INTRODUCTION

It has been estimated that ciguatera toxin is the most common cause of fish poisoning worldwide. To date, however, few reports have been published describing its public health impact in at-risk communities. Moreover, the increasing global trade in tropical and exotic fish, coupled with increasing tourism to endemic areas, makes research into the epidemiology of fish poisoning a subject of increasing public health relevance.

Ciguatera fish poisoning is endemic throughout much of the tropics and sub-tropics. It is caused by ciguatoxins that originate in dinoflagellate organisms, including Gambierdiscus toxicus. Such toxins lead to increased nerve membrane excitability through their action on voltage-gated sodium channels. The clinical manifestations of ciguatera fish poisoning vary widely; however, the usual presentation is with gastrointestinal, neurologic, or cardiovascular symptoms beginning 1–6 hours after the ingestion of fish containing the toxins. Features of peripheral neuropathy including paresthesia, dental pain, and paradoxical disturbance of thermal sensation, are the hallmarks of this condition. Nevertheless, except in severe cases, the results of electrophysiologic studies are usually normal.

In this paper, we describe the epidemiology of ciguatera fish poisoning on two of the northern islands of the archipelago of Vanuatu in the southwestern Pacific region.

MATERIALS AND METHODS

Study area and population. The islands of Vanuatu (formerly known as The New Hebrides) form a chain of 80 islands situated between the Solomon Islands and New Caledonia. The climate is tropical, with a long wet or summer season (November-May) and a shorter dry or winter season (June-October). Indigenous Melanesians (Ni-Vanuatu) constitute 98% of the population, with the remainder consisting mainly of Chinese, Vietnamese, and Europeans. In 1989, the national census estimated the population of Santo and Ambae to be 25,581 and 8,583, respectively. The demographic characteristics of Vanuatu are similar to those of many developing nations, with 17.5% of the population less than 5 years old and 55% less than 20 years old. More than 75% of the adult population work in subsistence farming, a category that includes fishing. A single hospital in Luganville, Santo, in the Northern District Hospital (NDH) serves as a referral center for the Northern District; however, more than 95% of the admissions to the NDH are from Santo alone. Lolowi Hospital is the only hospital on the island of Ambae. Most admissions to both hospitals are self-referred. Hospital-based studies were conducted in the Northern District and Lolowi Hospitals.

Data collection. We conducted a retrospective descriptive study at the Northern District and Lolowi Hospitals. Ward registers were examined for the 10-year period January 1, 1986 to December 31, 1995 to identify patients admitted with a diagnosis of either fish or ciguatera poisoning. The hospital notes for cases were traced and information on clinical symptoms was recorded onto a standard form. Where notes were not available, limited information regarding age, date of admission, and outcome (discharged or died) was recorded from the ward register. Some patients did not know their ages and were classified as more than 20 years old. Although the study was conducted in January 2000, the study period was chosen because a national strike caused a severe disruption in record keeping during the intervening years.

Data processing. Data were collected onto a standardized form and entered onto a computer spreadsheet (Excel; Microsoft, Inc., Redmond, WA). A case of fish poisoning was defined as a patient admitted to hospital with a diagnosis of either fish or ciguatera poisoning recorded in the ward register. An outbreak was defined as two or more cases presenting on the same day from the same area. The drainage populations for each hospital were estimated using figures from the 1989 national census, which was inflated by 2.8% per year to account for population growth. The mid-study (1990) populations were thus estimated at 26,297 (14,463 < 20 years old and 11,834 ≥ 20 years old) for the NDH and 8,823 (4,853 < 20 years old and 3,970 ≥ 20 years old) for Lolowi Hospital. Crude and age-adjusted rates of hospital admission with fish poisoning were then calculated.

RESULTS

Between January 1, 1986 and December 31, 1995, 198 cases of fish poisoning were admitted to the Northern District and Lolowi Hospitals. Of the 171 cases admitted to the NDH, 148 (86.5%) subjects were Ni-Vanuatu and 23 (13.5%) were Oriental. Seventy-two of these cases presented in 24 outbreaks. The type of fish consumed was recorded in only 11 cases (reef fish, 4; barracuda, 2; and eel, 5). One patient was recorded as having eaten the liver of the fish. Six cases were admitted with additional diagnoses, including upper respiratory tract infection, malaria, hypertension, and diabetes mellitus. One patient died during admission and another developed an organic
psychosis. Although the latter case was thought to be exacerbated by diabetes mellitus, neuropsychiatric disorders are a recognized feature of ciguatera poisoning.\textsuperscript{11}

Twenty-seven cases of fish poisoning were admitted to Lolowi Hospital during the study period. All patients were Ni-Vanuatu. Two individuals were admitted more than once. Another individual was diagnosed with post-ciguatera/malaria. No deaths were recorded. Five cases occurred in two outbreaks.

