[CANCER RESEARCH 47, 5771-5776, November 1, 1987]

Cancer in First and Second Generation Americans[1]

David B. Thomas[2] and Margaret R. Karagas

The Fred Hutchinson Cancer Research Center, Division of Public Health Sciences, Program in Epidemiology, Seattle, Washington 98104, and Department of Epidemiology, School of Public Health and Community Medicine, University of Washington, Seattle, Washington 98105

ABSTRACT

Mortality or incidence rates of ten major neoplasms in migrants from several countries, their respective countries of origin, their American-born offspring, and United States whites were compared. Rates in succeeding generations of Americans increased most rapidly for colon cancer and most slowly for breast cancer, with ovarian cancer occupying an intermediate position and prostate cancer showing inconsistent patterns of displacement of rates among various ethnic groups. Rates of stomach, liver, and esophageal cancers declined rapidly in succeeding generations of migrants, although small residual excess risks compared to whites persisted in second generation Americans. These residual excesses were greatest for stomach cancer and least for cancer of the esophagus. Differences in rates of lung and bladder cancers were commensurate with differences in smoking patterns among the generations and ethnic groups considered. This was also true for pancreatic cancer in Asians, but not in Latin Americans. The etiological implications of these observations are discussed.

INTRODUCTION

A number of papers have been published which provide rates of cancers in migrants, their country of origin, and their country of adoption. These were reviewed for migrants from Japan, China, and Latin America at the Second Symposium on Cancer Epidemiology in the Pacific Basin (1). Rates of cancers that occur infrequently in countries of origin and relatively more frequently in the United States tend to increase in migrants. These include cancers that may be related in part to a diet rich in animal products such as cancers of the colon, rectum, breast, prostate, ovary, corpus uteri, and testis. They also include some smoking-related cancers such as those of the lung, larynx, bladder, and pancreas. Rates of cancer that occur at relatively high rates in countries of origin and less frequently in the United States tend to decrease in migrants. These include cancers that may be related to contamination of foods by carcinogens (cancers of the stomach, esophagus, and liver) and also some neoplasms with a probable infectious etiology (cancers of the liver, nasopharynx, and cervix).

At a subsequent symposium Tominaga (2) compared rates in Japan, migrants from Japan, and Caucasians in the United States. He attempted to group cancers according to the patterns of these rates to identify neoplasms with possible common etiologies. Both of these reviews were based on rates in the country of origin of the migrants, rates in the ethnic group in the United States, and rates in Caucasian Americans. The rates for the ethnic group in the United States were based on either rates in the individuals who actually migrated plus their descendants, or just those who were foreign born (depending on the study). When rates for ethnic groups were used irrespective of place of birth, they were heavily weighted by rates in the migrants themselves. It is the purpose of this paper to review reports that distinguish rates of cancer in the migrants (first generation Americans) from rates in their offspring (second generation Americans), to contrast these rates with those for the countries of origin and Caucasian Americans, and to compare among various cancers the rates of displacement of risks toward those for Caucasian Americans. This could only be done for the major cancers, since rates for the rarer neoplasms are unstable in second generation Americans due to the predominance of younger individuals in these cohorts.

MATERIALS AND METHODS

Table 1 shows the reports that were reviewed and the geographical areas and years for which rates were obtained in each report. All but one (3) deal with mortality rates. In the first Japanese study (4), only rates for individuals between 45 and 64 yr of age were utilized. The study by Haenszel and Kurahara (5) was larger and may have been the first paper in which differences in rates of displacement of cancer risks for various neoplasms were specifically noted. Locke and King (6) utilized mortality rates from California, Hawaii, and New York City, which in the aggregate include 75% of the United States Japanese population. Using the same methodology, these same investigators (7) contrasted rates in United States whites, and first and second generation Chinese, and rates from Taiwan.

Menck *et al.* (3) compared incidence rates in Mexican migrants to Los Angeles, their United States born descendants, and Caucasians in Los Angeles. No reliable incidence rates are available for Mexicans in Mexico.

Although rates for second generation Puerto Ricans and Poles are not available, these groups have been included for comparative purposes. Rosenwaike *et al.* (8) contrasted mortality rates for Puerto Ricans and whites in New York City with those for Puerto Rico. Warshauer *et al.* (9) updated these observations, but only for cancers of the stomach, colon, and rectum. Nasca *et al.* (10) compared mortality rates for Poland with rates for Polish immigrants to New York State (exclusive of New York City) and rates for New York State Caucasians. Newman and Spengler (11) similarly contrasted rates in Poland with Polish immigrants and other whites in Ontario, Canada.

Using these sources, tables such as Table 2 (for breast cancer) were constructed for each major cancer. When necessary, standardized mortality ratios relative to United States whites were recomputed from the data provided in the individual reports. Rates in the country of origin, migrants, their offspring (second generation), and United States whites were thus contrasted for each neoplasm considered. To facilitate these comparisons, the relative rates were graphed. When ratios for the same nationality were consistent among studies, only the most recent ratios were depicted, since they generally were based on the largest numbers and the most stable rates. In the single instance of liver cancer, when there was an important difference between studies, results from both were included in the figure.

