
*Two cases reported being from Koror, but no hamlet data was reported.

Figure 3: Map Demonstrating the Geographic Distribution of Dengue Fever Risk in Palau by State



*The states of Hatohobei and Sonsorol not included due to their distant geographic location

Figure 4: Map Demonstrating the Geographic Distribution of Dengue Fever Risk in Koror by Hamlet



Discussion

Relatively little information exists on the occurrence of dengue fever in Palau. With Palau's new Reportable Disease Surveillance System, health professionals are better able to identify risk factors for local cases of dengue fever and to implement interventional measures to prevent further cases. This analysis is the first such epidemiological investigation.

Epidemiology

In examining the epidemic curves of dengue fever cases in Palau, there were a high number of cases reported in 2001, but also a general decrease over time in the numbers of reported cases. An outbreak occurred in July and August of 2004, and this is clearly seen in these graphs. No seasonality is evident in the graph of cases by quarter, which lends support to the conclusion by Hay *et al.* that population factors contribute far more to trends in the rates of dengue fever than do climatic factors[5].

In analyzing the surveillance data of reported cases of dengue fever from 2001 to 2006 in Palau, it was found that cases were more likely to be male, aged 0 to 20 years, Palauan, and reside in urban areas of Palau. There was no significant difference between the mean ages when comparing the urban and rural case populations. Concerning occupational environment as a risk factor for dengue fever, it should be noted that only 45% of cases provided occupational data that could be classified into indoor versus outdoor environments, which is an insufficient number for drawing solid conclusions regarding this risk factor. Nonetheless, the vast majority of cases with usable information (91.7%) had indoor occupations. It should be further noted that there is significant chance of confounding between the occupational environment and area of residence variables.

Filipino cases were significantly more likely to reside in rural areas, compared to Palauan cases. The risk for Filipinos in urban areas was 834 per 100,000 for the 5.4-year period (154.0 per 100,000 for average annual risk), but was 1872 per 100,000 in rural areas for the 5.4-year period (345.6 per 100,000 for average annual risk). This is not congruent with Palau's demographics, because a greater proportion of all Filipinos in Palau live in urban areas, compared to the residential statistics of the total population of Palau.

For cases that had provided travel history information, most had no history of travelling outside of Palau during the estimated exposure period. It should be noted that only 36% of cases reported travel data, which is an insufficient number for drawing solid conclusions regarding travel data. It does offer some suggestion of dengue fever being endemic in Palau, which is contradictory to research by ME Wilson that suggests that an urban population must be at least 150,000 to 1 million to sustain ongoing circulation of the dengue virus[7]. A larger sample size would be needed to better evaluate the potential endemicity of dengue fever in Palau.

There was a highly significant difference in dengue fever risks between the urban and rural populations. This is consistent with dengue fever's natural cycle, since it is a mosquito-borne disease that requires humans as its reservoir. Thus, with increasing population density, there is increased availability of reservoirs, and so it is expected to find increasing transmission of the disease. Wilder-Smith et al suggest that the population growth in the developing world in general creates especially ripe conditions for dengue fever because of the urbanization, deforestation, increase in dams and irrigation systems, poor housing, inadequate sewage and waste management systems, and the lack of reliable plumbing which makes water collection and storage necessary[2]. Furthermore, poor garbage control and the littering of containers, such as cans, plastic bottles, and tires, create the breeding ground for the Aedes aegypti mosquito, the primary vector for the dengue virus[8,9]. Some of these factors may be involved in Palau's dengue fever situation.

Spatial Analysis

The risk of dengue fever was higher in urban areas compared to rural areas. Aimliik, Airai, and Koror states had the highest risk of dengue fever. Within Koror, Dngeronger had considerably higher risk compared to other Koror hamlets. Eang, Idid, Iyebukel, Meketii, Meyuns, and Ngerbeched hamlets had moderate risk of dengue fever. Targeted prevention and control programs, including programs for community education and community participation in risk abatement, should be directed toward the states and hamlets with the greatest disease risk, particularly since Palau's Public Health system has limited resources to devote to these programs.

Limitations

This study has some important limitations to consider. Not all cases were lab confirmed, and dengue fever is often diagnosed empirically. Since dengue fever can be indistinguishable from other local diseases based on symptoms, it is important that lab confirmation be performed to make a proper diagnosis. Another limitation regarding diagnosis is that rural areas of Palau have diminished access to medical services, and laboratory diagnostics are less available to these areas. Thus, there is a strong possibility of underreporting of cases in Palau, especially in rural areas.

Misclassification bias is somewhat likely to exist. Palau is a small island country and there is much commuting between the rural and urban areas, thus a case could have easily been exposed in an area other than where they reside. This fact should be taken into account when examining the spatial analyses. Cases were classified into urban and rural cases based on residence area, and the location of their workplace or other possible exposure sites is ignored.

Recommendations

Based on this initial analysis, several recommendations can be made regarding prevention and control of dengue fever in Palau. Laboratory testing can be improved to detect more cases of this disease and avoid misdiagnoses. Furthermore, serovars surveillance should be continued to help identify sources of outbreaks, reservoirs, and also to help predict the risk of DHF. Vector control operations against mosquitos should be continued and should be focused on areas with the highest disease risk. Spatial analysis of dengue fever cases and disease risk should be continued, and will thus provide valuable information to direct and target the prevention and control activities to specific high-risk areas of Palau. A final recommendation is to promote greater public awareness so that families and communities can participate more actively in the prevention of this disease.

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