EPIDEMIOLOGY AND ECOLOGY OF GASTRIC CANCER IN COSTA RICA

Rafaela Sierra and Ramiro Barrantes

Costa Rica’s high incidence of gastric cancer and suitable data sources provide a good basis for studying the origins of this disease. The work reported here assesses regional and other variations within the country in terms of the age and sex of gastric cancer patients, the patients’ birthplaces and places of residence, and various environmental factors.

Introduction

Among the diseases involving malignant tumors, gastric cancer is the leading cause of death in Costa Rica (1–4). It has also been found that the incidence of gastric cancer in Costa Rica and the mortality resulting from the disease are exceeded only in Japan and Chile (5–8, 35). Within Costa Rica, however, Moya de Madrigal (9) has found that this tumor occurs with proportionately greater frequency in the central provinces than in the coastal provinces, and Miranda et al. (10) have also discerned differences between certain regions of the country. Since 1977, when cancer notification was made compulsory, a national registry of tumors has maintained a precise record of cases throughout the country. This latter circumstance, together with the frequency of the disease, makes Costa Rica an especially suitable country for the investigation of gastric cancer.

The objectives of the work reported here were as follows: (a) to study the epidemiology of gastric cancer in detail, using data from the National Registry of Tumors and other related sources; (b) to analyze changes in the areas of residence of gastric cancer patients vis-a-vis geographic areas with differing incidence levels; (c) to relate the data obtained to various ecological parameters—such as dietary, drinking-water, and soil constituents—that could affect the incidence of gastric cancer.

Materials and Methods

The sample employed consisted of 1,315 patients with gastric cancer. All persons with this disease who were listed in the records of the National Registry of Tumors from April 1977 to March 1980 were included. The basic information obtained on each subject was as follows: (a) age at first diagnosis; (b) place of birth (province and canton); (c) place of residence when the cancer was diagnosed (province, canton, district); (d) condition when the information was procured; (e) age at death; and (f) the method used to reach the diagnosis. The data were coded and analyzed by computer.

Age-standardized rates, adjusted4 on the basis of the “world population” (11), by sex, were found for the country as a whole and for each canton (municipality) where gastric cancer patients had been born. Using these rates as a guide, the following zones of risk

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4 This adjustment was made by applying the age-specific mortality figures for the study population to the numbers of people in the comparable age groups of the “standard population,” so as to find the number of deaths that would have occurred in the standard population if these age-specific death rates had prevailed.
were established: (1) very high risk—areas with an incidence greater than 108 cases per 100,000 inhabitants; (2) high risk—with an incidence between 66 and 108 cases per 100,000; (3) moderate risk—between 33 and 65 cases per 100,000; and (4) low risk—less than 33 cases per 100,000.5

For each region defined, all of the epidemiologic variables cited above were analyzed so as to examine the influences of sex, age, and population movements upon disease rates in the region. In addition, a retrospective study was made of trends in standardized gastric cancer death rates from 1960 to 1976, based on the annual statistical data for Costa Rica.

For the purpose of assessing environmental factors, data were obtained on variations in drinking-water and soil constituents. Specifically, the archives of the National Water Supply and Sewerage System provided data on the physical-chemical analyses of drinking-water samples in several areas; these samples were taken during two months of the dry season (January and February) and two months of the rainy season (September and October) during three years (1976, 1978, and 1980). The data obtained included values for pH, total hardness, calcium hardness, magnesium hardness, and the samples' content of iron, chlorides, silica, and sulphates in milligrams per liter.

Regarding soils, the Ministry of Agriculture provided data on the composition of soils in different parts of Costa Rica, based on soil samples processed at the Costa Rican Tropical Farming Research and Training Center (CATIE) in San José. The factors considered were pH and the samples' content of calcium, iron, potassium, phosphorus, zinc, magnesium, aluminum, and manganese. The levels defined as low for each factor were a pH below 5.5, and less than 0.3 milliequivalents of aluminum, 2.2 milliequivalents of calcium, 0.8 milliequivalents of magnesium, 0.20 milliequivalents of potassium, 1.0 milligram of phosphorus, 1.0 milligram of iron, 0.5 milligrams of manganese, 0.3 milligrams of zinc, and 0.1 milligrams of copper per 100 milliliters of soil. Multivariate analyses were performed, using specific computer programs, to assess these factors' possible influence upon the incidence of gastric cancer.

