The Epidemiology of Leptospirosis in Palau

A. Michal Stevens *MPH, MD Candidate[1], Karen Carter[2], Rosemary Kiep[2], Stevenson Kuartei MD[2], Ron Schneeweiss MD[1]*

[1]University of Washington School of Medicine
[2]Public Health Services, Ministry of Health, Republic of Palau

Research performed at the Palau Ministry of Health in 2006 under Dr. Stevenson Kuartei.
P.O. Box 6027, Koror, PW 96940, Email: s_kuartei@palau-health.net phone (680) 488-2552.

Correspondence may be sent to: *Michal Stevens, 13716 Midvale Ave N, Apt C, Seattle, WA 9813-7051, (907) 223-4632, Email: Ams42@uw.edu*

Abstract:

Background: *Leptospirosis has been a longstanding problem in Palau, and Public Health programs were implemented in 2000 to conduct surveillance for cases of the disease. Epidemiologic analysis of leptospirosis cases 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 leptospirosis cases in Palau.*

Results: *Between May of 2000 and June of 2006, 81 cases of leptospirosis occurred in Palau. Characteristics of the case population included being male (72.8%), being Palauan (70.4%), having an indoor occupation (71.0%), and living in an urban area of Palau (80.3%). It was also found that non-Palauan cases were significantly more likely to die of leptospirosis compared to the Palauan cases (p=0.0018). Non-Palauan cases were significantly more likely to live in rural areas of Palau (p=0.0001). There was no significant difference in the disease risk when comparing urban and rural areas. The crude disease risk for Palau is 401.9 (95% CI 313.8 – 489.9) cases per 100,000 for the 6.2-year study period, and the average annual risk was 65.2 per 100,000.*

Conclusions: *Leptospirosis continues to be present in Palau, and prevention and control measures should be continued and targeted toward specific states and hamlets of Koror. Furthermore, non-Palauan populations should be targeted for interventions to prevent more severe outcomes of this disease.*

Introduction

Leptospirosis can be a fatal disease, but is also a preventable disease. It occurs worldwide in all but the Polar Regions. It has many serovars, and the serovars are often associated with the specific reservoir animals. Reservoir animals include rats, pigs, cattle, dogs, and raccoons, to name only a few. Humans are infected

via urine-contaminated soil or water, contact with infected animal tissue, or rat bites. Persons working as farmers, field workers, fishermen, miners, veterinarians, animal husbandry workers, dairy workers, abattoir workers, and military troops are at increased risk of contracting leptospirosis. Furthermore, in developing countries, the risk to the general population is greater due to inadequate sanitation in urban areas. Outbreaks have been attributed to seasonal heavy rainfall, storms with heavy rainfall, flooding catastrophes, and mud flooring[1]. Prior studies have demonstrated that leptospirosis disease is more common in males, even though seroprevalence studies indicate similar exposure rates in women[2,3].

While many leptospirosis infections are either asymptomatic or have a mild clinical syndrome, Weil's disease is a more severe form on leptospirosis that affects typically 10% of those infected. Weil's disease mainly causes hepatic and renal impairment, hemorrhage, and vascular collapse, although it is known to cause a multitude of symptoms in other tissues as well. Weil's disease has a fatality rate of roughly 10%, depending partially on the serovar. The only known epidemiologic risk factor for mortality in Weil's disease is older age.[2]

Palau is an 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 the island of Babeldaob, and a small proportion of the population lives on other islands to the north of Babeldaob or to the southwest of Koror and Babeldaob. Palau is believed to be endemic with leptospirosis and improved lab testing and reporting of cases was implemented in 2000. A study by the Palau Ministry of Health in 2000 demonstrated that 8% (13/171) of adults with a "viral syndrome" were found to have leptospirosis[4]. In Palau, rats are considered the main reservoir host, but stray dogs and pigs are also considered a local carrier. Environmental programs for vector control have been found to decrease the risk of leptospirosis[5], and the Palau Ministry of Health has implemented control measures in the form of rat trapping and evaluation and correction of environmental defects that attract rats (such as nesting places and easy access to food and water). Very little epidemiological information is known about the occurrence of leptospirosis 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. Disparities in the risk for leptospirosis can also be used to target specific population groups for more focused prevention efforts. 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.