RESULTS

As shown in Fig. 1, rates of breast cancer for second generation migrants from Japan, China, and Mexico are all considerably lower than rates for United States whites. This would probably also be true for Puerto Ricans, since rates in migrants from Puerto Rico, like those in migrants from Japan, are no higher than rates in their country of origin. On the other hand,

Received 3/31/87; revised 7/16/87; accepted 8/6/87.

The costs of publication of this article were defrayed in part by the payment of page charges. This article must therefore be hereby marked *advertisement* in accordance with 18 U.S.C. Section 1734 solely to indicate this fact.

[1] This work was supported in part by Grant 5 P30 CA1570413 from the National Cancer Institute. Presented at the Fifth Symposium on Epidemiology and Cancer Registries in the Pacific Basin, November 16-21, 1986, Kauai, HI.

[2] To whom requests for reprints should be addressed, at Fred Hutchinson Cancer Research Center, Division of Public Health Sciences, 1124 Columbia Street, Seattle, WA 98104.

Downloaded from http://aacrjournals.org/cancerres/article-pdf/47/21/5771/2429563/cr0470215771.pdf by guest on 24 August 2022

Table 1 *Sources of data*

Nationality	First author (date)	North America		Country of origin
		Area	Yr	Yr
Japanese	Buell (1965)	CA	1949–1962	1950–1952, 1958–1959
	Haenszel (1968)	United States	1959–1962	1960–1961
	Locke (1980)	CA, HI, NY City	1968–1972	1969–1973
Chinese	King (1980)	CA, HI, NY City	1968–1972	1968–1972 (Taiwan)
Mexican	Menck (1975)[a]	Los Angeles	1972–1973	Data not used
Puerto Rican	Rosenwaike (1984)	NY City	1969–1971	1973–1977
	Warshauer (1986)[b]	NY City	1975–1979	1975–1979
Polish	Nasca (1981)	NY State	1969–1971	1969–1971
	Newman (1984)	Ontario	1969–1973	1969–1973

[a] Incidence rates.
[b] Colorectal and stomach cancer only.

rates in Polish migrants are considerably higher than rates in Poland, and close to those for white United States women.

The rate of displacement of rates for succeeding generations of migrants is much more rapid for colon than breast cancer (Fig. 2). This is true for Japanese, Chinese, and Mexicans, and presumably would also be true for Puerto Ricans; and rates in first generation Poles are already as high or higher than United States white rates. These findings are true for both sexes, but the rate of displacement appears to be somewhat more rapid for men than women.

Rates of displacement of risk of ovarian cancer (Fig. 3) tend to be intermediate between those for breast and colon cancer, at least for Japanese, Chinese, and Mexicans. The relative rate for native Chinese (Taiwan) is not shown because it was not available from the original report (7).

The pattern of displacement for prostate cancer is similar to that for breast cancer among the Japanese and Chinese, but not for the Mexicans, or presumably the Puerto Ricans or Poles (Fig. 4). Thus, there is a large residual difference in rates of prostate cancer between second generation Japanese and Chinese and Caucasian rates for the United States, but little or no difference for the other groups considered.

In contrast to neoplasms of the breast, colon, ovary, and prostate, carcinomas of the stomach occur more frequently in the countries of origin of all of the ethnic groups considered than in the United States. As shown in Fig. 5, rates of this neoplasm decline rapidly in succeeding generations of migrants. However, some residual excess in risk compared to United States whites is seen in the second generation Japanese, Chinese, and Mexicans (except in Chinese males). Unlike stomach cancer, little or no residual excess in rates of esophageal cancer, compared to rates in the United States whites, is evident by the second generation in America in all ethnic groups considered (Fig. 6).

As shown in Fig. 7, rates of liver cancer in Chinese migrants and their offspring declined rapidly, although there is still a small residual excess in second generation Chinese relative to the United States whites. A similar pattern was seen for the Japanese in an early study (4) when rates of liver cancer were relatively high in Japan. A later Japanese study (6) yielded results consistent with the first, except that rates in Japan had diminished markedly between the first and second investigation. The most appropriate rates in Japan for comparative purposes are those in the initial study, because they reflect more closely the rates at the time of migration. The information on Mexicans is not very informative due to a lack of rates for Mexico.

Fig. 8 shows that the rates of lung cancer increased markedly in migrants from Japan and China, but declined in their offspring (except for Chinese women). Rates similarly increased in migrants from Poland and Puerto Rico, but rates for their offspring are not available. Rates for native Mexicans are also not available, so it is not known whether migrants from Mexico have increased rates. Rates are higher for second than first generation male Mexican Americans, but rates for first and second generation females are similar.

The patterns for bladder cancer (Fig. 9) tend to be similar to those for lung cancer. One difference, however, between bladder and lung cancer is that the rates relative to United States whites in Japan and China are higher for bladder than for lung cancer.