In addition, an effort was made to examine possible correlations between rates of gastric cancer and certain nutritional parameters set forth in works by the Ministry of Health of Costa Rica (12, 13), the U.S. Agency for International Development (14), and the Nutrition Institute of Central America and Panama (15).

Results

The retrospective study of annual data indicated that mortality from gastric cancer declined by 26 per cent between 1960-1961 and 1975-1976 (Table 1). Similar declines in standardized gastric cancer mortality have been observed in other countries (16). Rates standardized by sex could not be obtained for this period, but gross rates by sex were obtained, and it was found that the decline was greater among females. This trend has also been observed elsewhere (2, 17, 18).

Overall, as Table 2 shows, the average annual incidence of gastric cancer among males and females in Costa Rica, standardized on the basis of the "world population," was 51.4 cases per 100,000 for males and 25.6 cases per 100,000 for females during the period 1977-

<table>
<thead>
<tr>
<th>Period</th>
<th>Annual mortality per 100,000 standardized for age</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-1961</td>
<td>51.00</td>
</tr>
<tr>
<td>1964-1966</td>
<td>49.30</td>
</tr>
<tr>
<td>1970-1971</td>
<td>41.71</td>
</tr>
<tr>
<td>1972-1974</td>
<td>39.11</td>
</tr>
<tr>
<td>1975-1976</td>
<td>37.74</td>
</tr>
</tbody>
</table>

Table 1. Gastric cancer mortality in Costa Rica per 100,000 inhabitants, standardized for age, in various periods from 1960 to 1976.

5Foreigners were not included in these data.
Table 2. The standardized\textsuperscript{a} annual incidence of gastric cancer in Costa Rica during 1977-1980, by age and sex per 100,000 inhabitants, and the estimated male:female case ratio, in regions grouped according to levels of risk.