Methods

This study analyzed surveillance data for leptospirosis 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 leptospirosis cases from 2000 to 2006 was

used. Records prior to 2005 were tracked on a spreadsheet in the Department of Environmental Health. 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 in Palau, date of admission, outcome, and if the case had ill contacts. Missing information was gathered via a medical record review of 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 data for confirmed, suspected, or probable cases, and analytic epidemiology was performed to assess any difference in urban versus rural occurrence of disease, as well as outcome. The statistical analyses were performed with SASv8 software (SAS Institute, Inc., Cary, NC). ArcGIS v9 (ESRI, Redlands, CA) was used to visualize the spatial distributions of risk for leptospirosis by Palau state and Koror hamlet.

An analysis of the relationship between environmental defects and local rat populations was performed to attempt to better understand local vectors and their potential associations with leptospirosis. Regression analysis was also used to assess possible associations between the environmental defects and the numbers of rodents trapped in the initial portion of the survey as predictors of the risk of leptospirosis by geographic area.

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 the age distribution. Data from the 2000 and 2005 censuses were used to compute a midpoint for many of the denominators.

Results

Between late May of 2000 and June of 2006, 81 cases of leptospirosis were reported (Figures 1 and 2). No seasonality is evident in the quarterly data. The majority of cases were male (59 of 81, 72.8%). The mean age of cases was 31.8 years old and the median was 31 years old. Ages of cases had a range of 74.5 years, from 1.5 to 76 years old. In examining the age-specific risks, adolescent and young to middle-aged adults had the highest risk for contracting leptospirosis (Table 1).

Seventy-seven percent of cases (62/81) provided usable information on their occupations. This data was classified into indoor versus outdoor occupation categories. Of those that could be classified, 44 (71.0%) had indoor occupations and only 18 (29.0%) had outdoor occupations. It was found that cases with outdoor occupations were significantly more likely to reside in rural areas of Palau compared to cases with indoor occupations (OR=4.03, 95% CI 1.12 – 15.50).

Figure 1: Time Curve of Leptospirosis Cases Reported in Palau by Year from May, 2000 to June, 2006

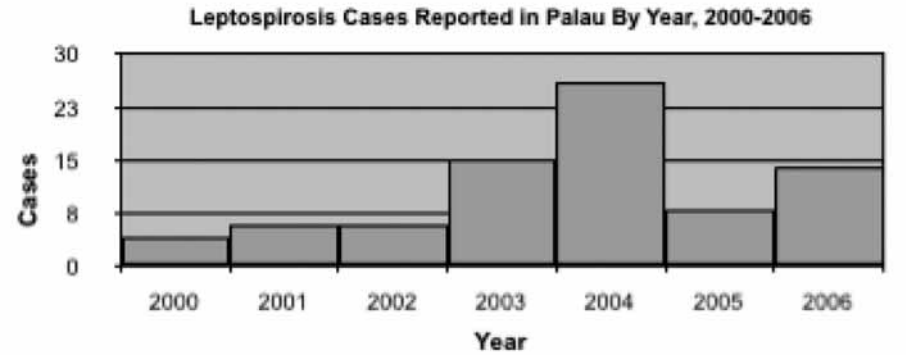


Figure 2: Time Curve of Leptospirosis Cases Reported in Palau by Quarter from May, 2000 to June 2006.