The patterns of displacement of risk of pancreatic cancer, shown in Fig. 10, are similar to those for lung cancer in the Japanese and Chinese. For Mexicans, however, and probably Puerto Ricans, rates of pancreatic cancer are virtually the same as for United States whites by the second generation (and even

Table 2 *Standardized mortality ratios for female breast cancer*

Nationality	County of origin	Migrants	Second generation	United States whites	First author (date)
Japanese[a]	0.2	0.2	0.3	1.0	Buell (1965)
Japanese[b]	0.17	0.28	0.23	1.0	Haenszel (1968)
Japanese	0.20	0.15	0.40	1.0	Locke (1980)
Chinese	0.2	0.52	0.52	1.0	King (1980)
Mexican[c]		0.59	0.57	1.0	Menck (1975)
Puerto Rican	0.41	0.38		1.0	Rosenwaike (1984)
Polish[d]	0.47	0.66		1.0	Newman (1984)
Polish	0.36	0.81		1.0	Nasca (1981)

[a] Includes women aged 45–64 yr.
[b] Includes women ages <65 yr.
[c] Standardized incidence ratios.
[d] Canadian whites used as the standard.

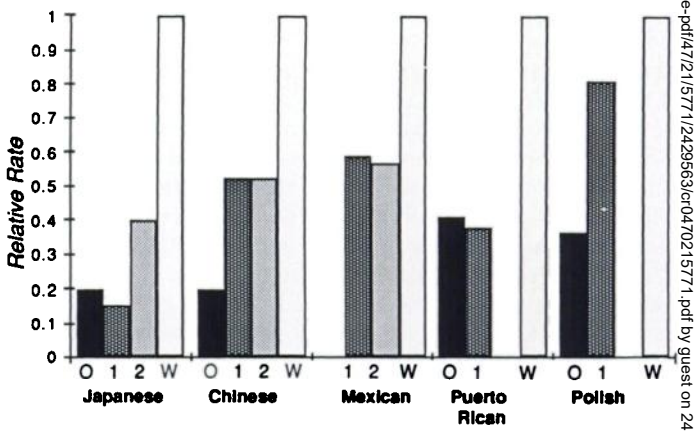

Fig. 1. Rates of breast cancer in countries of origin and first and second generation migrants relative to rates in white Americans. *O*, country of origin; *1*, first generation; *2*, second generation; *W*, United States whites.

Downloaded from http://aacrjournals.org/cancerres/article-pdf/47/21/5771/2429563/cr0470215771.pdf by guest on 24 August 2022

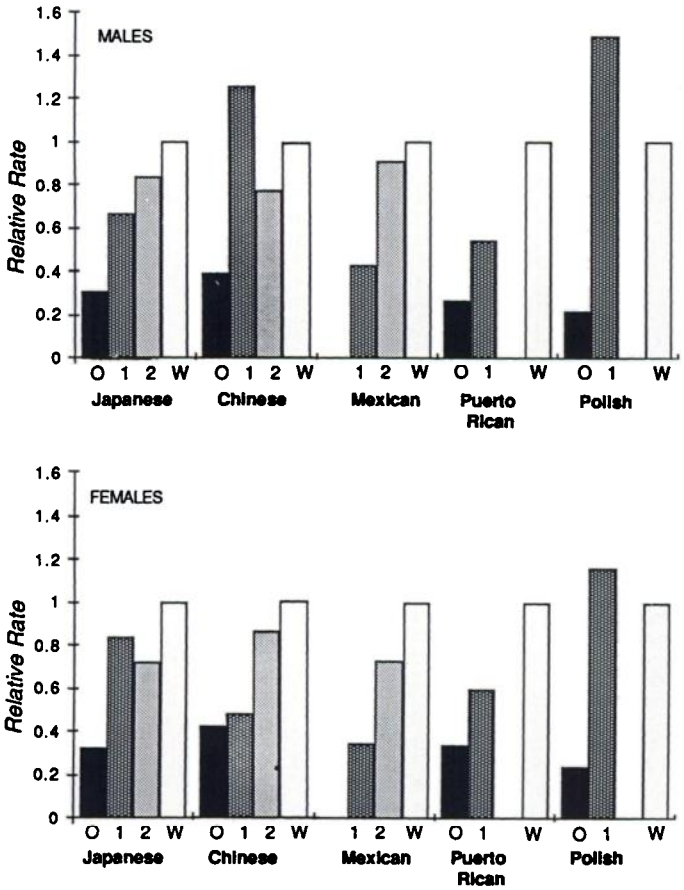

Fig. 2. Rates of colon cancer in countries of origin and first and second generation migrants relative to rates in white Americans. *O*, country of origin; *1*, first generation; *2*, second generation; *W*, United States whites.