<table>
<thead>
<tr>
<th>Regions, grouped by level of risk</th>
<th>≤ 24</th>
<th>25-29</th>
<th>30-34</th>
<th>35-39</th>
<th>40-44</th>
<th>45-49</th>
<th>50-54</th>
<th>55-59</th>
<th>60-64</th>
<th>65-69</th>
<th>70-74</th>
<th>≥ 75</th>
<th>Total</th>
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<tr>
<td>Very high risk:</td>
<td></td>
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<tr>
<td>Est. M:F case ratio\textsuperscript{b}</td>
<td>4.0</td>
<td>3.0</td>
<td>0.3</td>
<td>3.0</td>
<td>2.4</td>
<td>0.8</td>
<td>3.5</td>
<td>3.6</td>
<td>4.2</td>
<td>2.5</td>
<td>2.3</td>
<td>2.1</td>
<td>2.5</td>
</tr>
<tr>
<td>Male rate</td>
<td>1.9</td>
<td>14.4</td>
<td>5.6</td>
<td>39.0</td>
<td>86.0</td>
<td>108.5</td>
<td>268.7</td>
<td>635.1</td>
<td>436.3</td>
<td>1,081.8</td>
<td>1,165.5</td>
<td>1,239.3</td>
<td>153.2</td>
</tr>
<tr>
<td>Female rate</td>
<td>0.0</td>
<td>4.6</td>
<td>16.9</td>
<td>12.1</td>
<td>34.9</td>
<td>130.9</td>
<td>67.6</td>
<td>116.3</td>
<td>101.5</td>
<td>400.8</td>
<td>508.9</td>
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<td></td>
</tr>
<tr>
<td>Est. M:F case ratio\textsuperscript{b}</td>
<td>0.1</td>
<td>0.3</td>
<td>1.0</td>
<td>3.0</td>
<td>1.0</td>
<td>1.1</td>
<td>1.3</td>
<td>2.6</td>
<td>1.9</td>
<td>3.0</td>
<td>2.4</td>
<td>2.7</td>
<td>2.0</td>
</tr>
<tr>
<td>Male rate</td>
<td>0.0</td>
<td>4.5</td>
<td>10.5</td>
<td>17.7</td>
<td>20.2</td>
<td>75.3</td>
<td>131.6</td>
<td>278.3</td>
<td>333.1</td>
<td>630.7</td>
<td>583.7</td>
<td>952.0</td>
<td>88.4</td>
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<td>Female rate</td>
<td>0.2</td>
<td>12.7</td>
<td>10.1</td>
<td>5.5</td>
<td>19.8</td>
<td>66.2</td>
<td>102.7</td>
<td>102.8</td>
<td>171.7</td>
<td>188.8</td>
<td>257.0</td>
<td>324.1</td>
<td>40.4</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Est. M:F case ratio\textsuperscript{b}</td>
<td>0.2</td>
<td>1.5</td>
<td>2.5</td>
<td>0.5</td>
<td>2.5</td>
<td>2.4</td>
<td>1.6</td>
<td>2.6</td>
<td>1.5</td>
<td>3.1</td>
<td>1.5</td>
<td>2.7</td>
<td>2.1</td>
</tr>
<tr>
<td>Male rate</td>
<td>0.0</td>
<td>9.1</td>
<td>11.5</td>
<td>2.5</td>
<td>35.9</td>
<td>38.4</td>
<td>63.9</td>
<td>109.1</td>
<td>136.4</td>
<td>465.3</td>
<td>306.5</td>
<td>527.8</td>
<td>50.8</td>
</tr>
<tr>
<td>Female rate</td>
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<td>4.1</td>
<td>5.4</td>
<td>5.7</td>
<td>16.0</td>
<td>26.8</td>
<td>44.2</td>
<td>45.7</td>
<td>92.2</td>
<td>165.5</td>
<td>200.3</td>
<td>189.4</td>
<td>24.0</td>
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<tr>
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</tr>
<tr>
<td>Est. M:F case ratio\textsuperscript{b}</td>
<td>1.0</td>
<td>0.3</td>
<td>1.0</td>
<td>2.5</td>
<td>2.3</td>
<td>1.8</td>
<td>2.2</td>
<td>1.2</td>
<td>1.3</td>
<td>1.4</td>
<td>1.0</td>
<td>1.1</td>
<td>1.3</td>
</tr>
<tr>
<td>Male rate</td>
<td>0.1</td>
<td>0.0</td>
<td>0.6</td>
<td>6.1</td>
<td>9.6</td>
<td>14.4</td>
<td>22.8</td>
<td>33.1</td>
<td>51.6</td>
<td>78.7</td>
<td>66.4</td>
<td>128.8</td>
<td>12.6</td>
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<tr>
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<td>2.7</td>
<td>1.4</td>
<td>2.5</td>
<td>4.9</td>
<td>9.5</td>
<td>11.3</td>
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<td></td>
</tr>
<tr>
<td>Est. M:F case ratio\textsuperscript{b}</td>
<td>1.6</td>
<td>0.7</td>
<td>1.1</td>
<td>2.0</td>
<td>2.0</td>
<td>1.4</td>
<td>2.1</td>
<td>2.3</td>
<td>2.0</td>
<td>2.1</td>
<td>1.6</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Male rate</td>
<td>0.2</td>
<td>3.4</td>
<td>5.8</td>
<td>10.7</td>
<td>27.7</td>
<td>48.1</td>
<td>80.0</td>
<td>156.6</td>
<td>168.9</td>
<td>374.2</td>
<td>345.4</td>
<td>523.6</td>
<td>51.4</td>
</tr>
<tr>
<td>Female rate</td>
<td>0.1</td>
<td>4.6</td>
<td>5.2</td>
<td>4.9</td>
<td>13.1</td>
<td>32.0</td>
<td>36.2</td>
<td>64.1</td>
<td>79.6</td>
<td>169.9</td>
<td>205.3</td>
<td>236.8</td>
<td>25.6</td>
</tr>
</tbody>
</table>

\textsuperscript{a}According to the world population (11).

\textsuperscript{b}Estimates based on the proportions of males and females in the population.
1980. Figure 1 takes regional data for males during this period and shows how the levels of gastric cancer varied according to the subjects’ birthplaces. Except for four subregions in the northwest province of Guanacaste, all the cantons showing moderate, high, and very high levels of gastric cancer were found to be in the central part of the country. One group of cantons (Acosta, Mora, Puriscal, Tarrazú, and Turrubares) with very high rates form a single contiguous area which is the largest area of this kind in the country. (Miranda et al. (10) previously reported that some of these regions had a high incidence of gastric cancer; and Salas (19) has reported that inhabitants of the country’s central region run a greater risk of developing lesions of the gastric mucosa than do people in the coastal regions.) In most other cantons, which have a variety of differing geographic conditions, the incidence of gastric cancer has been low. If the disease levels in the cantons are estimated by using the birthplaces of female rather than male subjects, the rates involved are generally lower, but the inter-canton differences are similar to those for males (see Figure 2).

