Cancer Incidence among American Indians and Alaska Natives, 1980 through 1987

ABSTRACT

Objectives. This study uses Indian Health Service inpatient data to estimate cancer incidence among American Indians and Alaska Natives.

Methods. Hospital discharge data for 1980 through 1987 were used to identify cases of cancer for 21 sites in women and 18 sites in men. Estimates of incidence were directly standardized to data from the Surveillance, Epidemiology, and End Results Program for the same time frame.

Results. Cancers of the gallbladder, kidney, stomach, and cervix show generally high rates among many American Indian and Alaska Native communities, and cancers of the liver and nasopharynx are high in Alaska. Of the relatively common cancers in Whites, American Indians and Alaska Natives experience lower rates for cancers of the breast, uterus, ovaries, prostate, lung, colon, rectum, and urinary bladder and for leukemia and melanoma. Variation among geographic areas and among tribal groups is observed for many important cancer sites.

Conclusions. This study demonstrates significant variations of cancer rates among American Indians and Alaska Natives, with important implications for Indian Health Service cancer control programs. The study also supports the potential use of hospital discharge data for estimating chronic disease among diverse American Indian and Alaska Native communities. (*Am J Public Health.* 1993;83:1589–1598)

Paul A. Nutting, MD, MSPH, William L. Freeman, MD, MPH, David R. Risser, PhD, MPH, Steven D. Helgerson, MD, MPH, Roberta Paisano, MHSA, John Hisnanick, PhD, Shelli K. Beaver, MSPH, Irene Peters, MSPH, John P. Carney, MBA, and Marjorie A. Speers, PhD

Introduction

Cancer incidence rates in American Indian and Alaska Native populations are generally considered to be lower than those in the general US population,[1–3] largely on the basis of regional studies from the New Mexico Tumor Registry,[2,4] Montana,[5] western Washington state,[6] northwestern Ontario,[7] Manitoba,[8] British Columbia,[9] and New York.[10] However, studies of cancer among Alaska Natives have shown generally higher rates,[11,12] and investigators in western Washington and Montana have found that tumor registry data systematically underestimate cancer rates in American Indians because of misclassification of numerator data.[5,13] Faced with the need to plan rational cancer control programs for a wide spectrum of American Indian and Alaska Native communities, the Indian Health Service requires a better understanding of variations in cancer rates among different populations. Unfortunately, no single study has examined cancer incidence rates across a broad cross section of US American Indian and Alaska Native populations using methods that compare rates in these populations with those in the general population or compare rates among groups of American Indians and Alaska Natives. Scattered reports from specific communities, however, suggest higher rates for certain cancer sites[5,7,10–12,14] and the strong possibility of substantial variation in rates among these populations, due in part to ethnicity, genetic stock, geography, and cultural and behavioral factors.[12,15–18]

This study examined hospital discharge data maintained by the Indian Health Service to describe the burden of cancer by sex and site for the areas covered by the service and for nine major tribal groups. Although discharge data are not population based and do not necessarily capture all incident cases presented to the health care system, they are readily available and potentially useful for surveillance of chronic disease. This study explored the use of discharge data for estimating cancer rates; thus, it represents an important beginning to the systematic study of cancer and its variation among

Paul A. Nutting is with the Ambulatory Sentinel Practice Network and Department of Family Medicine, University of Colorado Health Sciences Center, Denver. William L. Freeman, John Hisnanick, and John P. Carney are with the Office of Health Program Research and Development, Indian Health Services, Tucson, Ariz. David R. Risser is with the Division of Medical System Research and Development, Office of Health Program Research and Development, Albuquerque, NM. Steven D. Helgerson is with the Health Care Financing Administration, Seattle, Wash. At the time of the study, Dr Helgerson was with the Indian Health Service, Seattle, Wash. Roberta Paisano is with the Cancer Prevention and Control Program, Indian Health Service Headquarters West, Albuquerque, NM. Shelli K. Beaver and Irene Peters are with the Research Program, Indian Health Service, Albuquerque. Marjorie A. Speers is with the Division of Chronic Disease Control and Community Intervention, National Center for Chronic Disease Prevention and Health Promotion, Atlanta, Ga.

Requests for reprints should be sent to Paul A. Nutting, MD, MSPH, Center for Studies in Family Medicine, University of Colorado Health Sciences Center, 1180 Clermont St, Denver, CO 80220.

This paper was accepted March 15, 1993.

Note. The opinions expressed are the authors' and do not reflect official policy of the Indian Health Service or the Centers for Disease Control and Prevention.

American Indian and Alaska Native communities.

Background

A review of the literature of cancer in American Indians and Alaska Natives produced 22 nonduplicated, original reports of population-based studies conducted since 1970.[4–11,14,18–29] The results illustrate the variation in morbidity and mortality observed among different American Indian and Alaska Native populations studied to date. No population-based study has described cancer incidence in these populations with more than a regional scope.

The Indian Health Service provides direct care to approximately 1.1 million eligible American Indians and Alaska Natives.[30] The basic unit of operation for local health programs is the service unit, which integrates primary care and public health functions for a defined population and arranges for needed health care services not available in the local facility to be provided through contracts with providers in nearby metropolitan areas. The Indian Health Service operates 127 service units, with most located in the West and in Alaska. Of these units, 52 are operated by the local tribal authority on contract from the service. The Indian Health Service operates 43 hospitals, with another 7 operated by individual tribes. Management of the service units is coordinated by the following 12 regional administrative units, called Indian Health Service areas: Alaska, Albuquerque (New Mexico), Aberdeen (North Dakota, South Dakota, and Nebraska), Billings (Montana and Wyoming), Bemidji (Minnesota, Michigan, and Wisconsin), Portland (Oregon, Idaho, and Washington), Nashville (11 states east of the Mississippi River), Navajo (portions of Arizona and New Mexico), Oklahoma (Oklahoma, Kansas, and Texas), Phoenix (Arizona, Utah, and Nevada), Tucson (southern Arizona), and California. Hospital and outpatient care is also provided through contracts with local providers in instances in which service units are unable to provide needed services.

Methods

The Data Set

The Indian Health Service Inpatient Data System captures a standard data set for each patient discharged from a service or contract facility. All service and contract hospitals report to the system, with the exception of those in California and seven hospitals operated by contract to the local tribal authority. The latter include four hospitals in Alaska, one in Mississippi, and two in Oklahoma. Within the Nashville area, this exception in reporting left only the hospital serving the Eastern Cherokee in North Carolina. Since the Eastern Cherokee were included in the analysis by tribal group, the Nashville area was omitted from the analysis of Indian Health Service areas. Similarly, the California area, with no reporting hospitals, was not included. Finally, the Tucson area data were analyzed with those of the Phoenix area, since the Tucson area serves fewer than 20 000 individuals who share demographic and cultural characteristics with the service population of the Phoenix area. Consequently, data were examined for the populations served by nine Indian Health Service areas. Data reported for calendar years 1980 through 1987 were used in this analysis.

Estimation of Incident Cases

An algorithm was developed and tested to examine the data set and appropriately attribute multiple discharges to a single individual by means of social security number, sex, date of birth, community of residence, and hospital record number. In order to reduce the number of prevalent cases erroneously considered to be incident cases, another algorithm was developed to remove cases involving a site-specific cancer diagnosis in 1980 and 1981 from the estimates of incident cases for the study period 1982 through 1987. Thus, an incident case during the study time frame was identified as one involving an individual who had a site-specific cancer diagnosis during 1982 through 1987 with no cancer diagnosis at the same site in 1980 or 1981.

Rates were computed by Indian Health Service area and by nine major tribal groups. Rates computed by area were based on counts of incident cases attributed to a given area based on coded community of residence. Incident cases were attributed to a tribal group on the basis of both tribal affiliation code and community of residence at the time of initial cancer diagnosis. Patients living beyond the geographic area of the tribal organization were excluded from the tribal-specific analysis to maintain consistency with the denominator estimates, which were also based on tribal affiliation and place of residence (as described below).

Cancer sites were included in the analysis if their rate in either sex (directly age adjusted to the 1970 US population) was greater than 10 per 100 000 person-years or if other published studies had suggested an American Indian or Alaska Native rate significantly different from that in the non-Indian population. Consequently, the analysis considered 21 specific cancer sites in women and 19 in men.

Several sources of systematic error were considered in the estimates of incident cases. First, as noted above, four hospitals in the Alaska area and two in the Oklahoma area did not report inpatient discharge data. The populations served by the units that included the six hospitals were therefore omitted both from numerator counts and from the estimation of the population at risk. Second, it was believed that members of two service populations in the Northwest (Puget Sound and western Oregon) used non-Indian Health Service facilities; thus, these populations were omitted from the numerator and denominator estimates for the Portland area.