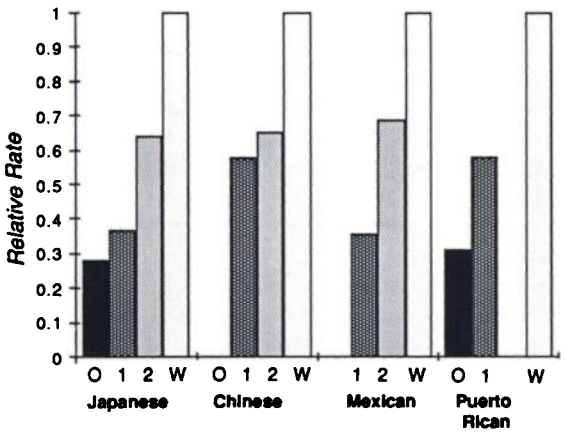

Fig. 3. Rates of ovarian cancer in countries of origin and first and second generation migrants relative to rates in white Americans. *O*, country of origin; *1*, first generation; *2*, second generation; *W*, United States whites.

in the migrants themselves in women).

Other carcinomas were also considered, but are not presented graphically because rates in second generation ethnic groups were based on small numbers and were thus unstable. The pattern for carcinomas of the testis is similar to that for the ovary. Rates for leukemias were uninformative because individual histological types were not considered separately. Uniform residual deficit in rates of Hodgkin's and non-Hodgkin's lymphomas were noted in all second generation groups considered, but the patterns of displacement were variable, probably due to the instability of the rates.

DISCUSSION

Differences in observed mortality rates in different populations can be due to true differences in the frequency of occurrence of disease, or to a number of well-known potential sources of error. These sources of error include differences in completeness of case ascertainment, diagnostic and coding practices, survival, and completeness of enumeration of the population at risk. The authors of the reports cited in this review generally acknowledged and considered the possible influence of these factors on their findings and (correctly) concluded that they are unlikely explanations for their observed results. Since the studies cited were generally of high quality, we can, with caution,

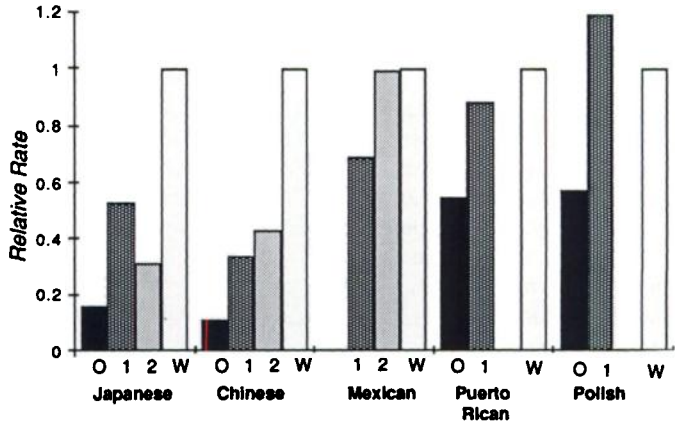

Fig. 4. Rates of prostate cancer in countries of origin and first and second generation migrants relative to rates in white Americans. *O*, country of origin; *1*, first generation; *2*, second generation; *W*, United States whites.

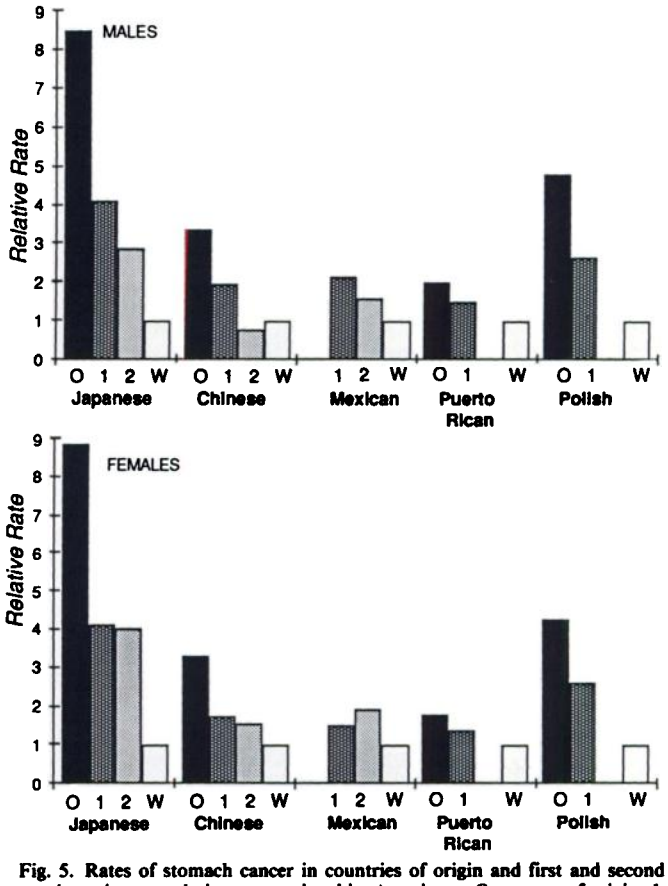

Fig. 5. Rates of stomach cancer in countries of origin and first and second generation migrants relative to rates in white Americans. *O*, country of origin; *1*, first generation; *2*, second generation; *W*, United States whites.