If the data are ordered according to the subjects’ places of residence instead of their birthplaces, cantons with higher case-rates for both males and females still tend to be concentrated in the central part of the country. However, the rates in these central localities, considered as places of residence, are generally lower than when they are considered as birthplaces, because the patients have tended to emigrate to regions with lower incidences. This movement of cancer patients corresponds to movement of the country’s general population (20, 21).

Table 2 shows age and sex-specific inci-

Figure 1. The relationship between birthplaces and rates of gastric cancer among males in Costa Rica, by region, as indicated by the birthplaces of male patients whose cases were diagnosed in 1977-1980.
Figure 2. The relationship between birthplaces and rates of gastric cancer among females in Costa Rica, by region, as indicated by the birthplaces of female patients whose cases were diagnosed in 1977-1980.

In addition, these data indicate that 35 per cent of the males and 37 per cent of the females ill with gastric cancer were under 60 years of age. These results differ from those of Miranda and colleagues (10), who found that over 70 per cent of the gastric cancer patients they studied were under 60 years of age.

Table 3 lists all the patients studied by their place of birth, and then by their place of residence when gastric cancer was diagnosed. The resulting matrix shows that only 25 per cent of the 283 gastric cancer victims born in the regions of very high risk were living in such regions when their disease was diagnosed. (Most had emigrated, and a majority of these were residing in regions of low risk.) Progressively larger percentages (30.6, 52.5, and 79.5 per cent) of those born in the regions of high, moderate, and low risk, respectively, were residing in those regions when their disease was diagnosed. Conversely, a relatively high percentage of the subjects residing in the very high risk regions when their disease was diagnosed (68.2 per cent) were born there, while smaller percentages (48.2, 51.5, and 25.4 per cent, respectively) of the subjects residing in the high, moderate, and low risk regions were born in those respective regions. These four...
Table 3. Data showing the influence of population movements upon the incidence of gastric cancer in regions of Costa Rica with different levels of risk for the period 1977-1980. For example, of the 283 patients born in regions of very high risk, 71 (25.1 per cent) were living in such regions and 30 (10.6 per cent) were living in areas of high risk when their cases were diagnosed. Similarly, of the 104 patients living in regions of very high risk when their cases were diagnosed, 71 (68.2 per cent) had been born in such regions and 12 (11.5 per cent) had been born in regions of high risk.

<table>
<thead>
<tr>
<th>Regions of residence, by incidence level</th>
<th>Very high incidence regions</th>
<th>High incidence regions</th>
<th>Moderate incidence regions</th>
<th>Low incidence regions</th>
<th>Total (all regions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% of subjects</td>
<td>% of subjects</td>
<td>% of subjects</td>
<td>% of subjects</td>
<td>% of subjects</td>
</tr>
<tr>
<td></td>
<td>residing in indicated regions</td>
<td>residing in indicated regions</td>
<td>residing in indicated regions</td>
<td>residing in indicated regions</td>
<td>residing in indicated regions</td>
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<td></td>
<td>No of subjects</td>
<td>No of subjects</td>
<td>No of subjects</td>
<td>No of subjects</td>
<td>No of subjects</td>
</tr>
<tr>
<td>Very high incidence regions</td>
<td>71</td>
<td>68.2</td>
<td>25.1</td>
<td>30</td>
<td>27.3</td>
</tr>
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<td>High incidence regions</td>
<td>12</td>
<td>11.5</td>
<td>6.9</td>
<td>53</td>
<td>48.2</td>
</tr>
<tr>
<td>Moderate incidence regions</td>
<td>20</td>
<td>19.3</td>
<td>8.2</td>
<td>19</td>
<td>17.3</td>
</tr>
<tr>
<td>Low incidence regions</td>
<td>1</td>
<td>1.0</td>
<td>0.9</td>
<td>8</td>
<td>7.2</td>
</tr>
<tr>
<td>Total (all regions)</td>
<td>104</td>
<td>100</td>
<td>12.8</td>
<td>110</td>
<td>100</td>
</tr>
</tbody>
</table>
regional differences are statistically significant (\(X^2 = 203.9; p < 0.01\)).