Crude annual admission rates with fish poisoning (95% confidence interval) to the Northern District and Lolowi Hospitals were 65 (55−75) and 29 (19−43)/100,000 population, respectively.

Age and sex. The age and sex of the cases is shown in Table 1. Fish poisoning was more common in adults than in children, and the age distribution was similar in both hospitals. Among adults, males were more frequently admitted to the hospital than females (Table 1), with a male: female ratio of 4:1. This marked sex difference was not seen in children < 10 years old: however, the numbers in this age group were limited. This imbalance was not seen in those admitted with other diagnoses.\textsuperscript{16}

Temporal and seasonal patterns. Figures 1 and 2 show the variation of admissions by year and month. The apparent peak of cases in 1992 included several small clusters of 4−5 cases presenting to the NDH. In 1988, a large outbreak of fish poisoning occurred when 13 Vietnamese fisherman were admitted on the same night in July. This outbreak accounts for the apparent peak in the month of July (Figure 2).

Clinical data. Hospital records were available for 95 (48%) of 198 patients. The availability of information from patients admitted with fish poisoning was similar to that of information for individuals admitted with other diagnoses (Goodman A, unpublished data) and was not believed to represent a systematic bias. The clinical data are shown in Table 2. Although the onset of symptoms occurred shortly after the consumption of the suspected fish in all cases, the length of time to hospital presentation was variable. Most patients presented within three hours to nine days; however, in one patient, presentation was delayed for one month.

Treatments prescribed included atropine for bradycardia and intravenous fluids for hypotension or dehydration. Promethazine hydrochloride (an antihistamine) was commonly prescribed for pruritus. Other treatments included antacids, hyoscine butylbromide (to reduce gut motility and gastric secretions), codeine preparations (for diarrhea), and oral rehydration solution and prochlorperazine (for nausea and vomiting). Mannitol was not prescribed in this series.

**DISCUSSION**

Our report confirms that fish poisoning is an important cause of morbidity in Vanuatu. Although fish poisoning is widely viewed as a health problem in tropical and sub-tropical countries, remarkably few incidence studies have appeared in

### Table 1

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Males no. (%)</th>
<th>Females no. (%)</th>
<th>Total no. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–9</td>
<td>8 (4.0)</td>
<td>6 (3.0)</td>
<td>14 (7.1)</td>
</tr>
<tr>
<td>10–19</td>
<td>19 (9.6)</td>
<td>5 (2.5)</td>
<td>24 (12.1)</td>
</tr>
<tr>
<td>20–29</td>
<td>45 (22.7)</td>
<td>7 (3.5)</td>
<td>52 (26.3)</td>
</tr>
<tr>
<td>30–39</td>
<td>24 (12.1)</td>
<td>2 (1.0)</td>
<td>26 (13.1)</td>
</tr>
<tr>
<td>40–49</td>
<td>14 (7.1)</td>
<td>0 (0.0)</td>
<td>14 (7.1)</td>
</tr>
<tr>
<td>50–59</td>
<td>7 (3.5)</td>
<td>2 (1.0)</td>
<td>9 (4.5)</td>
</tr>
<tr>
<td>60–69</td>
<td>5 (2.5)</td>
<td>5 (2.5)</td>
<td>10 (5.1)</td>
</tr>
<tr>
<td>Adults (age unknown)</td>
<td>39 (19.7)</td>
<td>10 (5.1)</td>
<td>49 (24.7)</td>
</tr>
<tr>
<td>Total</td>
<td>161 (81.3)</td>
<td>37 (18.7)</td>
<td>198 (100)</td>
</tr>
</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Clinical data</th>
<th>No. with data</th>
<th>No. with clinical feature (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal pain</td>
<td>95</td>
<td>30 (32.6)</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>95</td>
<td>64 (67.4)</td>
</tr>
<tr>
<td>Vomiting</td>
<td>95</td>
<td>59 (62.1)</td>
</tr>
<tr>
<td>Hypotension*</td>
<td>79</td>
<td>34 (43.0)</td>
</tr>
<tr>
<td>Bradycardia†</td>
<td>78</td>
<td>36 (46.1)</td>
</tr>
<tr>
<td>neurologic symptoms‡</td>
<td>95</td>
<td>17 (17.8)</td>
</tr>
<tr>
<td>Urinary symptoms§</td>
<td>95</td>
<td>7 (7.4)</td>
</tr>
<tr>
<td>Joint pain</td>
<td>95</td>
<td>15 (15.7)</td>
</tr>
</tbody>
</table>