Downloaded from http://aacrjournals.org/cancerres/article-pdf/47/21/5771/2429563/cr0470215771.pdf by guest on 24 August 2022

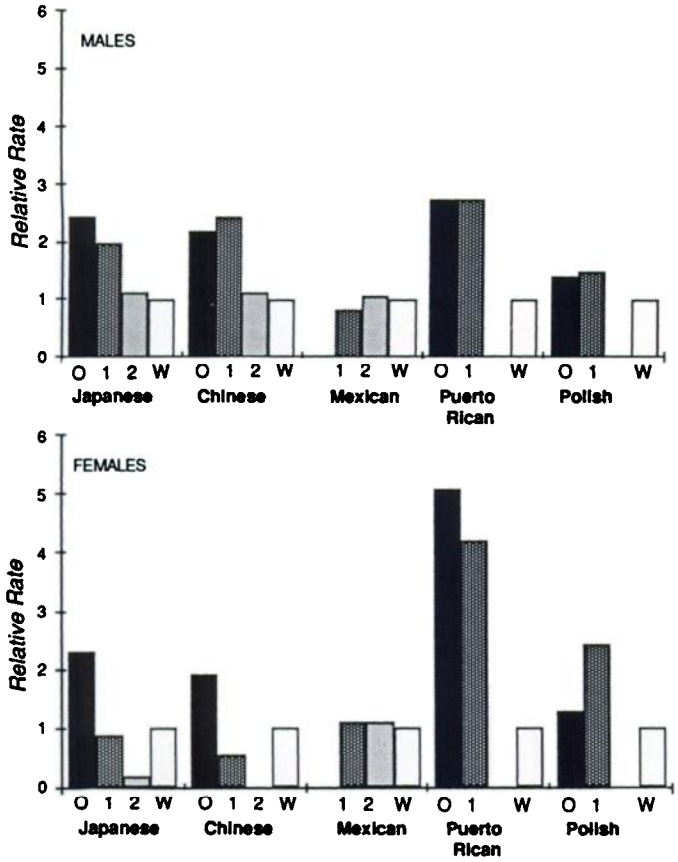

Fig. 6. Rates of esophageal cancer in countries of origin and first and second generation migrants relative to rates in white Americans. *O*, country of origin; *1*, first generation; *2*, second generation; *W*, United States whites.

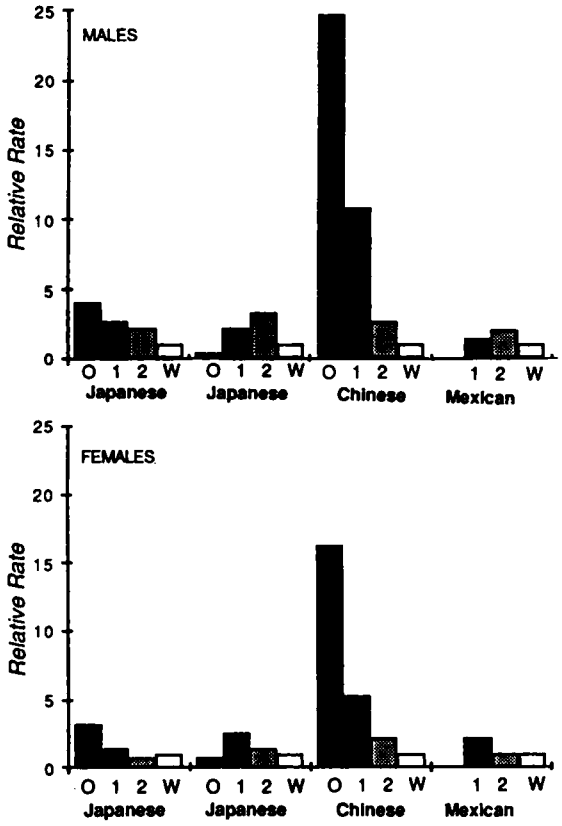

Fig. 7. Rates of liver cancer in countries of origin and first and second generation migrants relative to rates in white Americans. *O*, country of origin; *1*, first generation; *2*, second generation; *W*, United States whites. The two sets of Japanese data are from Refs. 4 and 6, respectively.