Other sources of systematic error were identified, but specific adjustments could not be made. For example, it is generally believed that American Indians and Alaska Natives in the Oklahoma area have better access to employer-based coverage of health services outside the Indian Health Service system. Also, inpatient data may not reflect care for some cancer sites, and these inconsistencies may vary by area as a result of differences in access and use of services as well as regional variation in practice patterns for cancer. Finally, there are probable sources of random error in the data as well, including errors in coding and data entry, as considered below.

Estimation of the Population at Risk

The population served by the Indian Health Service consists of all American Indians and Alaska Natives living on or near their reservation or formal seat of tribal government; this population was estimated to be just above 1 million in 1987.[30] The Indian Health Service population is considerably younger than the general US population. At the time of the 1980 census, the median age of American Indians and Alaska Natives was 22.6, compared with 30.0 for the US population. Approximately 32% of American Indians and Alaska Natives were less than 15 years old, and 5% were more than 64 years of age, compared with 23% and 11%, respectively, for the US population.[30]

Estimates of the denominator populations used to compute area and tribal rates were based on Indian Health Service

TABLE 1—Female Cancer in American Indians and Alaska Natives: Incidence Rates (95% Confidence Intervals) per 100 000 Population, by Indian Health Service Area

Cancer Site (ICD-9 Code)	SEER Whites	All Indian Health Service Areas	Aberdeen	Alaska	Albuquerque	Bemidji	Billings	Navajo	Oklahoma	Portland	Phoenix
Oral and pharynx (140.0–149.9)	6.5	3.0 (2.0, 3.9)	3.7 (0.0, 7.4)	13.1 (4.5, 21.6)	1.4 (0.0, 4.2)	0 ...	4.6 (0.0, 9.8)	1.7 (0.1, 3.4)	2.5 (1.0, 4.0)	1.2 (0.0, 3.6)	2.4 (0.1, 4.7)
Salivary gland (142.0–142.9)	0.8	0.6 (0.2, 1.1)	0.9 (0.0, 2.7)	3.7 (0.0, 8.3)	1.4 (0.0, 4.2)	0 ...	0 ...	0.5 (0.0, 1.5)	0 ...	0 ...	1.3 (0.0, 3.0)
Nasopharynx (147.0–147.9)	0.3	0.7 (0.3, 1.2)	1.1 (0.0, 3.2)	5.6 (0.5, 10.7)	0 ...	0 ...	0 ...	0.2 (0.0, 0.5)	0.5 (0.0, 1.1)	0 ...	0.8 (0.0, 2.3)
Esophagus (150.0–150.9)	1.6	0.9 (0.3, 1.4)	1.1 (0.0, 3.2)	1.3 (0.0, 4.0)	0 ...	0 ...	0 ...	0 ...	1.3 (0.3, 2.4)	1.2 (0.0, 3.6)	1.3 (0.0, 3.0)
Stomach (151.0–151.9)	4.7	6.8 (5.4, 8.3)	9.0 (3.1, 14.9)	8.9 (1.8, 16.0)	18.6 (8.0, 29.2)	6.8 (0.0, 20.1)	5.0 (0.0, 10.0)	9.5 (5.6, 13.4)	3.9 (2.1, 5.8)	1.5 (0.0, 4.4)	5.6 (1.8, 9.4)
Colorectal (153.0–154.1, 159.0)	43.5	20.8 (18.2, 23.3)	16.4 (8.5, 24.3)	90.2 (66.8, 113.6)	22.0 (10.4, 33.7)	57.7 (22.5, 92.8)	19.2 (7.6, 30.8)	9.5 (5.7, 13.3)	18.5 (14.5, 22.6)	19.7 (9.1, 30.4)	13.1 (7.2, 19.1)
Liver (155.0)	1.2	2.0 (1.2, 2.8)	5.5 (1.1, 10.0)	7.2 (0.7, 13.6)	4.0 (0.0, 9.4)	0 ...	2.0 (0.0, 5.9)	1.8 (0.2, 3.5)	0.7 (0.0, 1.5)	0 ...	1.5 (0.0, 3.5)
Gallbladder (156.0)	1.4	7.1 (5.6, 8.6)	4.6 (0.6, 8.6)	14.4 (4.9, 23.9)	6.7 (0.1, 13.3)	5.3 (0.0, 15.8)	2.8 (0.0, 7.0)	9.6 (5.6, 13.6)	3.0 (1.4, 4.6)	5.6 (0.0, 11.2)	16.1 (9.7, 22.5)
Pancreas (157.0–157.9)	8.0	5.0 (3.8, 6.3)	10.5 (4.4, 16.7)	11.0 (3.1, 18.9)	5.8 (0.1, 11.6)	9.8 (0.0, 23.4)	4.0 (0.0, 9.5)	6.5 (3.2, 9.9)	2.1 (0.7, 3.5)	4.9 (0.0, 10.5)	3.9 (0.7, 7.2)
Lung and bronchus (162.2–162.9)	36.3	16.8 (14.5, 19.1)	32.1 (21.3, 43.0)	58.4 (40.8, 76.1)	12.1 (3.5, 20.6)	52.3 (18.0, 86.5)	37.8 (22.0, 53.5)	4.1 (1.4, 6.8)	12.1 (8.8, 15.4)	10.3 (2.6, 18.0)	10.9 (5.6, 16.1)
Melanoma of skin (172.0–172.9)	9.5	1.1 (0.6, 1.7)	0 ...	3.2 (0.0, 7.8)	2.1 (0.0, 5.4)	0 ...	0 ...	1.0 (0.0, 2.3)	1.2 (0.3, 2.1)	3.0 (0.0, 7.2)	1.2 (0.0, 2.8)
Breast (174.0–174.9)	105.0	30.2 (27.2, 33.1)	46.7 (34.2, 59.3)	51.5 (35.9, 67.0)	19.5 (9.5, 29.4)	20.4 (0.6, 40.2)	42.2 (26.5, 58.0)	26.0 (19.8, 32.2)	30.9 (25.6, 36.1)	20.1 (9.2, 31.0)	18.8 (12.6, 25.0)
Cervix (180.0–180.8)	7.8	19.5 (17.2, 21.8)	23.5 (15.3, 31.6)	29.5 (18.3, 40.7)	31.3 (18.7, 43.9)	10.8 (0.0, 26.2)	32.3 (18.6, 45.9)	24.4 (18.5, 30.4)	11.4 (8.3, 14.5)	8.8 (2.7, 14.9)	20.5 (13.7, 27.2)
Corpus and uterus (179, 182–182.8)	23.3	7.4 (6.0, 8.9)	8.1 (2.7, 13.4)	1.4 (0.0, 4.3)	4.5 (0.0, 9.1)	3.3 (0.0, 9.9)	11.2 (2.8, 19.7)	3.7 (1.5, 6.0)	7.5 (4.9, 10.0)	8.5 (1.5, 15.4)	14.4 (9.4, 19.5)
Ovary (183.0)	14.3	9.9 (8.2, 11.6)	10.5 (4.2, 16.7)	14.6 (6.1, 23.2)	16.4 (6.8, 26.0)	0 ...	18.3 (7.6, 28.9)	11.2 (7.0, 15.5)	7.1 (4.6, 9.6)	6.1 (0.6, 11.6)	9.6 (4.9, 14.4)
Urinary bladder (188.0–188.9)	7.7	1.3 (0.7, 1.9)	0.9 (0.0, 2.7)	4.2 (0.0, 9.1)	1.6 (0.0, 4.6)	6.8 (0.0, 20.1)	0 ...	1.0 (0.0, 2.5)	1.5 (0.4, 2.6)	1.8 (0.0, 5.3)	0.3 (0.0, 0.7)
Kidney/renal (189.0–189.1)	5.4	5.4 (4.1, 6.6)	5.0 (0.6, 9.4)	17.0 (7.3, 26.8)	5.4 (0.1, 10.7)	9.0 (0.0, 21.9)	6.3 (0.1, 12.4)	8.4 (4.7, 12.1)	3.2 (1.5, 4.8)	2.4 (0.0, 6.1)	1.8 (0.0, 3.6)
Hodgkin's disease (201.0–201.9)	2.6	0.4 (0.0, 0.8)	0 ...	0.5 (0.0, 1.5)	2.0 (0.0, 5.9)	0 ...	0 ...	1.0 (0.0, 2.5)	0.2 (0.0, 0.7)	0 ...	0 ...
Non-Hodgkin's (200.0–200.9, 202.0–202.9)	10.8	4.5 (3.4, 5.7)	8.6 (2.9, 14.3)	2.8 (0.0, 6.1)	4.3 (0.0, 9.3)	8.7 (0.0, 22.6)	4.2 (0.0, 9.2)	2.8 (0.7, 4.8)	4.7 (2.7, 6.7)	6.8 (0.8, 12.9)	3.0 (0.2, 5.8)
Multiple myeloma (203.0)	3.2	3.6 (2.5, 4.6)	3.2 (0.0, 6.8)	3.7 (0.0, 8.0)	5.6 (0.1, 11.1)	0 ...	2.8 (0.0, 7.0)	4.6 (1.8, 7.3)	2.8 (1.2, 4.3)	2.8 (0.0, 6.8)	3.5 (0.6, 6.3)
Leukemia (204.0–208.9)	7.8	4.7 (3.6, 5.8)	6.9 (2.2, 11.6)	1.7 (0.0, 4.2)	7.2 (1.0, 13.3)	11.3 (0.0, 27.2)	8.2 (2.2, 14.1)	5.3 (2.7, 7.9)	2.2 (0.8, 3.5)	3.1 (0.0, 6.9)	5.8 (2.3, 9.4)
All sites (140.0–208.9)	334.5	173.2 (166.0, 180.3)	212.7 (185.6, 239.9)	355.6 (312.5, 398.8)	214.3 (179.4, 249.2)	214.9 (147.8, 282.0)	232.0 (194.6, 269.4)	170.3 (154.1, 186.6)	124.1 (113.7, 134.5)	132.2 (105.3, 159.0)	167.5 (148.0, 187.0)