* Blood pressure was not recorded in 16 patients.
† Heart rate was not recorded in 17 patients.
‡ These included confusion (1), paresthesia (7), pruritus (4), temperature perception reversal (2), numbness of the mouth (1), and dental pain (2).
§ These included dysuria and difficulty in passing urine.
the published literature. On the basis of the few studies that have used hospital-based case detection, the incidence varies widely from 7.8/100,000 per year in Reunion Island to 360/100,000 in St. Thomas in the United States Virgin Islands. We estimate hospital admission rates of 29 and 65/100,000 population in the communities studied. These incidence figures represent a minimum estimate of the true burden of disease attributable to fish poisoning in Vanuatu for two reasons. First, we made no attempt in our study to identify cases of fish poisoning that had been misclassified under other diagnoses such as neurologic or gastrointestinal illnesses. Second, we anticipated that patients presenting to hospital represented only a small proportion of all cases of fish poisoning. This conclusion is supported by a recent community survey conducted in coastal areas in Vanuatu that estimated an incidence of 460/100,000 population/year.

Previous studies have found little evidence for a sex difference in the incidence of fish poisoning, although one study conducted in Tahiti found an increased risk in males (risk ratio = 1.6). Nevertheless, in the current study 80% of the cases admitted to hospital were male. Since previous studies have failed to find an association between the severity of the disease and sex, we believe that the sex bias seen in the current study may be attributable to behavioral factors. For example, in Vanuatu it is traditional for men to eat before the rest of the family, and nutritional interviews have shown that Ni-Vanuatu males eat more fish than other members of the family (Phelps L., unpublished data). Moreover, men are more likely to eat the head and entrails of the fish when sharing it with their families (Phelps L., 1997, *The Aetiology and Prevalence of Malnutrition in Children in Vanuatu*, MSc thesis, Leeds Metropolitan University). Conversely, women traditionally avoid fish during pregnancy or while breastfeeding (Phelps L., 1997, *The Aetiology and Prevalence of Malnutrition in Children in Vanuatu*, MSc thesis, Leeds Metropolitan University), a practice that may prevent cases in infants, since the transfer of ciguatera toxin via breast milk has been reported.

More than 40% of patients admitted to the hospital with fish poisoning in our study were in their third or fourth decade, an observation that is consistent with data from previous studies. A number of explanations may account for this. First, children may be less susceptible to the toxin or, for cultural reasons, may be exposed less often. Second, eating fish with low levels of toxin over many years may lead to accumulation of or sensitization to the toxin in older patients, a hypothesis supported by the worsening of symptoms with repeated episodes of ciguatera poisoning. Therefore, the explanation for the increased incidence of fish poisoning in this age group remains unresolved. Previous studies have shown some evidence for seasonality of fish poisoning, which has been ascribed to fluctuations in the abundance of dinoflagellate organisms. In the current study we found little evidence of seasonality of fish poisoning in Vanuatu.

Of the patients hospitalized with a diagnosis of fish poisoning in our study, common clinical features included gastrointestinal disturbance, hypotension, and bradycardia (Table 2). Paresthesia or neurologic sequelae occurred in only 18% and mortality was negligible. Mannitol, an osmotic diuretic found by other investigators to be effective in the treatment of ciguatera poisoning, was not used on the islands of Santo or Ambae. Whether this reflects limited drug availability, a lack of awareness of its possible benefits, or a belief that it is ineffective, the limited use of mannitol in the Pacific has been previously noted.

In conclusion, ciguatera fish poisoning causes considerable morbidity in Vanuatu. However, most communities continue to consume fish, which remains an important source of dietary protein. Although we were unable to detect any appreciable acute mortality, the long-term effects on survival are unknown. Two factors argue for an increased awareness regarding the features and management of fish poisoning outside endemic areas. First, the growth in global tourism puts travelers at potential risk. Second, the increasing global trade in tropical fish, in conjunction with the absence of wide-scale testing for the toxin, makes ciguatera poisoning a potential risk in parts of the world where there is little experience of the disease. Both travelers to high-risk areas and their physicians should be aware of the risks and manifestations of fish poisoning.

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REFERENCES