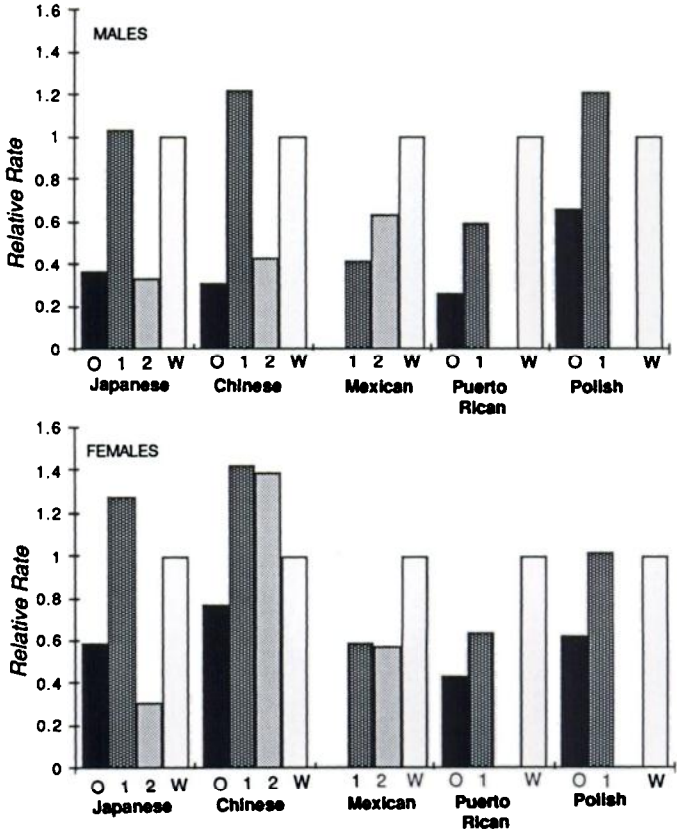

Fig. 8. Rates of lung cancer in countries of origin and first and second generation migrants relative to rates in white Americans. *O*, country of origin; *1*, first generation; *2*, second generation; *W*, United States whites.

consider possible etiological implications of the finding summarized in this paper.

Some of the patterns of displacement of rates observed in this review may be explained on the basis of changes in exposure to known risk factors. Others may not, but a comparison of displacement patterns for such neoplasms, among different ethnic groups, provides information regarding possible differences and similarities in the etiologies of the tumors considered.

The residual low rates for breast cancer in the Japanese, Chinese, and Mexicans suggests that there may be some factor in their cultures that is carried over into the second generation that is protective, or that some risk factor for breast cancer is avoided by second generation individuals as well as by their migrant parents. In contrast, it appears that the factors that are responsible for the low rates of colon cancer in some countries are given up by migrants to the United States more rapidly than the factors responsible for the low rates of breast cancer; or, conversely, migrants to the United States more readily come in contact with the factors that are responsible for high rates of colon cancer in the United States than the factors responsible for the high rates of breast cancer. For both breast and colon cancer, fats and other dietary components have been implicated as the possible factors responsible for the differences in rates among different countries and among succeeding generations of Americans (12). The different patterns of displacement of the rates for these two neoplasms clearly show that the dietary or other environmental factors of etiological importance are different for these two diseases.

By the same reasoning, the factors responsible for the increasing risk of ovarian cancer in succeeding generations may be different from those for colon or breast cancer, although the patterns of displacement of rates for ovarian cancer are suffi-

Downloaded from http://aacrjournals.org/cancerres/article-pdf/47/21/5771/2429563/cr0470215771.pdf by guest on 24 August 2022

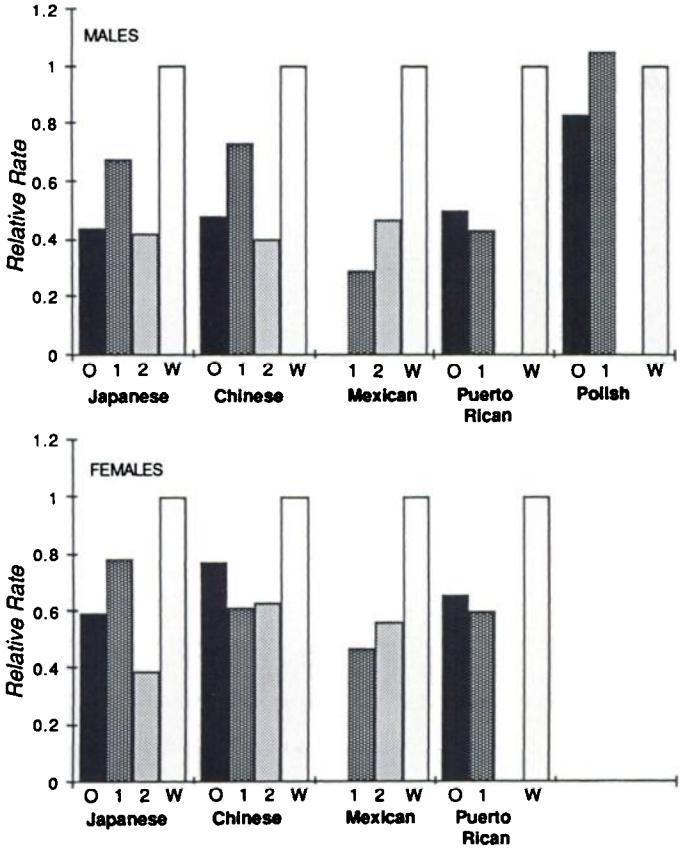

Fig. 9. Rates of bladder cancer in countries of origin and first and second generation migrants relative to rates in white Americans. *O*, country of origin; *1*, first generation; *2*, second generation; *W*, United States whites.

however, there is a small residual excess in second generation Japanese and Chinese, suggesting some persistent exposure in these groups, probably to hepatitis B virus.