Note. Rates have been directly standardized to the 1970 US population. ICD-9 = *International Classification of Diseases,* 9th edition; SEER = Surveillance, Epidemiology, and End Results Program.

population data derived by means of projection techniques from the 1980 census. Adjustments were made, however, to correspond to corrections required in the numerator estimates, as described above. Specifically, the service populations of the six units with hospitals not reporting to the data system (four in the Alaska area and two in the Oklahoma area) and the two units believed to be underused in the Portland area were omitted from the denominator populations.

For computation of tribal-specific rates, the population at risk was estimated from the number of individuals reporting a specific tribal affiliation in the 1980 census[31] and residing in counties overlapping traditional or current tribal land and in geographic proximity to the formal tribal government. The number of tribal members at risk were summed across the counties constituting the tribal area. For the Apache tribe, the Arizona communities of White River and San Carlos, as well as the New Mexico community of Mescalero, were aggregated. The Sioux consisted of the communities in North Dakota and South Dakota. The Tohono O'Odham/Pima consisted of the communities at Sells and Sacaton in Arizona. The Navajo consisted of the communities on the Navajo reservation in northwestern New Mexico and northeastern Arizona. The Eskimo, Aleut, and Athabascan were drawn from appropriate aggregations of the communities in Alaska. The Oklahoma Cherokee and Eastern Cherokee consisted of those individuals who resided in Oklahoma and North Carolina, respectively, and who identified themselves as Cherokee.

Computation and Comparison of Rates

Incidence rates for nine Indian Health Service areas and for nine major tribal groups were computed and directly adjusted by age and sex (in 5-year intervals) to the 1970 US population. Methods described by Armitage[32] were used to compute 95% confidence intervals for each rate, and rates were considered to differ if the confidence interval of one did not include the rates for the other. The principal analysis compared rates computed for nine Indian Health Service areas and nine major tribal groups with rates reported for US Whites in the Surveillance, Epidemiology, and End Results (SEER) Program during 1982 through 1987 (J. Horm, unpublished data, 1982–1987). A secondary analysis examined variation among the nine areas and the nine tribal groups.

Estimation of Error in the Data Set

In order to estimate the magnitude of random error in the data set, rates computed from the data set and from the New Mexico Tumor Registry were compared for the cancer sites and time frame used in this study. The tumor registry collects cancer cases from New Mexico and systematically includes American Indian and Alaska Native cases in Arizona reported by the Indian Health Service. This area is roughly equivalent to the areas of Albuquerque, Navajo, Phoenix, and Tucson. In the comparison, both tumor registry and inpatient data system cases were restricted to patients who resided in Indian Health Service areas within Arizona and New Mexico. A previous Indian Health Service Cancer Program study had corrected minor errors in the tumor registry data, largely involving racial misclassification of cases.

For comparison, rates from both data sets were adjusted by age and sex to the 1970 US population, and the rates from the Indian Health Service inpatient data system were compared with those derived from the tumor registry; the latter were considered the "gold standard." Ratios were constructed by dividing the Indian Health Service rate by the tumor registry rate. All ratios observed for both sexes fell within the range of 0.7 to 2.1, with 38.5% below and 53.8% above 1.0. The male and female ratios for all cancer sites combined were 0.96 and 0.85, respectively, and 88% of the site-specific ratios were between 0.70 and 1.25.

A second analysis was carried out to compare results reported here with the population-based studies reported by the New Mexico Tumor Registry for 1973 through 1981[4] and by Lanier et al. for 1969 through 1983.[11] Indirect standardization to the 1982 through 1987 SEER data for US Whites produced standardized incidence ratios that expressed the ratio of cancer cases observed to those expected if the study population experienced the same age- and sex-specific rates as the standard population. (Tables of the standardized incidence ratios for nine Indian Health Service administrative areas and nine major tribal groups are available on request from the authors.)

Results

The data set used in the analysis contained records of just over 760 000 discharges for the period 1980 through 1987. There were 4387 cancer cases during the 1982 through 1987 time frame used to estimate incident cases.

Comparison with Rates in US Whites

Tables 1 and 2 show age- and sex-adjusted incidence rates for the aggregate Indian Health Service population and for the population served by each of the nine areas included in this study. The overall male and female cancer rates were significantly lower than the rates for US Whites. Men experienced increased rates of morbidity for cancers of the nasopharynx (1.5 per 100 000), kidney (8.4), and gallbladder (2.4), while women had an excess of cancers of the stomach (6.8), gallbladder (7.1), and uterine cervix (19.5). American Indians and Alaska Natives experienced lower rates for several cancer sites that occur with relative frequency in US Whites. Women had lower rates of breast, uterus, and ovary cancer; men had a lower rate of prostate cancer; and both men and women had lower rates of lung cancer, colon and rectum cancer, urinary bladder cancer, leukemia, and melanoma. In all Indian Health Service areas and for both sexes, with the exception of women in Alaska, the all-site rates were lower and ranged generally from 30% to 60% of the rates for US Whites.

Among women, several specific cancer sites were elevated relative to US White women. These included cancer of the nasopharynx (Alaska), stomach (Albuquerque and Navajo), gallbladder (Alaska, Navajo, and Phoenix), cervix (Aberdeen, Alaska, Albuquerque, Billings, Navajo, Oklahoma, and Phoenix), and colorectal, lung and bronchus, and kidney (Alaska). Among men, cancers of the nasopharynx, stomach, and liver were elevated in Alaska; gallbladder cancer was elevated in Navajo; and kidney cancer was elevated in Alaska and Navajo.

Consistent with the general belief of lower cancer incidence in American Indian and Alaska Native populations, a number of cancers were seen to be less common than in US White populations. Notably, many of the cancers that are relatively common in the general US population were observed to be lower in many Indian Health Service areas. Cancer of the lung and bronchus was less common among men in Aberdeen, Bemidji, and Billings and among both sexes in Albuquerque, Navajo, Oklahoma, Portland, and Phoenix. Cancers of both the breast and the corpus uterus were reduced among women in each of the nine Indian Health Service areas. Colorectal cancer

TABLE 2—Male Cancer in American Indians and Alaska Natives: Incidence Rates (95% Confidence Intervals) per 100 000 Population, by Indian Health Service Area