It was also observed in this study that 86.8 per cent of the subjects' cases had been diagnosed by traditional methods (biopsy or X-ray examination or both). Only 13.2 per cent of the diagnoses were based solely upon clinical examinations. It was also noted that 60 per cent of those ill with gastric cancer died within a year of the diagnosis.

Regarding the possible influence of soil characteristics, a stepwise multiple regression analysis was performed in order to assess the possible influence of certain soil characteristics upon rates of gastric cancer. The only factors found to have any statistically significant association with differences in the rates of gastric cancer were potassium content, pH, zinc content, and iron content in that order of importance (see Table 4). The other factors considered were excluded from the regression equation because they appeared to have no significant influence upon the dependent variable. Overall, it should be noted that the variables of pH and the soil content of potassium, zinc, and iron appear to account for 22 per cent of the variation in the rates of gastric cancer. When the four variables are taken together, pH shows the highest significance, yielding a total determination coefficient of 0.224. The signs of the regression coefficients (b) are negative for potassium and iron and positive for pH and zinc. In accordance with the regression conditions explained earlier, this indicates that an increase in the gastric cancer incidence is associated with higher concentrations of potassium and iron, lower concentrations of zinc, and a lower pH. No significant associations were found between the incidence of gastric cancer and any of the previously mentioned factors relating to drinking-water or diet.

**Discussion**

The age-standardized data presented in Table 1 indicate that gastric cancer mortality is declining in Costa Rica, and there is evidence that this decline is greater among women than among men. The same phenomenon has been observed in other countries (8, 16, 18, 22). The interpretation of this finding is not easy, but it seems reasonable to conclude that environmental factors play an important role in development of the disease.

Comparing our data with those of other authors (4, 23), we find that in Costa Rica the prospects for gastric cancer patients' survival have improved very little during the last 20 years. This leads to the conclusion that the declining mortality observed is due to a declining incidence of the disease in Costa Rica.

Despite this decline, however, gastric cancer's incidence and mortality in Costa Rica continue to exceed the incidence and mortality found in other countries. This finding was reported previously by Strong et al. (3) for the period 1962-1963 and by Moya de Madrigal (9) for 1956-1968. Miranda et al. (10) found incidence rates lower than those

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**Table 4. Stepwise multiple regression analysis between selected soil features and the rate of gastric cancer in different regions of Costa Rica during 1977-1980, treating the latter as a dependent variable. No statistically significant correlations were found between the rate of gastric cancer and soil levels of aluminum, calcium, copper, magnesium, manganese, or phosphorus.**

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Value of $R^2$</th>
<th>Increase in $R^2$</th>
<th>Value of $b$</th>
<th>Standard error of $b$</th>
<th>Value of $F$</th>
<th>Value of $P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium</td>
<td>0.059</td>
<td>0.059</td>
<td>-0.746</td>
<td>0.347</td>
<td>4.61</td>
<td>&lt;0.05</td>
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<tr>
<td>pH</td>
<td>0.138</td>
<td>0.079</td>
<td>0.548</td>
<td>0.211</td>
<td>5.86</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.193</td>
<td>0.055</td>
<td>0.619</td>
<td>0.280</td>
<td>5.73</td>
<td>&lt;0.01</td>
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<tr>
<td>Iron</td>
<td>0.224</td>
<td>0.031</td>
<td>-1.182</td>
<td>0.696</td>
<td>5.13</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
presented here for the period 1969-1973, but they used a different methodology.

Contrary to Tulinius' (16) statement that gastric cancer rates are usually low in the tropics, Costa Rica, located in the tropical zone, has very high rates of gastric cancer. High rates of the disease have also been found in Cali, Colombia (24-26), and Táchira, Venezuela (27). Not much is known about the situation in many other tropical countries because in most instances reliable data are lacking. Moreover, many of those countries have health problems such as malnutrition and infectious diseases that cause death at ages younger than those at which gastric cancer typically becomes a serious health problem. In Costa Rica, however, the distribution of diseases has shifted recently from a preponderance of infectious and parasitic diseases to a preponderance of certain noncommunicable diseases such as cancer, cardiovascular diseases, and congenital diseases (28). This change has occurred within a single generation.