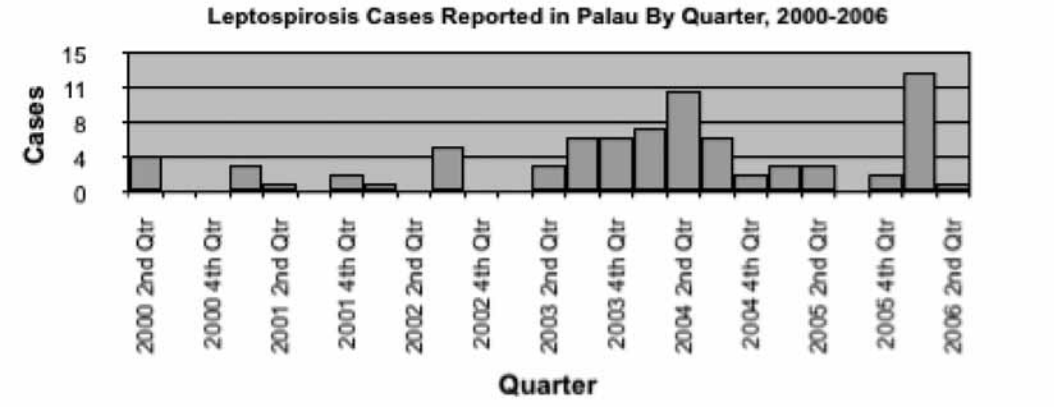


Table 1: Age Categories of Leptospirosis Cases Reported in Palau, 2000-2006, and Age-Specific Risks

Age Group	No.	%	Midpoint from Census Data*	Age-Specific Risk (per 100,000)
0 - 9	4	4.94	2,946	135.8
10 - 19	17	20.99	3,157	538.6
20 - 29	15	18.52	3,051	491.7
30 - 39	20	24.69	3,941	507.5
40 - 49	11	13.58	3,172	346.8
50 - 59	10	12.35	1,682	594.7
60+	4	4.94	1,571	254.6

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

Table 2: Ethnicity Categories of Leptospirosis Cases Reported in Palau, 2000-2006

Ethnicity	No.	%
Palauan	57	70.37
Filipino	12	14.81
Bangladeshi	6	7.41
Other	6	7.41

Cases were categorized into urban or rural areas of residence, with Koror and Airai being considered the only urban areas in Palau. With this information, it was found that 65 (80.3%) cases lived in urban areas and only 16 (19.7%) lived in rural areas. The majority of cases were Palauan (57, 70.4%), followed by Filipino (12, 14.8%) and Bangladeshi (6, 7.4%).

There were 4 deaths due to leptospirosis during the study period. Non-Palauan cases were significantly more likely to die of leptospirosis compared to Palauan cases (p=0.0018; no Palauans died of leptospirosis).