Cancer Site (ICD-9 Code)	SEER Whites	All Indian Health Service Areas	Aberdeen	Alaska	Albuquerque	Bemidji	Billings	Navajo	Oklahoma	Portland	Phoenix
Oral and pharynx (140.0–149.9)	16.8	5.7 (4.4, 7.0)	5.9 (1.4, 10.3)	16.5 (8.3, 24.8)	7.5 (1.6, 13.5)	11.8 (0.0, 28.0)	7.7 (0.9, 14.4)	5.4 (2.6, 8.1)	3.8 (1.9, 5.7)	2.7 (0.0, 6.3)	3.4 (0.6, 6.3)
Salivary gland (142.0–142.9)	1.2	0.7 (0.2, 1.1)	1.0 (0.0, 2.9)	1.2 (0.0, 3.4)	1.4 (0.0, 3.3)	5.9 (0.0, 17.4)	0 ...	0.4 (0.0, 1.1)	0.2 (0.0, 0.7)	0 ...	1.3 (0.0, 3.1)
Nasopharynx (147.0–147.9)	0.6	1.5 (0.8, 2.1)	0.4 (0.0, 1.3)	11.9 (4.8, 18.9)	1.9 (0.0, 4.7)	0 ...	0 ...	1.5 (0.1, 3.0)	0.5 (0.0, 1.2)	0 ...	0 ...
Esophagus (150.0–150.9)	5.2	2.7 (1.8, 3.6)	1.8 (0.0, 4.3)	6.4 (0.8, 12.1)	5.6 (0.1, 11.2)	0 ...	2.9 (0.0, 6.8)	0 ...	3.5 (1.7, 5.4)	4.3 (0.0, 9.1)	1.8 (0.0, 3.8)
Stomach (151.0–151.9)	10.7	9.5 (7.8, 11.2)	10.7 (4.7, 16.8)	24.4 (14.2, 34.7)	20.1 (9.6, 30.6)	5.9 (0.0, 17.4)	7.2 (0.8, 13.7)	10.3 (6.4, 14.2)	4.0 (2.1, 6.0)	9.4 (2.7, 16.1)	8.6 (4.1, 13.0)
Colorectal (153.0–154.1, 159.0)	61.7	15.0 (12.9, 17.2)	20.2 (11.6, 28.8)	50.6 (35.2, 66.0)	6.9 (1.4, 12.3)	58.0 (23.7, 92.3)	17.1 (7.1, 27.1)	8.2 (4.7, 11.7)	11.8 (8.4, 15.1)	14.2 (5.6, 22.8)	8.9 (4.3, 13.5)
Liver (155.0)	2.8	2.6 (1.8, 3.5)	2.0 (0.0, 4.7)	9.2 (3.6, 14.8)	5.7 (0.1, 11.3)	7.6 (0.0, 18.9)	3.9 (0.0, 8.7)	3.6 (1.2, 5.9)	0.5 (0.0, 1.2)	1.4 (0.0, 4.2)	1.3 (0.0, 3.2)
Gallbladder (156.0)	0.8	2.4 (1.6, 3.3)	2.9 (0.0, 6.3)	3.5 (0.0, 7.6)	6.1 (0.1, 12.1)	5.2 (0.0, 15.5)	1.6 (0.0, 4.7)	3.8 (1.4, 6.2)	0.5 (0.0, 1.2)	1.5 (0.0, 4.5)	3.8 (0.8, 6.9)
Pancreas (157.0–157.9)	10.8	5.8 (4.4, 7.1)	5.8 (1.2, 10.4)	14.1 (6.3, 21.9)	5.6 (0.1, 11.1)	16.6 (0.0, 35.4)	5.3 (0.0, 10.6)	6.9 (3.7, 10.2)	3.8 (1.9, 5.7)	3.2 (0.0, 7.6)	3.8 (0.8, 6.9)
Lung and bronchus (162.2–162.9)	82.5	27.8 (24.9, 30.8)	46.2 (33.1, 59.2)	85.2 (65.6, 104.7)	14.4 (5.4, 23.4)	42.3 (12.9, 71.7)	56.4 (38.0, 74.9)	12.3 (8.0, 16.5)	28.4 (23.2, 33.6)	12.8 (5.0, 20.6)	6.3 (2.4, 10.3)
Melanoma of skin (172.0–172.9)	12.3	1.1 (0.5, 1.7)	0 ...	0 ...	1.4 (0.0, 4.3)	7.7 (0.0, 19.5)	0 ...	1.2 (0.0, 2.5)	1.7 (0.4, 3.0)	3.1 (0.0, 7.4)	0 ...
Prostate (185.0)	88.0	25.8 (22.9, 28.6)	30.9 (20.2, 41.6)	33.2 (20.6, 45.7)	34.3 (20.6, 48.1)	33.1 (6.6, 59.6)	43.0 (26.7, 59.4)	25.6 (19.6, 31.7)	20.5 (16.1, 25.0)	27.0 (14.5, 39.5)	14.4 (8.4, 20.5)
Urinary bladder (188.0–188.9)	31.7	3.8 (2.7, 4.9)	4.8 (0.6, 9.0)	6.6 (1.2, 12.1)	5.5 (0.1, 10.9)	5.2 (0.0, 15.5)	6.5 (0.1, 12.9)	2.4 (0.5, 4.4)	4.3 (2.2, 6.3)	2.6 (0.0, 6.2)	0.3 (0.0, 1.0)
Kidney/renal (189.0–189.1)	5.4	8.4 (6.8, 10.0)	7.3 (2.2, 12.4)	15.6 (7.1, 24.1)	9.9 (2.5, 17.2)	11.4 (0.0, 27.1)	7.5 (0.9, 14.0)	10.0 (6.2, 13.9)	6.1 (3.7, 8.5)	8.6 (1.6, 15.6)	8.0 (3.6, 12.2)
Hodgkin's disease (201.0–201.9)	3.5	0.3 (0.0, 0.5)	0 ...	0.5 (0.0, 1.5)	0 ...	4.3 (0.0, 12.8)	1.4 (0.0, 4.1)	0 ...	0.3 (0.0, 0.7)	0 ...	0 ...
Non-Hodgkin's (200.0–200.9, 202.0–202.9)	15.9	4.4 (3.3, 5.5)	4.2 (0.5, 7.8)	10.2 (3.6, 16.9)	7.4 (0.9, 13.9)	2.1 (0.0, 6.3)	4.4 (0.3, 8.5)	3.7 (1.4, 5.9)	3.5 (1.8, 5.3)	5.2 (0.4, 10.0)	3.5 (0.7, 6.3)
Multiple myeloma (203.0)	4.7	3.8 (2.7, 4.9)	5.3 (1.0, 9.7)	3.7 (0.0, 7.9)	7.3 (0.9, 13.8)	4.3 (0.0, 12.8)	3.0 (0.0, 7.3)	3.7 (1.3, 6.2)	2.5 (0.9, 4.0)	2.7 (0.0, 6.6)	4.8 (1.4, 8.1)
Leukemia (204.0–208.9)	13.4	4.7 (3.6, 5.8)	5.9 (1.7, 10.2)	3.0 (0.0, 6.3)	3.8 (0.6, 6.9)	7.8 (0.0, 19.3)	3.7 (0.0, 7.8)	4.9 (2.4, 7.3)	4.0 (2.2, 5.9)	1.8 (0.0, 3.8)	5.3 (2.2, 8.4)
All sites (140.0–208.9)	427.2	142.1 (135.6, 148.7)	174.8 (150.0, 199.6)	324.3 (286.8, 361.9)	170.8 (140.7, 200.9)	227.7 (160.8, 294.7)	174.7 (142.8, 206.5)	30.0 (116.4, 143.7)	107.7 (97.6, 117.7)	104.6 (81.4, 127.8)	93.2 (78.6, 107.9)

Note. Rates have been directly standardized to the 1970 US population. ICD-9 = *International Classification of Diseases,* 9th edition; SEER = Surveillance, Epidemiology, and End Results Program.

rates were lower than those of US Whites for both sexes in Aberdeen, Albuquerque, Billings, Navajo, Oklahoma, Portland, and Phoenix. Cancer of the prostate was significantly lower in each area. Bladder cancer was lower in both sexes in all areas, with the exception of women in Alaska and Bemidji. While not common among US Whites, melanomas, leukemias, and non-Hodgkins lymphomas were even less common in most Indian Health Service areas.

Tables 3 and 4 compare cancer rates among nine tribal groups with those of US Whites and the aggregate Indian Health Service population. Consistent with the comparisons by area, the all-site rates were lower than those for US Whites, with the exception of Eastern Cherokee women and the three tribal groups of Alaska. All-site rates were higher for Eskimo and Athabascan women, lower for Eskimo men, and not substantially different from those of US Whites for Athabascan men and Aleuts of both sexes. For the other tribal groups, however, the all-site rates were lower than those for US Whites, ranging generally from 30% to 50% for men and 40% to 60% for women.

Cancer of the nasopharynx exceeded US rates for both sexes in the Eskimo and Athabascan populations and among male Aleuts, and salivary gland cancer was excessive in Athabascan and Aleut women. Cancer of the stomach was elevated in Eskimo men and Navajo women. Colorectal cancer was high in Eskimo women, and liver cancer was elevated among Eskimos of both sexes and among Sioux women. Gallbladder cancer dramatically exceeded US rates for Apache, Eskimo, and Tohono O'Odham/Pima women and for Navajos of both sexes, with rates ranging from 4 to 20 times those for US Whites. Interestingly, there appears to be a relative female preponderance (relative to US Whites) among most of the tribal groups for gallbladder cancer. Cervical cancer was elevated among Apache, Tohono O'Odham/Pima, Navajo, Sioux, and Eskimo women, ranging from 2.8 to 4.6 times the rates for US White women. Tohono O'Odham/Pima rates of cancer of the corpus uterus exceeded those of US White women, although lower rates were observed among all other tribal groups, consistent with the pattern noted for the areas.