The cancer most strongly related to tobacco smoking is that of the lung (16), and the patterns of risk depicted in Fig. 8 probably reflect the smoking habits of the various groups considered. For example, it is likely that the Japanese and Chinese migrants smoked more frequently after coming to the United States where tobacco products were perhaps more easily affordable than in their countries of origin, whereas their better educated offspring may have smoked less.

The patterns of displacement of rates for bladder cancer are similar to those for lung cancer, which is not unexpected because bladder cancer is also strongly related to smoking in the United States (17). However, the ratio of rates in the countries of origin of the Japanese and Chinese migrants relative to rates for United States whites are considerably greater for bladder than lung cancer. These higher ratios may reflect the influence of *Schistosoma haematobium* (18), and it would be useful to investigate the histological types of bladder cancer in various generations of Japanese and Chinese. Most bladder cancer that occurs in the United States is transitional cell, whereas bladder tumors that have been related to schistosomiasis tend to be of the squamous type.

The high rates of esophageal cancer in Japan and China are probably not due primarily to smoking and alcohol, which are the main determinants of this neoplasm in the United States (19). They are more likely due, in part, to foodstuffs that have been contaminated with microorganisms that form nitroso compounds or other carcinogens. If this is true, then the decline in rates in succeeding generations suggests that such contamination of food utilized by these ethnic groups in the United States

ciently similar to those of colon and breast cancer as to also be compatible with some factors being common to one or both of these neoplasms. The patterns of displacement of rates in succeeding generations are also not the same for prostatic cancer as for cancers of the colon and breast. The Chinese and Japanese apparently retain cultural habits that protect them against prostate cancer into the second generation, but the migrants from Latin America and Poland do not.

Careful studies of differences and similarities in the diets of first and second generation Japanese, Chinese, Puerto Ricans, and Mexicans might identify factors of etiological important in the genesis of cancers of the breast, colon, ovary, and prostate.

The sharp decline in rates of stomach cancer in succeeding generations in all ethnic groups considered strongly indicates that the high rates in the countries of origin are due to environmental factors in those countries to which migrants and their offspring are less intensely exposed after migrating. The marked reduction in the rates for the migrants themselves indicates that exposure to these factors in adult life is of etiological importance. On the other hand, the persistent, albeit small, excess rates in second generation Americans compared to rates in United States whites suggest that some exposure to these etiological factors persists in the United States born ethnic groups considered. These factors are probably dietary, and smoked, cured, salted, or pickled foods have been most strongly implicated (13).

The high rates of liver cancer in China, and formerly also in Japan, are most likely due to endemic hepatitis B virus (14) and possibly also due to exposure to aflatoxins (15). Exposure to these factors is reduced in migrants to the United States, and their rates of liver cancer decline accordingly. Here, too,

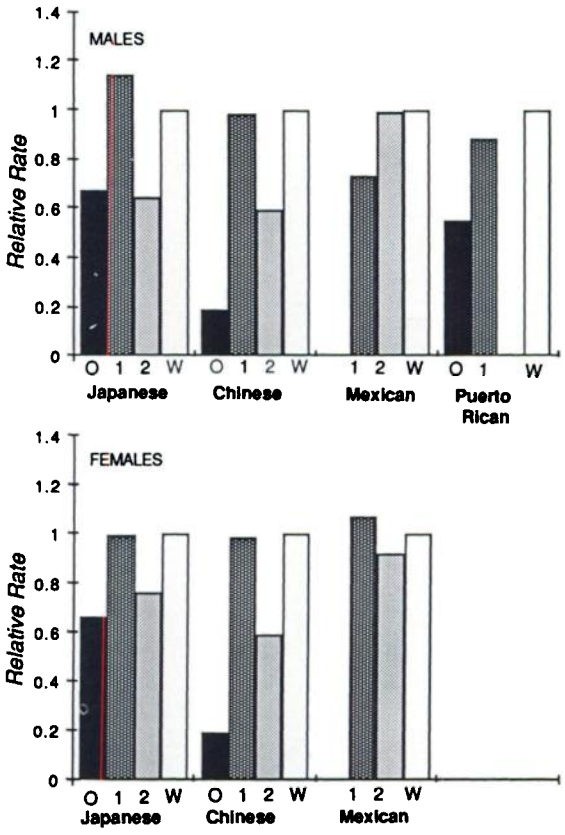

Fig. 10. Rates of pancreatic cancer in countries of origin and first and second generation migrants relative to rates in white Americans. *O*, country of origin; *1*, first generation; *2*, second generation; *W*, United States whites.