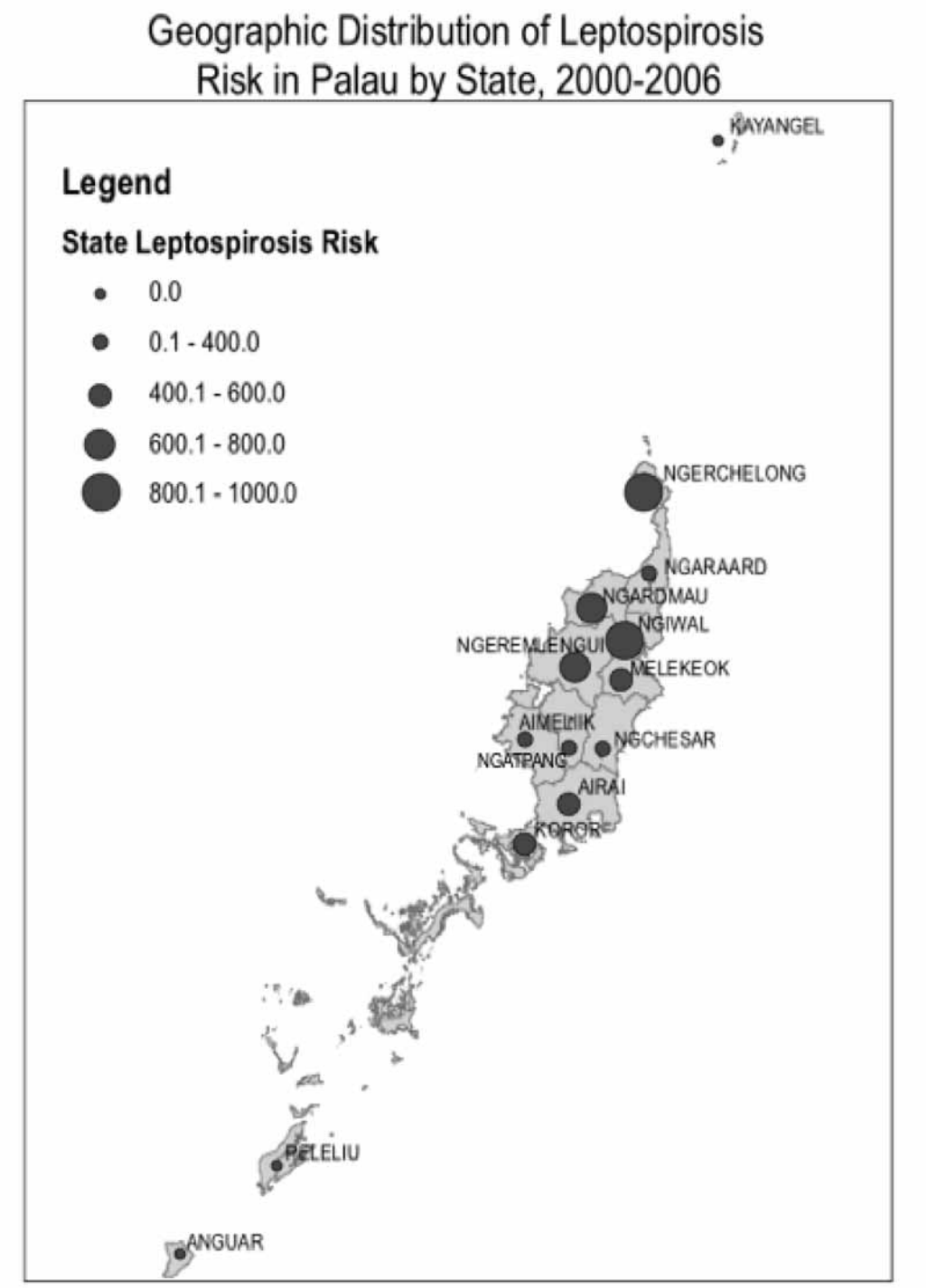
No significant trend in gender distribution was detected for urban versus rural cases (OR=1.79, 95% CI 0.46 – 7.00). Urban cases were noted to be younger than rural cases (urban mean age: 29.9 years, rural mean age: 39.6 years; p=0.0311). Non-Palauans were significantly more likely to be from rural areas than Palauan cases (OR=8.8, 95% CI 2.60 – 29.79, p=0.0001). The crude risk for leptospirosis is 401.9 (95% CI 313.8 – 489.9) cases per 100,000 for the 6.2-year study period (average annual risk of 65.2 cases per 100,000). The summary disease risk for Palau's urban area is 422.1 cases per 100,000 over the 6.2-year study period (95% CI 319.5 – 524.7) (average annual risk of 68.4 cases per 100,000). The summary disease risk for Palau's rural areas is 332.7 cases per 100,000 over the 6.2-year study period (95% CI 164.4 – 501.1; average annual risk of 53.9 cases per 100,000) (Table 3 and Figure 3). A t-test showed no significant difference in risk between the unweighted means of the urban and rural Palauan states (F-value=1.39, F p-value=0.38, pooled T-value= -0.55, p=0.59).