As noted in the analysis of rates by area, many cancer rates by tribal group were less than those of US Whites. With the notable exception of Athabascan women, breast cancer rates were reduced among all tribal groups, ranging from 18% (Tohono O'Odham/Pima) to 55% (Sioux) of the White rates. Cancer of the lung and bronchus was generally below US White rates, except for similar rates among Eskimos of both sexes, Sioux women, and Athabascan and Aleut men. Rates exceeded those for US Whites, however, among Athabascan and Aleut women.

Variation among Indian Health Service Areas and Tribal Groups

Considerable variation was observed both among areas and among tribal groups for cancers of the oropharynx, nasopharynx, stomach, colon and rectum, liver, lung and bronchus, breast, cervix, uterus, and kidney and for cancers of all sites. Within the pattern of variation, there were relatively high rates in Alaska and relatively low rates in the Oklahoma and Navajo areas, also reflected in the tribal groups of the region.

Knowledge of variation is useful to support rational planning, development of clinical policies, and resource allocation across the diverse communities served by the Indian Health Service. The magnitude of variation observed among American Indian and Alaska Native populations is often dramatic. Relative to US White men, cancer of the liver was experienced only 18% as often in Oklahoma men and 50% as often by men in Portland and Phoenix; however, these rates ranged to three times the US White rate in Alaska. Lung cancer rates were 13 to 14 times higher among Alaska and Bemidji women than among Navajo women. There was a twelvefold difference in colorectal cancer rates between Eskimo and Tohono O'Odham/Pima women, a twenty-threefold difference in prostate cancer rates between Apache and Eastern Cherokee men, a twelvefold difference in stomach cancer rates between Portland and Albuquerque women, and a seventeenfold difference in leukemia rates between Eskimo and Tohono O'Odham/Pima women.

Comparison with Other Studies

In order to examine the precision of the judgments made in this study, we compared standardized incidence ratios computed from our data (available from the authors on request) with those reported from the New Mexico Tumor Registry for 1973 through 1981[4] and from an Alaska population-based study for 1969 through 1983.[11] The studies from the tumor registry were compared with our data for the Albuquerque area, although the tumor registry includes a substantial population of Navajos whose reservation extends into northwestern New Mexico. The data from Alaska were compared with our findings for the Aleut, Athabascan, and Eskimo populations, permitting comparison of results at the tribal-specific level.

Of the 16 cancer sites with standardized incidence ratios suggesting variation from US Whites found for the Albuquerque area, all were confirmed by studies from the tumor registry. Of the 27 cancer site variations from US Whites suggested by the standardized incidence ratios for the three tribal groups in Alaska, Lanier[11] reported significant findings for 21 (78%) and reported an observed-to-expected ratio in the same direction (more or less than 1.0) in 25 (93%). Our data suggested elevations of cancer rates for lung and ovary in Athabascan women not found by Lanier, although she projected a possible increasing trend in lung cancer from her 1968 through 1983 time frame.

Conversely, of the 40 findings reported from the New Mexico Tumor Registry,[4] we found 38 (95%) with standardized incidence ratios in the same direction. Data from the tumor registry suggested lower rates for cancer of the ovary and esophagus in men that were not confirmed by our data. However, the tumor registry included a substantial number of Navajos, and our data report a decrease in esophageal cancer for both the Navajo area and the Navajo as a tribal group. A similar decrease in cancer of the ovary (standardized incidence ratio = 0.7) was observed in Navajos. Of the 43 significant findings reported by Lanier[11] for the three tribal groups in Alaska, we found 36 (84%) with standardized incidence ratios in the same direction. Lanier reported elevations for cancer of the salivary gland in Eskimo women, cancer of the nasopharynx in Aleut women, cancer of the esophagus in Eskimo men, cancer of the gallbladder in Athabascan women, and multiple myeloma in Athabascan men, as well as a decrease in breast cancer in Athabascan women, that were not found in our data.

Discussion

This study confirms the impression of generally lower cancer rates among American Indians and rates among Alaskan Natives that approach those of the US general population. More important, however, is the demonstration of dramatic variation in cancer burden within the Indian Health Service population, as noted for leukemia, stomach, liver, lung, prostate, and colorectal cancers. These find-

TABLE 3—Female Cancer in American Indians and Alaska Natives: Incidence Rates (95% Confidence Intervals) per 100 000 Population, for All Indian Health Service Areas and Nine Major Tribal Groups

Cancer Site (ICD-9 Code)	SEER Whites	All Indian Health Service Areas	Apache	Eskimo	Tohono O'Odham/Pima	Navajo	Sioux	Oklahoma Cherokee	Athabascan	Aleut	Eastern Cherokee
Oral and pharynx (140.0–149.9)	6.5	3.0 (2.0, 3.9)	0 ...	14.9 (2.7, 27.0)	3.3 (0.0, 8.1)	2.0 (0.1, 3.8)	2.6 (0.0, 6.1)	1.3 (0.0, 3.0)	17.5 (0.0, 38.4)	15.6 (0.0, 46.1)	6.2 (0.0, 18.2)
Salivary gland (142.0–142.9)	0.8	0.6 (0.2, 1.1)	0 ...	0 ...	2.1 (0.0, 6.2)	0.6 (0.0, 1.7)	1.5 (0.0, 4.4)	0 ...	11.6 (0.0, 29.0)	15.6 (0.0, 46.1)	0 ...
Nasopharynx (147.0–147.9)	0.3	0.7 (0.3, 1.2)	0 ...	8.9 (0.1, 17.7)	0 ...	0.2 (0.0, 0.6)	0 ...	0.6 (0.0, 1.9)	3.3 (0.0, 9.8)	0 ...	0 ...
Esophagus (150.0–150.9)	1.6	0.9 (0.3, 1.4)	3.0 (0.0, 8.9)	2.4 (0.0, 7.0)	3.1 (0.0, 9.1)	0 ...	1.7 (0.0, 5.1)	0.6 (0.0, 1.9)	0 ...	0 ...	0 ...
Stomach (151.0–151.9)	4.7	6.8 (5.4, 8.3)	7.9 (0.0, 17.0)	12.2 (0.7, 23.7)	10.9 (0.0, 22.1)	10.9 (6.5, 15.4)	11.3 (2.9, 19.7)	2.5 (0.1, 5.0)	7.3 (0.0, 21.5)	6.9 (0.0, 20.5)	7.4 (0.0, 21.8)
Colorectal (153.0–154.1, 159.0)	43.5	20.8 (18.2, 23.3)	13.0 (0.1, 25.8)	116.1 (80.9, 151.3)	9.4 (0.0, 20.0)	10.7 (6.4, 15.0)	19.4 (8.7, 30.2)	26.1 (18.0, 34.2)	96.2 (31.9, 160.5)	89.9 (26.9, 152.9)	26.7 (0.0, 53.7)
Liver (155.0)	1.2	2.0 (1.2, 2.8)	7.2 (0.0, 17.2)	12.6 (1.2, 23.9)	0 ...	2.1 (0.2, 3.9)	8.8 (1.7, 15.9)	0 ...	0 ...	0 ...	0 ...
Gallbladder (156.0)	1.4	7.1 (5.6, 8.6)	20.5 (5.0, 35.9)	27.6 (10.2, 44.9)	33.4 (13.5, 53.4)	10.8 (6.3, 15.4)	5.9 (0.1, 11.7)	2.6 (0.1, 5.1)	0 ...	0 ...	10.7 (0.0, 31.8)
Pancreas (157.0–157.9)	8.0	5.0 (3.8, 6.3)	3.9 (0.0, 11.4)	2.4 (0.0, 7.0)	3.4 (0.0, 10.1)	7.4 (3.6, 11.2)	13.4 (4.5, 22.3)	2.6 (0.1, 5.2)	34.0 (0.0, 73.6)	36.4 (0.3, 72.5)	7.4 (0.0, 21.8)
Lung and bronchus (162.2–162.9)	36.3	16.8 (14.5, 19.1)	8.3 (0.0, 17.7)	53.2 (30.5, 75.9)	17.9 (3.5, 32.3)	4.6 (1.6, 7.6)	34.1 (20.0, 48.1)	16.4 (10.0, 22.9)	111.3 (50.1, 172.4)	101.7 (37.2, 166.3)	35.2 (0.4, 69.9)
Melanoma of skin (172.0–172.9)	9.5	1.1 (0.6, 1.7)	0 ...	5.6 (0.0, 13.6)	2.3 (0.0, 6.9)	1.1 (0.0, 2.6)	0 ...	2.3 (0.2, 4.4)	0 ...	0 ...	0 ...
Breast (174.0–174.9)	105.0	30.2 (27.2, 33.1)	26.2 (9.7, 42.8)	50.7 (30.4, 70.9)	18.5 (5.7, 31.3)	28.7 (21.8, 35.6)	57.9 (40.0, 75.7)	37.7 (28.0, 47.4)	106.1 (48.3, 163.9)	40.1 (0.0, 81.4)	43.9 (8.3, 79.6)
Cervix (180.0–180.8)	7.8	19.5 (17.2, 21.8)	31.8 (14.1, 49.5)	33.1 (17.9, 48.3)	41.7 (21.5, 62.0)	26.3 (19.7, 32.8)	29.2 (17.7, 40.6)	10.7 (5.7, 15.7)	39.4 (4.1, 74.8)	29.7 (0.0, 61.9)	24.4 (0.0, 52.0)
Corpus and uterus (179, 182–182.8)	23.3	7.4 (6.0, 8.9)	9.8 (1.0, 18.6)	2.5 (0.0, 7.5)	31.7 (26.4, 47.0)	4.2 (1.7, 6.8)	11.5 (3.4, 19.6)	4.3 (1.1, 7.5)	0 ...	0 ...	0 ...
Ovary (183.0)	14.3	9.9 (8.2, 11.6)	19.3 (4.6, 34.0)	12.1 (1.7, 22.6)	11.8 (0.7, 22.9)	13.0 (8.1, 17.9)	12.5 (3.7, 21.3)	7.7 (3.3, 12.1)	38.5 (6.8, 70.2)	15.6 (0.0, 46.1)	25.3 (0.0, 53.9)
Urinary bladder (188.0–188.9)	7.7	1.3 (0.7, 1.9)	0 ...	2.1 (0.0, 6.3)	0 ...	1.2 (0.0, 2.8)	1.5 (0.0, 4.4)	1.2 (0.0, 2.8)	13.4 (0.0, 39.6)	7.6 (0.0, 22.5)	0 ...
Kidney/renal (189.0–189.1)	5.4	5.4 (4.1, 6.6)	1.4 (0.0, 4.1)	14.8 (2.4, 27.2)	7.4 (0.0, 15.9)	9.6 (5.4, 13.8)	2.9 (0.0, 6.9)	4.3 (1.1, 7.4)	45.4 (4.5, 86.2)	14.5 (0.0, 36.6)	7.4 (0.0, 22.0)
Hodgkin's disease (201.0–201.9)	2.6	0.4 (0.0, 0.8)	0 ...	0.9 (0.0, 2.5)	0 ...	1.2 (0.0, 2.8)	0 ...	0 ...	0 ...	0 ...	0 ...
Non-Hodgkin's (200.0–200.9, 202.0–202.9)	10.8	4.5 (3.4, 5.7)	0 ...	0.9 (0.0, 2.5)	8.9 (0.0, 19.2)	3.1 (0.8, 5.5)	8.0 (0.9, 15.1)	4.4 (1.2, 7.7)	7.3 (0.0, 21.5)	9.6 (0.0, 28.5)	16.7 (0.0, 39.9)
Multiple myeloma (203.0)	3.2	3.6 (2.5, 4.6)	2.3 (0.0, 6.7)	4.0 (0.0, 9.6)	7.6 (0.0, 16.4)	5.5 (2.4, 8.7)	5.1 (0.0, 10.9)	3.9 (0.8, 7.0)	0 ...	0 ...	10.7 (0.0, 31.8)
Leukemia (204.0–208.9)	7.8	4.7 (3.6, 5.8)	2.9 (0.0, 6.3)	0.8 (0.0, 2.4)	14.1 (1.4, 26.8)	5.6 (2.7, 8.5)	7.3 (1.1, 13.4)	3.1 (0.3, 5.8)	8.2 (0.0, 24.4)	0 ...	20.2 (0.0, 43.4)
All sites (140.0–208.9)	334.5	173.2 (166.0, 180.3)	202.1 (156.2, 248.1)	402.5 (341.0, 463.9)	279.0 (225.4, 332.6)	191.5 (173.2, 209.8)	286.9 (247.1, 326.8)	150.2 (131.1, 169.4)	553.9 (416.6, 691.3)	459.5 (323.7, 595.2)	283.9 (190.8, 377.0)