Downloaded from http://aacrjournals.org/cancerres/article-pdf/47/21/5771/2429563/cr0470215771.pdf by guest on 24 August 2022

is not of importance in the etiology of esophageal cancer in this country. The low rates in Japanese and Chinese females in the second generation could be accounted for by the patterns of alcohol and tobacco consumption in the second generation individuals. The very small residual excess rates in males may not be and warrant further investigation.

Cancer of the pancreas is largely of unknown etiology, although a portion is probably caused by cigarette smoking (20), and the patterns of rates in succeeding generations of Japanese and Chinese, which are similar to those for lung cancer, may be a result of smoking habits. However, the high rates of pancreatic cancer in migrants from Latin America cannot be explained solely on the basis of their smoking habits. Studies of pancreatic cancer in such groups might thus be informative.

The findings presented in this paper suggest additional topics for further investigation. Additional comparisons of rates in first and second generation Americans should be made. These should utilize incidence rather than mortality rates; include ethnic groups in addition to the Chinese, Japanese, and Mexicans; and be extended to additional neoplasms not considered in this report. Careful studies of changes in dietary habits by generation in various ethnic groups with different patterns of risk displacement may provide etiological clues.

REFERENCES

1. Thomas, D. B. Epidemiologic studies of cancer in minority groups in the western United States. Natl. Cancer. Inst. Monogr., *53:* 103–113, 1979.
2. Tominaga, S. Cancer incidence in Japanese in Japan, Hawaii, and western United States. Natl. Cancer. Inst. Monogr., *69:* 83–92, 1985.
3. Menck, H. R., Henderson, B. E., Pike, M. C., Mack, T., Martin, S. P., and SooHoo, J. Cancer incidence in the Mexican-American. J. Natl. Cancer Inst., *55:* 531–536, 1975.
4. Buell, P., and Dunn, J. E. Cancer mortality among Japanese issei and nisei of California. Cancer (Phila.), *18:* 656–664, 1965.
5. Haenszel, W., and Kurihara, M. Studies of Japanese migrants. I. Mortality from cancer and other diseases among Japanese in the United States. J. Natl. Cancer Inst., *40:* 43–68, 1968.
6. Locke, F. B., and King, H. Cancer mortality risk among Japanese in the United States. J. Natl. Cancer Inst., *65:* 1149–1156, 1980.
7. King, H., and Locke, F. B. Cancer mortality among Chinese in the United States. J. Natl. Cancer Inst., *65:* 1141–1148, 1980.
8. Rosenwaike, I. Cancer mortality among Puerto Rican-born residents in New York City. Am. J. Epidemiol., *119:* 177–185, 1984.
9. Warshauer, M. E., Silverman, D. T., Schottenfeld, D., and Pollack, E. S. Stomach and colorectal cancers in Puerto Rican-born residents of New York City. J. Natl. Cancer Inst., *76:* 591–595, 1986.
10. Nasca, P. C., Greenwald, P., Burnett, W. S., Chorost, S., and Schmidt, W. Cancer among the foreign-born in New York State. Cancer (Phila.), *48:* 2323–2328, 1981.
11. Newman, A. M., and Spengler, R. F. Cancer mortality among immigrant populations in Ontario, 1969 through 1973. Can. Med. Assoc. J., *130:* 399–405, 1984.
12. Thomas, D. B., and Chu, J. Nutritional and endocrine factors in reproductive organ cancers: opportunities for primary prevention. J. Chron. Dis., *39:* 1031–1050, 1986.
13. Nomura, A. Stomach. *In:* D. Schottenfeld and J. F. Fraumeni (eds.), Cancer Epidemiology and Prevention, pp. 624–637. Philadelphia, PA: W. B. Saunders Co., 1982.
14. Blumberg, B. S., and London, W. T. Hepatitis B virus and the prevention of primary cancer of the liver. J. Natl. Cancer Inst., *74:* 267–273, 1985.
15. Enwonwu, C. O. The role of dietary aflatoxin in the genesis of hepatocellular cancer in developing countries. Lancet, *2:* 956–958, 1984.
16. Loeb, L. A., Ernster, V. L., Warner, K. E., *et al.* Smoking and lung cancer: an overview. Cancer Res., *44:* 5940–5958, 1984.
17. Matanoski, G. M., and Elliott, E. A. Bladder cancer epidemiology. Epidemiol. Rev., *3:* 203–229, 1981.
18. Brand, K. G. Schistosomiasis-cancer: etiological considerations. Acta Trop. *36:* 203–214, 1979.
19. Day, N. E., and Munos, N. Esophagus. *In:* D. Schottenfeld and J. F. Fraumeni (eds.), Cancer Epidemiology and Prevention, pp. 596–623. Philadelphia, PA: W. B. Saunders Co., 1982.
20. Mack, T. M. Pancreas. *In:* D. Schottenfeld and J. F. Fraumeni (eds.), Cancer Epidemiology and Prevention, pp. 638–667. Philadelphia, PA: W. B. Saunders Co., 1982.

Downloaded from http://aacrjournals.org/cancerres/article-pdf/47/21/5771/2429563/cr0470215771.pdf by guest on 24 August 2022