Table 3: Number and Percent of Leptospirosis Cases, Population, and Disease Risk for Palau States, 2000-2006

State	No. of Cases	% of Cases	2005 Population	Risk (per 100,000)	Lower 95% CI for Risk	Upper 95% CI for Risk	Urban/ Rural
Airai	14	17.50	2723	514.1	244.8	783.5	Urban
Koror	51	63.75	12676	402.3	291.9	512.8	Urban
Aimeliik	1	1.25	270	370.4	-355.6	1096.3	Rural
Anguar	0	0.00	320	0.0	0.0	0.0	Rural
Hatohobei	0	0.00	44	0.0	0.0	0.0	Rural
Kayangel	0	0.00	188	0.0	0.0	0.0	Rural
Melekeok	2	2.50	391	511.5	-197.4	1220.4	Rural
Ngaraard	1	1.25	581	172.1	-165.2	509.5	Rural
Ngardmau	1	1.25	166	602.4	-578.3	1783.1	Rural
Ngatpang	1	1.25	464	215.5	-206.9	637.9	Rural
Ngchesar	1	1.25	254	393.7	-378.0	1165.4	Rural
Ngerchelong	4	5.00	488	819.7	16.4	1623.0	Rural
Ngeremlengui	2	2.50	317	630.9	-243.5	1505.3	Rural
Ngiwal	2	2.50	223	896.9	-346.1	2139.8	Rural
Peleliu	0	0.00	702	0.0	0.0	0.0	Rural
Sonsorol	0	0.00	100	0.0	0.0	0.0	Rural

*State was unknown for 1 case.

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



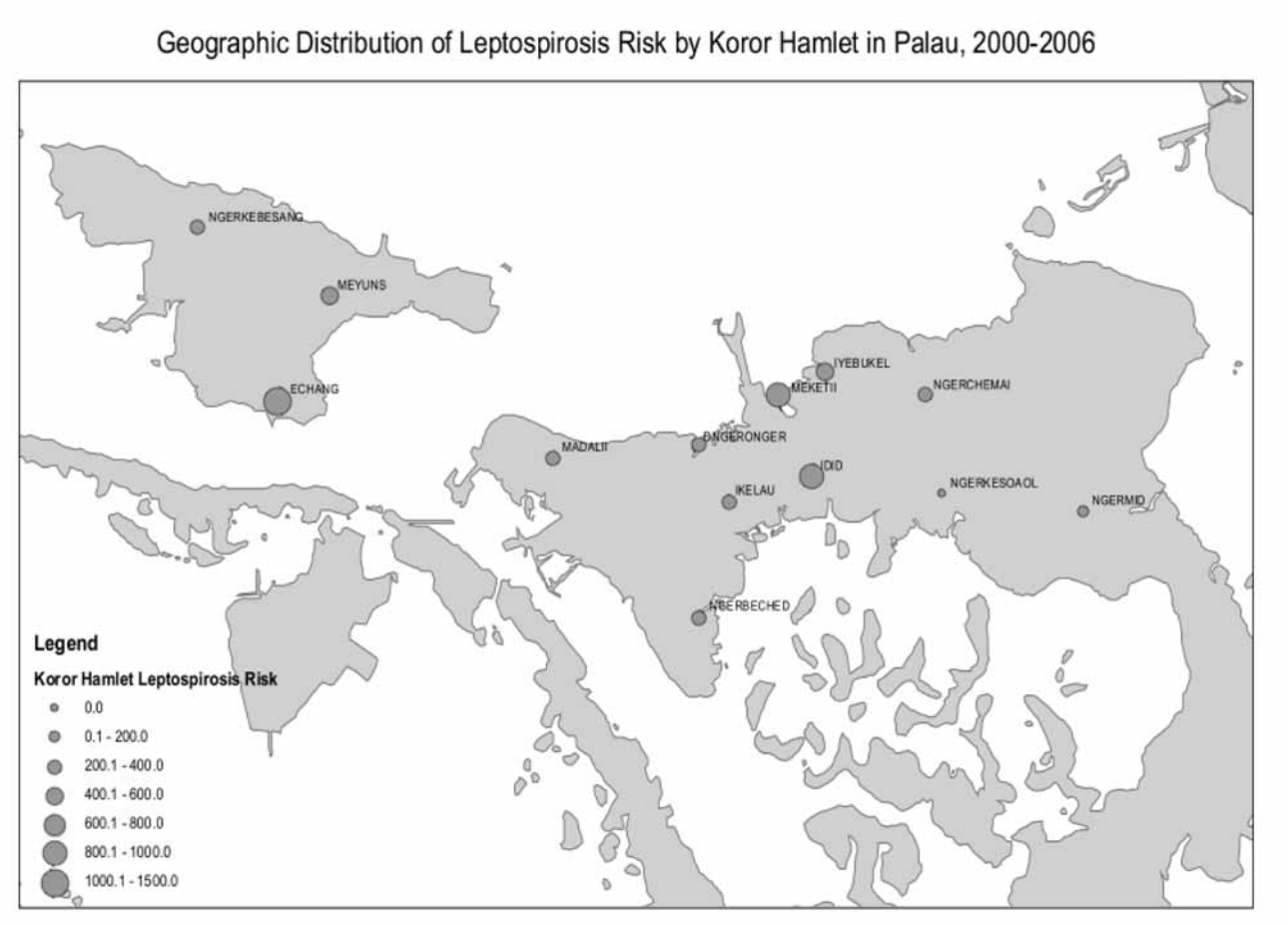
*The states of Hatohobei and Sonsorol not included due to their distant geographic location