Note. Rates have been directly standardized to the 1970 US population. ICD-9 = *International Classification of Diseases,* 9th edition; SEER = Surveillance, Epidemiology, and End Results Program.

TABLE 4—Male Cancer in American Indians and Alaska Natives: Incidence Rates (95% Confidence Intervals) per 100 000 Population, for All Indian Health Service Areas and Nine Major Tribal Groups

Cancer Site (ICD-9 Code)	SEER Whites	All Indian Health Service Areas	Apache	Eskimo	Tohono O'Odham/Pima	Navajo	Sioux	Oklahoma Cherokee	Athabascan	Aleut	Eastern Cherokee
Oral and pharynx (140.0–149.9)	16.8	5.7 (4.4, 7.0)	12.4 (0.2, 24.6)	12.3 (2.8, 21.7)	7.4 (0.0, 16.3)	5.6 (2.6, 8.5)	6.2 (0.6, 11.9)	6.3 (2.2, 10.5)	21.3 (0.0, 45.3)	41.0 (4.9, 77.2)	7.9 (0.0, 23.4)
Salivary gland (142.0–142.9)	1.2	0.7 (0.2, 1.1)	0 ...	0 ...	6.1 (0.0, 14.7)	0.4 (0.0, 1.2)	0 ...	0 ...	0 ...	9.2 (0.0, 27.1)	0 ...
Nasopharynx (147.0–147.9)	0.6	1.5 (0.8, 2.1)	0 ...	11.4 (2.1, 20.7)	0 ...	1.7 (0.1, 3.3)	0.7 (0.0, 2.1)	0.7 (0.0, 2.1)	14.4 (0.0, 34.3)	25.3 (0.0, 53.9)	0 ...
Esophagus (150.0–150.9)	5.2	2.7 (1.8, 3.6)	0 ...	2.4 (0.0, 7.1)	0 ...	0 ...	0 ...	5.0 (1.3, 8.7)	18.4 (0.0, 43.8)	18.3 (0.0, 43.7)	0 ...
Stomach (151.0–151.9)	10.7	9.5 (7.8, 11.2)	13.4 (1.3, 25.5)	28.9 (13.9, 43.9)	12.2 (1.1, 23.3)	10.8 (6.5, 15.1)	11.3 (3.3, 19.2)	5.6 (1.7, 9.5)	15.3 (0.0, 37.0)	37.4 (4.1, 70.7)	9.7 (0.0, 28.6)
Colorectal (153.0–154.1, 159.0)	61.7	15.0 (12.9, 17.2)	9.3 (0.0, 19.9)	53.2 (32.7, 73.7)	1.3 (0.0, 3.8)	9.3 (5.3, 13.3)	24.7 (12.6, 36.8)	12.2 (6.4, 18.0)	40.4 (4.8, 75.9)	114.8 (47.3, 182.3)	33.5 (0.6, 66.5)
Liver (155.0)	2.8	2.6 (1.8, 3.5)	0 ...	14.2 (5.2, 23.3)	5.8 (0.0, 13.7)	4.1 (1.4, 6.7)	1.5 (0.0, 4.6)	0 ...	7.2 (0.0, 21.3)	0 ...	0 ...
Gallbladder (156.0)	0.8	2.4 (1.6, 3.3)	0 ...	3.8 (0.0, 9.1)	5.3 (0.0, 12.8)	3.9 (1.3, 6.4)	4.7 (0.0, 10.0)	0 ...	9.2 (0.0, 27.2)	0 ...	0 ...
Pancreas (157.0–157.9)	10.8	5.8 (4.4, 7.1)	3.3 (0.0, 9.7)	15.7 (4.6, 26.7)	0 ...	7.9 (4.2, 11.5)	6.2 (0.1, 12.3)	5.0 (1.3, 8.7)	20.7 (0.0, 44.1)	16.4 (0.0, 39.2)	9.7 (0.0, 28.6)
Lung and bronchus (162.2–162.9)	82.5	27.8 (24.9, 30.8)	6.1 (0.0, 14.6)	106.1 (77.3, 134.8)	10.5 (0.2, 20.9)	13.1 (8.4, 17.9)	46.2 (29.7, 62.7)	35.0 (25.4, 44.8)	88.4 (36.3, 140.5)	92.3 (34.7, 149.8)	26.8 (0.0, 57.2)
Melanoma of skin (172.0–172.9)	12.3	1.1 (0.5, 1.7)	0 ...	0 ...	0 ...	1.3 (0.0, 2.8)	0 ...	2.9 (0.1, 5.7)	0 ...	0 ...	0 ...
Prostate (185.0)	88.0	25.8 (22.9, 28.6)	3.3 (0.0, 9.7)	19.4 (6.7, 32.1)	29.7 (12.1, 47.4)	26.5 (19.9, 33.1)	32.5 (18.6, 46.3)	26.5 (18.1, 35.0)	91.8 (37.6, 146.0)	47.3 (5.7, 89.0)	74.8 (23.1, 126.4)
Urinary bladder (188.0–188.9)	31.7	3.8 (2.7, 4.9)	3.3 (0.0, 9.8)	5.4 (0.0, 11.7)	0 ...	2.3 (0.3, 4.4)	3.2 (0.0, 7.5)	9.1 (4.2, 14.1)	17.1 (0.0, 40.8)	8.1 (0.0, 23.8)	9.2 (0.0, 27.3)
Kidney/renal (189.0–189.1)	5.4	8.4 (6.8, 10.0)	5.8 (0.0, 13.9)	20.8 (7.8, 33.8)	20.2 (6.2, 34.1)	10.9 (6.7, 15.2)	4.1 (0.0, 8.8)	3.6 (0.4, 6.8)	9.2 (0.0, 27.2)	19.9 (0.0, 47.4)	9.7 (0.0, 28.6)
Hodgkin's disease (201.0–201.9)	3.5	0.3 (0.0, 0.5)	0 ...	0.9 (0.0, 2.6)	0 ...	0 ...	0 ...	0.4 (0.0, 1.2)	0 ...	0 ...	0 ...
Non-Hodgkin's (200.0–200.9, 202.0–202.9)	15.9	4.4 (3.3, 5.5)	5.8 (0.0, 13.9)	9.9 (1.7, 18.1)	3.3 (0.0, 9.6)	4.2 (1.6, 6.7)	3.1 (0.0, 6.8)	3.3 (0.6, 6.0)	27.5 (0.0, 58.6)	3.8 (0.0, 11.2)	0 ...
Multiple myeloma (203.0)	4.7	3.8 (2.7, 4.9)	3.3 (0.0, 9.7)	4.4 (0.0, 10.6)	7.7 (0.0, 16.4)	4.2 (1.5, 7.0)	5.5 (0.0, 11.0)	0 ...	0 ...	9.2 (0.0, 27.1)	18.5 (0.0, 44.0)
Leukemia (204.0–208.9)	13.4	4.7 (3.6, 5.8)	3.1 (0.0, 9.0)	2.9 (0.0, 6.3)	12.4 (2.3, 22.5)	5.5 (2.7, 8.3)	6.7 (0.9, 12.5)	6.6 (2.7, 10.6)	9.2 (0.0, 27.2)	0 ...	31.5 (0.0, 63.6)
All sites (140.0–208.9)	427.2	142.1 (135.6, 148.7)	108.3 (73.2, 143.3)	365.6 (313.0, 418.1)	149.0 (110.7, 187.3)	142.2 (127.0, 157.4)	203.8 (169.9, 237.7)	144.9 (125.3, 164.6)	419.9 (307.9, 532.0)	443.9 (320.2, 567.5)	298.2 (198.0, 398.5)