The classification of regions as having very high, high, moderate, and low incidences of gastric cancer makes it possible to study virtually all of the epidemiologic variables of the disease and the environmental features of each region, and to pinpoint noteworthy differences between regions. There is, of course, a direct and universally observed correlation between age and the incidence of gastric cancer among both men and women in all regions. It thus appears that gastric cancer has a long latent period and that the risk of developing it is greater after age 40 (24, 29).

Another relevant point is that the observed incidence of gastric cancer is higher among men than among women in all regions. The reason for this difference is unknown, but several authors have presented similar findings (30-34).

Our own study found that the male:female ratio in Costa Rica has been higher in regions where the disease risk was very high, high, or moderate (as compared to low), and that the ratio has varied considerably from one age group to another. In this latter regard, below age 30 gastric cancer has been commoner among females than males in regions classified as having a high, moderate, or low incidence of the disease. In contrast, however, the disease struck a substantial preponderance of males under age 30 in regions where the incidence was very high. This last finding has not been reported elsewhere in the literature, which tends to reflect the idea that fewer men than women become ill with the disease before reaching 30 or 35 years of age, but that afterwards the incidence among men increases rapidly until it becomes double the incidence among women (31, 34, 36, 37).

The differences that we have observed between male and female gastric cancer patients indicate that men are more susceptible than women to carcinogens of the stomach, or that they are more exposed to carcinogenic agents, or that both conditions apply. There is thus a need for careful study of environmental conditions, the habits of males with gastric cancer, and appropriate control subjects.

It is reasonable to assume that most of the Costa Rican cases studied were diagnosed accurately, since only 13 per cent of the diagnoses depended solely on clinical findings. It also appears that most cases were diagnosed only after the cancer was well advanced, since the survival rate was low and over 60 per cent of the patients died within a year of the diagnosis. These data, plus other authors' findings that gastric cancer patients in Costa Rica have a low rate of survival (2, 3, 23), demonstrate a clear need for early diagnosis of gastric cancer, not only among people visiting health centers for medical reasons but also among those who believe themselves to be healthy, especially those born in the country's areas of high risk. This need is underscored by recent studies showing that 90 per cent of the gastric cancer patients operated on while the tumor is at an early state survive more than five years (38, 39).

Both our study and other findings (25) sug-
gest that a person’s birthplace is a major determinant of the risk of gastric cancer. That is, a relatively high proportion of those born in regions now classified as being “high risk” or “very high risk” have proceeded to develop the disease, even if they have moved from these high-risk areas to regions where the risk is low. By and large, the cantons of high and very high risk are cantons with net emigration, from which people have been emigrating to the large banana plantations of the Atlantic and southern Pacific regions or to the northern provinces of Alajuela, and Heredia (21). In this vein, it seems noteworthy that studies of emigrant populations in other countries have shown that the incidence of gastric cancer among people born in areas of high risk remains high even after they have resided in areas of low risk for many years (25, 40, 41).

The portion of our study dealing with soil samples found correlations between the incidence of gastric cancer and four variables—pH, potassium, zinc, and iron. Each variable considered alone had little influence, but when all four variables were combined the linear pattern changed and pH assumed an important role. In this regard, an article in The Lancet (33) has stated that a possible correlation of zinc and copper with gastric cancer could be due to the levels of those metals being affected by the presence of some other factor in the soil. It is also known that pH plays an important role in the behavior of elements in the soil and the absorption and utilization of such elements by plants. Moreover, some of the cantons with very high risk levels—including Acosta, Mora, Puriscal, and Tarrazú—have poor soils because of deforestation and haphazard cultivation. In general, these practices have been leaching the soil, causing it to erode, and increasing its acidity to a point where today the soils in these areas yield only poor crops or are completely barren.

On a related subject, studies with experimental animals have shown that deprivation of certain trace elements during critical periods of growth and development, or during long periods of adult life, can significantly alter the functioning of the immune system. It has also been shown that traces of metals in the diet affect the onset and progression of a considerable number of neoplasias (42). Together, these findings demonstrate a need to perform studies that assess multivariate processes, rather than simply attempting to correlate rates of gastric cancer with any single environmental factor.