The majority of cases (51/81, 63%) occurred in Koror, making it necessary to carry the analysis to the hamlet level. Table 4 provides the leptospirosis risk by Koror hamlet and Figure 4 demonstrates the spatial occurrence of leptospirosis by hamlet (Figure 4).

Table 4: Number and Percent of Leptospirosis Cases, Population, and Disease Risk for Koror Hamlets, 2000-2006

Koror Hamlet	No. Of Cases	% of Koror Cases	2005 Population	Risk (per 100,000)	Lower 95% CI for Risk	Upper 95% CI for Risk
Dngeronger	1	1.96	275	363.6	-349.1	1076.4
Echang	5	9.8	353	1416.4	174.9	2658.0
Idid	7	13.73	722	969.5	251.3	1687.8
Ikelau	1	1.96	435	229.9	-220.7	680.5
Iyebukel	6	11.76	1065	563.4	112.6	1014.2
Madalii	7	13.73	2207	317.2	82.2	552.1
Meketii	5	9.8	505	990.1	122.2	1858.0
Meyuns	5	9.8	1153	433.7	53.5	813.8
Ngerbeched	5	9.8	1534	325.9	40.2	611.6
Ngerchemai	7	13.73	1871	374.1	97.0	651.3
Ngerkebesang	1	1.96	427	234.2	-224.8	693.2
Ngerkesoaol	0	0	933	0.0	0.0	0.0
Ngermid	1	1.96	1196	83.6	-80.3	247.5

Figure 4: Map Demonstrating the Geographic Distribution of Leptospirosis Risk in Koror by



Discussion

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

Epidemiology

Epidemic curves of leptospirosis cases show that there was a dramatic increase in the numbers of cases reported in 2003 to 2004, and there was also an apparent increase in the number of cases reported in early 2006. These increases could be due to a true increase in the number of diagnosed cases, or possibly increased reporting practices. No seasonality was evident in the quarterly data (Figures 1 and 2).

In examining surveillance data of leptospirosis cases reported in Palau from 2000 to 2006, it was found that cases were more likely to be Palauan, male, and adolescent, or young to middle-aged adults (Tables 1 and 2). Young- to middle-aged men may be more likely to engage in outdoor activities, and thus have greater risk of exposure to leptospirosis.

However, cases tended to have indoor occupations and reside in urban areas of Palau. It should be noted that there is significant opportunity for confounding between these variables, and they are also rather poor surrogate markers for determining where and in what circumstance a person was exposed, especially given the ease of commuting between urban and rural areas in this small island country.
The age distribution of cases seemed to vary between urban and rural areas of Palau, with cases between the ages of 20 and 39 years being more likely to occur in rural areas. Cases in rural areas also had a significantly higher mean age compared to cases from urban areas. Outdoor jobs are more common in rural areas of Palau.