Note. Rates are directly standardized to the 1970 US population. ICD-9 = *International Classification of Diseases*, 9th edition; SEER = Surveillance, Epidemiology, and End Results Program.

ings underscore the danger inherent in generalizing health issues across the many distinct American Indian and Alaska Native communities and tribal groups.

Substantial variation may also be observed within an Indian Health Service area that is only apparent on tribal-specific analysis. For example, in the Phoenix area, cancer of the uterus is elevated among Tohono O'Odham/Pima women but lower among Apache women, with the elevation in the former not reflected in the relatively low rates for the Phoenix area. Cancers of the gallbladder and uterine cervix are consistently elevated across a broader range of Indian Health Service areas and tribal groups, and they appear to exceed US White rates in one or both sexes in Aberdeen, Alaska, Albuquerque, Navajo, Portland, and Phoenix. Nonetheless, variability in rates across areas is also apparent, with rates that cannot be distinguished from those of US Whites in Bemidji, Billings, and Oklahoma and rates that range upward to a tenfold elevation among women of Alaska and Phoenix.

Some caution is in order in interpreting the rates reported from this study. Discharge data probably underestimate some cancers that do not require hospitalization, and underuse of the Indian Health Service system may result in low estimates of community cancer care. The degree of underestimation may also vary by Indian Health Service area and by tribal group as a function of local service use and practice patterns. Finally, many of the incidence rates reported are based on relatively small numbers when disaggregated to the area or tribal level. Multiple comparisons are also a legitimate concern whenever so many different associations are considered. Nonetheless, the findings are useful in generating hypotheses for more detailed studies that could link Indian Health Service data with state cancer registry and vital data.[5]

For several cancer sites, further research would be particularly important to support cancer control programs. First, invasive cervical cancer rates exceed US rates in six Indian Health Service areas (ranging to 3.8 times the US rate in Alaska and Billings) and appear to actually exceed breast cancer rates in the Albuquerque and Phoenix areas. Prevention of invasive cervical cancer is well within the state of the art, and several research and demonstration projects are currently under way in the Indian Health Service to increase participation in cervical cancer screening programs. Cancer of the uterine corpus is elevated in Tohono O'Odham/Pima women and appears to be due to an excess of endometrial cancer. This finding has been discussed previously (J. Justice, unpublished data, 1974), and it certainly deserves more careful study to confirm the elevated rate and to examine potential risk factors. If the excess is confirmed, a program to alert women to the danger signs and need for screening would be appropriate. Dramatically elevated rates of cancer of the gallbladder are apparent in many American Indian and Alaska Native populations and have been shown to be associated with the presence of gallstones.[21,33,34] While standard screening procedures have not been tested for this cancer, the relatively high rates and generally poor outcome may stimulate research on strategies for prevention or early detection. It is interesting to speculate on the observation of no excess gallbladder cancer in two Cherokee populations that have been geographically separated for many generations. If confirmed by further study, this finding might provide the opportunity to study the relative effect of genetic and environmental factors on gallbladder cancer.

Cancer of the lung and bronchus has generally been lower among American Indians and Alaska Natives, presumably as a result of a nonsmoking tradition among many of these populations. Even so, lung cancer continues to be the most frequent cancer among American Indian and Alaska Native men and the fourth most frequent among women, trailing breast, colorectal, and cervical cancer. Moreover, our data suggest that lung cancer rates in women in Billings, Aberdeen, and Bemidji approach those of their White counterparts. Most alarming, however, is the evidence of high smoking rates among American Indian and Alaska Native adolescents[35] and young adults.[36,37] Programs targeting smoking cessation continue to be one of the most important cancer prevention strategies.

More difficult policy challenges confront the Indian Health Service in regard to several cancers that are less common in American Indian and Alaska Native communities, but for which current screening recommendations are based on the higher baseline rates of the general US population. In the face of the considerable deterioration in performance of screening tests that accompany lower population rates and the large number of serious health problems among American Indian and Alaska Native communities competing for limited health care resources, it is not clear that such recommendations should be applied uniformly. For example, rates of breast cancer in most Indian Health Service areas range from 18% to 50% of those in Whites. A recent Indian Health Service study examined the dramatically increased cost per breast cancer death prevented by screening mammography programs as a result of the relatively low incidence levels common to American Indian and Alaska Native populations.[38] A similar paradox exists in the cases of colorectal and prostate cancer, for which rates in many American Indian and Alaska Native communities are generally substantially lower than those in the US population. Coupled with substantial intertribal variation, such deviation from the rates of the US White population further stresses the need to match cancer control strategies to the rates observed in individual communities. The availability of better information on cancer incidence by community affords the opportunity to plan locally appropriate and cost-efficient methods for cancer surveillance.

Based on comparisons with existing studies of cancer in American Indian and Alaska Native populations, the Indian Health Service inpatient data set appears to be useful in estimating the variation of cancer incidence between these populations and US Whites and across relevant subsets of the service population. Several analyses have been conducted that support improvements in the quality of the data (S. Valway, unpublished data, 1989).[5,39] Similar rates and sources of error have been demonstrated in studies of cancer using discharge data in other settings as well.[40,41] Hospital discharge data, nonetheless, are generally believed to be useful for cancer surveillance,[40–42] particularly when accompanied by efforts to improve their quality.[43,44]

Summary and Conclusions

This study has demonstrated dramatic variation in cancer rates among the Indian Health Service areas and among nine major tribal groups. Such variation underscores the diversity among American Indian and Alaska Native groups and the need to target cancer control programs as a function of the epidemiology of preventable cancer. The impression that cancer rates are generally lower among American Indian and Alaska Native communities in the Southwest and that these rates approach those of US Whites in Alaska is generally confirmed. Rates among Eastern Cherokee women, however, also appear to approach those of

US Whites. Cancers of the gallbladder, stomach, and cervix show generally high rates among many American Indian and Alaska Native communities, and cancers of the liver and nasopharynx are high in Alaska. Conversely, several cancer sites that are relatively prevalent among US Whites (e.g., cancers of the breast, ovary, and uterus in women; prostate cancer in men; and colorectal cancer, lung and bronchus cancer, urinary bladder cancer, leukemia, and melanoma in both men and women) are less common. Finally, this study suggests that Indian Health Service inpatient data are useful in hypothesis-generating studies of rates and variations among American Indian and Alaska Native populations for chronic disease but that further attention to their quality may be necessary if they are to serve as an effective surveillance system. □

Acknowledgments

The work reported here was accomplished with funding from the National Cancer Institute (grant Y02-CN-90667) and the Office of Planning Evaluation and Legislation of the Indian Health Service.