With regard to the ways nutrition and food habits could affect the incidence of gastric cancer in Costa Rica, very little can be said until specific studies are made. According to studies by the Ministry of Health (8), the nutritional status of the Costa Rican population has improved in recent years, and this may be one reason why gastric cancer rates are declining. However, the work done to date on nutrition and diet in Costa Rica is not sufficient for valid conclusions to be drawn about possible relationships between these factors and the incidence of gastric cancer. Therefore, this is an additional area that needs to be examined in detail, taking into account the findings now available concerning the epidemiology of gastric cancer in our country.

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SUMMARY

Because the incidence of gastric cancer is very high in Costa Rica and suitable collections of data are available, the country affords a good opportunity for studying the origins of this disease. The work reported here, conducted by Costa Rica’s Institute of Health Research, concerns itself primarily with regional variations in gastric cancer morbidity within the country. These regional variations are analyzed in terms of the age and sex of gastric cancer patients, the movement of such patients from their regions of birth to other regions, and local dietary, drinking-water, and soil features that could affect the incidence of the disease.

This regional analysis shows that most regions with very high rates of gastric cancer in 1977-1980 are located in the central portion of the country. When the data are ordered according to patients’ birthplaces, the pattern is more pronounced than when the data are organized by the patients’ places of residence at the time of diagnosis, because many patients had moved from high-risk areas to areas where the disease incidence was low. This movement of people who developed gastric cancer followed a more general population shift away from these central regions.

Regarding the male:female case ratio, this ratio was found to be relatively high in regions where the incidence of gastric cancer was very high, high, or moderate (≥33 cases per 100,000 inhabitants). Also, in regions of very high risk (>108 cases per 100,000 inhabitants) the male:female case ratio appears very high among those under 30 years of age.

More broadly, differences observed between male and female case-rates indicate that men are more susceptible than women to carcinogens of the stomach, or that they are more exposed to carcinogenic agents, or that both conditions apply.

It also appears that the incidence of gastric cancer in Costa Rica has declined in recent decades, a trend similar to ones observed in other countries. On the other hand, very little progress has been made in enhancing the survival prospects of the country’s gastric cancer patients; and since that survival rate is low, with over 60 per cent of the patients dying within a year of the disease being diagnosed, there is a clear need for earlier diagnosis—especially among apparently healthy people living in high-risk areas. This need is underscored by recent studies showing that 90 per cent of the gastric cancer patients operated on while the tumor is at an early stage survive at least five years.

Regarding soil features, some correlation was found between the incidence of gastric cancer in different regions and soil pH, potassium content, zinc content, and iron content. No statistically significant correlations were observed between the incidence of gastric cancer and other regional variables tested—including nutritional variables, drinking-water characteristics, and other soil constituents.

The nature of these findings, together with other available research findings, suggests a need for studies that examine the interactions of multiple variables.

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**PRIMARY PNEUMONIC PLAGUE IN THE UNITED STATES**

On 5 August 1983, plague was diagnosed in a girl 13 years of age in South Carolina. She became ill while en route to Maryland from her previous residence in Santa Fe, New Mexico, and subsequently died. The area in which she had lived had been recognized as a locality where sylvatic plague was enzootic.

A chest radiograph taken before death revealed extensive pulmonary infiltrates. Antemortem aspirations of the right inguinal lymph node demonstrated Gram-negative bipolar staining bacilli on Giemsa stain. Both this aspirate and multiple cultures of blood yielded *Yersinia pestis*. In addition, fluorescent antibody stains for *Y. pestis* were positive for specimens consisting of blood smears, culture material, and pulmonary secretions.

Primary pneumonic plague has been described as rare in the United States, with only three cases—all in laboratory workers—being reported between 1926 and 1975. However, five persons have developed primary pneumonic plague since 1975, presumably as a result of exposure to household pets with secondary plague pneumonia.

Recent investigations suggest that plague pneumonia (i.e., secondary to bubonic plague) is more common. No transmission of pneumonic plague to contacts of patients with the disease has been documented in the United States since 1925.

Delay in diagnosing and treating plague increases the potential for pulmonary involvement and person-to-person transmission. In the past eight years, 32 (20 per cent) of 164 plague patients reported to the Centers for Disease Control have developed pulmonary disease. Three (33 per cent) of the nine plague patients who had been interstate travellers developed pneumonias, including the girl mentioned above.

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*Source: United States Centers for Disease Control, Morbidity and Mortality 32(32), 1983.*