When examining age distribution by gender, a disproportionate number of cases were female in the oldest age category (≥40 years). This is supported by the local knowledge that older women often work in taro patches, and thus may be at higher risk of contracting leptospirosis in this environment.

Ethnicity is apparently a very important factor in this study. Non-Palauan cases were significantly more likely to come from rural areas, compared to Palauans. Furthermore, non-Palauan cases were much more likely to die of leptospirosis. This trend demands further investigation into the risk factors for contracting leptospirosis, developing Weil's disease, and also access to care for this population group.

The crude average annual risk for leptospirosis is 65.2 cases per 100,000. The difference in risk for leptospirosis between the rural and urban areas was not statistically significant. There is a lack of recent published data from other nearby small island countries for comparison.

Spatial Analysis

Analyses of leptospirosis risk by geographic location revealed that the disease risk was higher in urban areas compared to rural areas, but this was not statistically significant. Ngiwal and Ngerchelong states had the highest risk of leptospirosis disease, while Ngeremlengui, Ngardmau, Melekeok, and Airai states have moderate risk also. In Koror, Echang, Idid, and Meketii hamlets had the greatest risk of leptospirosis disease. 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.

Rat Control

The Palau Ministry of Health's Division of Environmental Health conducted a vector control survey as part of an interventional study for controlling rat populations. This survey involved trapping rats and evaluating environmental conditions at selected households in 4 states and 6 Koror hamlets in Palau. Two such surveys were conducted, with the first survey also involving recommendations for improving environmental defects. Effectiveness of the intervention was measured by a reduction in the number of environmental defects and the number of rodents trapped. The presence of an abandoned vehicle and having trapped a rodent were the only significant predictors of leptospirosis risk. Furthermore, only the presence of an abandoned vehicle was predictive of trapping a rodent, when trapping a rodent was assessed as an outcome. Rat control operations should be continued to minimize the risk of leptospirosis.

To place further importance on rat control programs, it is known that Leptospira interrogans serovar icterohemorrhagiae is the main serovar associated with rats, and this serovar is also associated with the more severe manifestation of leptospirosis, called Weil's disease. Specifically addressing this vector may help diminish the number of severe cases and deaths due to this disease.

Limitations

This study has some important limitation to consider. Not all cases were lab confirmed, and leptospirosis is often diagnosed empirically, rather than with lab diagnostics. Since leptospirosis 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 limited access to medical services, and laboratory diagnostics are less available to these areas. Thus, there is a strong possibility of underreporting of leptospirosis cases in Palau, especially in rural areas.

Misclassification bias is likely to exist, particularly for the classification of indoor versus outdoor occupational environment, since this classification scheme was based on the reported occupation, although the actual work conditions were not specifically known. Ambiguous or missing information likely affected the quality of these variables for this study. Furthermore, Palau is a small island country and much commuting takes place between the rural and urban areas, thus a case could have easily been exposed in an area other that 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.

Sample size is definitely a limitation for this study, with only 81 cases reported during this 6.2-year period. The strength of many associations in this research is lower than would be expected with a larger sample size. Thus, associations should be carefully considered with this limitation in mind.

Recommendations

Based on this analysis, several recommendations can be made regarding prevention and control of leptospirosis in Palau. Laboratory testing can be improved to detect more cases of this disease and avoid misdiagnoses. Furthermore, periodic serovar surveillance can be performed to identify which serovars are most problematic. This information may further indicate what species of animal carriers are reservoirs, and can help direct the continuing prevention and control operations. With rats, environmental defects should continue to be assessed and corrected to minimize the presence of rats near human habitations. Spatial analysis of leptospirosis 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. Public Health entities should work to promote greater public awareness so that families and communities can participate more actively in the prevention of this disease. Finally, measures should be taken to ensure that minority groups are able to seek care when they are ill. This may involve providing informative materials in foreign languages and assisting with transportation to a hospital or clinic.

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"The strength of the heart comes from the soundness of the faith."

Saudi Arabian Proverb