We would like to thank our project officers, Drs Gregory Christenson and John Horm of the National Cancer Institute and Ramona Ornelas, Office of Planning Evaluation and Legislation, Indian Health Service, for their professional assistance and encouragement.

References

1. Rhoades ER, Hammond J, Welty TK, Handler AO, Amler RW. The Indian burden of illness and future health interventions. *Public Health Rep.* 1987;102:361.
2. Boss L. Cancer. In: Welty TK, ed. *Indian Health Conditions.* Rockville, Md: Indian Health Service; 1986.
3. Mahoney MC, Michalek AM. A meta-analysis of cancer incidence in United States and Canadian native populations. *Int J Epidemiol.* 1991;20:323–327.
4. *Cancer Incidence and Mortality in the United States: 1973–81.* Bethesda, Md: National Institutes of Health; 1984. NIH publication 85-1837.
5. Bleed DM, Risser DR, Sperry S, Hellhake D, Helgerson SD. Cancer incidence and survival in American Indians registered for Indian Health Service care in Montana, 1982–1987. *JNCI.* In press.
6. Norsted TL, White E. Cancer incidence among Native Americans of western Washington. *Int J Epidemiol.* 1989;18:22–27.
7. Young TK, Frank JW. Cancer surveillance in a remote Indian population in northwestern Ontario. *Am J Public Health.* 1983;73:515–520.
8. Young TK, Choi NW. Cancer risks among residents of Manitoba Indian reserves, 1970–1979. *Can Med Assoc J.* 1985;132:1269–1272.
9. Gallagher RP, Elwood JM. Cancer mortality among Chinese, Japanese, and Indians in British Columbia, 1964–73. *Natl Cancer Inst Monogr.* 1979;53:89–94.
10. Mahoney MC, Michalek AM, Cummings KM, Nasca PC, Emrich LJ. Cancer mortality in a northeastern native population. *Cancer.* 1989;64:187–190.
11. Lanier AP, Bulkow LR, Ireland B. Cancer in Alaskan Indians, Eskimos, and Aleuts, 1969–83: implications for etiology and control. *Public Health Rep.* 1989;104:658–664.
12. Lanier AP, Blot WJ, Bender TR, et al. Cancer in Alaskan Eskimos and Aleuts. *JNCI.* 1980;65:1157–1159.
13. Frost F, Taylor V, Fries E. Racial misclassification of Native Americans in a Surveillance, Epidemiology, and End Results cancer registry. *JNCI.* 1992;84:957–961.
14. Horner RD. Cancer mortality in Native Americans in North Carolina. *Am J Public Health.* 1990;80:940–944.
15. Sievers ML, Fisher JR. Cancer in North American Indians: environment versus heredity. *Am J Public Health.* 1983;73:485–487.
16. Sievers ML, Fisher JR. Diseases of North American Indians. In: Rothschild HR, ed. *Biocultural Aspects of Disease.* New York, NY: Academic Press; 1981:228.
17. Hampton JW. The heterogeneity of cancer in Native American populations. In: Jones L, ed. *Minorities and Cancer.* New York, NY: Springer-Verlag; 1989.
18. Devor EJ, Buechley RW. Gallbladder cancer in hispanic New Mexicans. *Cancer.* 1980;45:1705–1712.
19. Sorem KA. Cancer incidence in the Zuni Indians of New Mexico. *Yale J Biol Med.* 1985;58:489–496.
20. Wiggins CL, Becker TM, Key CR, Samet JM. Stomach cancer among New Mexico's American Indians, Hispanic Whites, and non-Hispanic Whites. *Cancer Res.* 1989;49:1595–1599.
21. Morris DL, Buechley RW, Key CR, Morgan MV. Gallbladder disease and gallbladder cancer among American Indians in tricultural New Mexico. *Cancer.* 1978;42:2472–2477.
22. Schaefer O, Hildes JA, Medd LM, Cameron DG. The changing pattern of neoplastic disease in Canadian Eskimos. *Can Med Assoc J.* 1975;112:1399–1404.
23. Black WC, Key CR. Epidemiologic pathology of cancer in New Mexico's tri-ethnic population. *Pathol Ann.* 1980;15:181–194.
24. Alberts SR, Lanier AP. Leukemia, lymphoma, and multiple myeloma in Alaskan natives. *JNCI.* 1987;78:831–837.
25. Creagan ET, Fraumeni JF. Cancer mortality among American Indians, 1950–67. *JNCI.* 1972;49:956–967.
26. Mahoney MC, Michalek AM, Cummings KM, Nasca PC, Emrich LJ. Cancer surveillance in a northeastern Native American population. *Cancer.* 1989;64:191–195.
27. Samet JM, Key CR, Kutvirt DM, et al. Respiratory disease mortality in New Mexico's American Indians and Hispanics. *Am J Public Health.* 1980;70:492–497.
28. Mao Y, Morrison H, Semenciw R, et al. Mortality on Canadian Indian reserves 1977–1982. *Can J Public Health.* 1986;77:263–268.
29. Boss LP, Lanier AP, Dohn PH, et al. Cancers of the gallbladder and biliary tract in Alaskan natives: 1970–79. *JNCI.* 1982;69:1005–1007.
30. *Trends in Indian Health: 1989.* Rockville, Md: Indian Health Service; 1989.
31. *1980 Census. Characteristics of American Indians by Tribes and Selected Areas: 1980.* Washington, DC: US Dept of Commerce; 1980. Publication PC80-2-1C.
32. Armitage P, Berry G. *Statistical Methods in Medical Research.* Oxford, England: Blackwell Scientific Publications; 1987:117, 401.
33. Black WC, Key CR, Carmany TB, Herman D. Carcinoma of the gallbladder in a population of southwestern American Indians. *Cancer.* 1977;39:1267–1279.
34. Lowenfels AB, Linstrom CG, Conway MJ, Hastings PR. Gallstones and risk of gallbladder cancer. *JNCI.* 1985;75:77–80.
35. Blum RW, Harmon B, Harris L, Bergeisen L, Resnick MD. American Indian-Alaska Native youth health. *JAMA.* 1992;267:1637–1644.
36. Goldberg HI, Warren CW, Oge L, et al. Prevalence of behavioral risk factors in two American Indian populations in Montana. *Am J Prev Med.* 1991;7:155–160.
37. Sugarman JR, Warren CW, Oge L, Helgerson SD. Using the Behavioral Risk Factor Surveillance System to monitor year 2000 objectives among American Indians. *Public Health Rep.* 1992;107:449–456.
38. Nutting PA. Breast cancer screening: examining options for clinical policy. In: Nutting PA, Carney JP, Helgerson SD, eds. *Preventable Cancer Mortality in American Indian and Alaskan Native Women.* Tucson, Ariz: Office of Health Program Research and Development, Indian Health Service; 1990.
39. Byrd RS, Nutting PA, Lentzner HR. Validity and completeness of hospitalization data for stroke in two Indian Health Service areas. Presented at the Epidemiologic Intelligence Service Conference, April 1991, Atlanta, Ga.
40. Porter JB, Walker AM, Jick H. Cancer of the breast, colon, ovary, and testis in the United States: rates 1970–78 from a hospital reporting system. *Am J Public Health.* 1984;74:585–588.
41. Toniolo P, Pisani P, Vigano C, Gatta G, Repetto F. Estimating incidence of cancer from a hospital discharge reporting system. *Rev Epidemiol Sante Publ.* 1986;34:23–30.
42. Centers for Disease Control. Hospital discharge rates for four major cancers—United States, 1970–1986. *MMWR.* 1988;37:585–588.
43. Institute of Medicine. *Reliability of Hospital Discharge Abstracts.* Washington, DC: National Academy Press; 1977.
44. Demlo LK, Campbell PM. Improving hospital discharge data: lessons from the National Hospital Discharge Survey. *Med Care.* 1981;19:1030.