Based on data from the Connecticut Tumor Registry this report offers trends for the incidence of cancer over a period of thirty years (1935-1965). Findings are reported and a comparison is made of the Connecticut data with that from Alameda County, California.

Analysis of Trends in Age-Adjusted Incidence Rates for 10 Major Sites of Cancer

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Introduction

An important component in the descriptive epidemiology of cancer is the variation in disease frequency over time. Secular changes in cancer incidence often stimulate the formulation of causal hypotheses. For administrative purposes trends can be extrapolated to provide information on the future size of the cancer problem.

Some of the more striking secular changes in cancer occurrence, such as the increase in lung cancer among men and the decrease in stomach cancer among both sexes, are readily apparent in data sets covering rather brief periods of time. In order to detect more subtle secular changes it is necessary to study trends over a period of several decades. Because death from cancer reflects the efficacy of treatment as well as the rate of occurrence, incidence rates are preferred to mortality rates when studying temporal changes in the occurrence of the disease.

This report is based on data from the Connecticut Tumor Registry. It is well-suited for the analysis of long-term time trends. The incidence of cancer among residents of the State of Connecticut has been accumulated by the Registry beginning with the year 1935. For comparative purposes, Connecticut cancer mortality rates are also presented based on cancer deaths enumerated by the Public Health Statistics Section of the Connecticut State Department of Health.

Material

The Connecticut Tumor Registry attempts to collect information on all newly diagnosed cases of cancer among residents of the state. Information is received primarily from hospitals, on a voluntary basis. In addition, all death certificates mentioning cancer are forwarded to the Registry by the Public Health Statistics Section and matched against the file of cases in the Registry. Deaths that are not registered and for which no additional information is obtained (e.g., from queries to the certifying physician) are included in the Registry as "death certificate only" cases. The year of death is considered to be the year of diagnosis. As shown in Table 1, the proportion of "death certificate only" cases registered as cancer in Connecticut has decreased steadily over time.

All diagnoses of cancer, whether microscopically confirmed or not, are included as incident cases. The proportion of microscopically confirmed cases has increased over time from 44% of the cases reported during the years 1935-38 to 86% during the years 1962-65.

Methods

Sex - and age-specific incidence rates were computed for 10 major primary sites of cancer for each year from 1935 to 1965, inclusive. These annual incidence rates were age-adjusted using the age distribution of the 1950 U.S. population as a standard.

To help detect any changes in the age-adjusted incidence rates between the first and second halves of this 1935-65 time period, linear least-square regressions were fitted to the 16 rates for 1935-50 and also to the 16 rates for 1950-65 (the rate for 1950 was included in both analyses as a matter of convenience in order to have time periods of equal length). The annual change in the incidence rates and the difference in this change between the 2 time periods, as measured by the slopes of the 2 regression lines, were tested for statistical significance by "t" tests. Those "t" values that would occur by chance with a probability of less than 0.001

Table 1—Sources of Cancer Cases Reported to the Connecticut Tumor Registry by Sex and Selected Periods of Diagnosis

	1935-1938		1950-1953		1962-1965	
	Male	Female	Male	Female	Male	Female
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Hospital	60.0	62.5	83.4	87.1	94.3	95.6
Live	59.6	62.4	82.0	86.7	89.7	93.6
Autopsy	0.4	0.1	1.4	0.4	4.6	2.0
Death Certificate	40.0	37.5	16.6	12.9	5.7	4.4

are termed "highly significant" and those with a probability of 0.001 or greater but less than 0.05 are termed "significant."

To facilitate the presentation of the data, the 31 annual rates were condensed into 8 time periods by forming unweighted averages of 4 consecutive annual age-adjusted rates for each sex and primary site subgroup (the rates for the year 1950 were included in both the 1947-50 and the 1950-53 time periods for the convenience of having 8 time periods, all covering 4 years). Mortality rates were treated similarly although data prior to 1940 were not included due to changes that occurred at that time in the classification of cancer deaths by primary site.

Trends in age-adjusted incidence and mortality were graphed on semi-log paper so that the rate of change in the rates could be readily examined.

Results

Stomach Cancer

The incidence of stomach cancer decreased steadily for both sexes over the entire study period 1935-65 (Table 2 and Figure 1). Within each half of the study period, the negative slopes of the regression lines were highly significant for both sexes (Table 3). The slopes for the years 1935-50

Table 2—Age-Adjusted Incidence Rates Per 100,000 By Primary Site, Sex and Period of Diagnosis, Connecticut, 1935-1965[1]

ICD No.	Primary Site	Sex	Period of Diagnosis 1935-38	1939-42	1943-46	1947-50	1950-53	1954-57	1958-61	1962-65
151	Stomach	M	36.0	31.3	29.0	28.7	26.2	22.4	20.3	17.5
		F	21.8	19.0	15.7	15.7	12.7	11.5	10.5	8.3
153	Large Intestine	M	19.7	21.2	23.9	25.9	27.2	28.9	30.0	30.4
		F	22.8	23.3	26.1	29.5	28.6	29.9	28.3	30.0
154	Rectum	M	16.0	17.9	19.0	20.0	20.4	20.1	18.4	17.9
		F	12.2	12.9	12.1	14.3	14.2	13.2	13.4	11.9
162.1	Lung and Bronchus	M	9.5	13.7	17.2	25.2	32.4	40.5	46.7	48.0
		F	3.6	3.0	3.7	4.4	4.9	5.3	7.3	8.0
170	Breast	F	56.5	56.6	54.9	62.4	66.0	61.7	67.2	68.1
171	Cervix Uteri	F	22.0	18.6	19.1	22.5	22.6	25.1	28.2	34.7
172	Corpus Uteri	F	7.3	8.3	7.5	11.6	12.6	13.1	14.9	16.3
175.0	Ovary	F	11.4	13.2	11.3	13.5	13.0	13.9	14.0	12.8
177	Prostate	M	24.9	27.4	25.3	31.3	34.0	36.5	40.2	37.7
181.0	Bladder	M	10.7	11.7	11.9	16.9	17.5	19.2	20.3	21.6
		F	5.0	4.0	5.0	5.4	5.3	6.0	5.5	6.5

[1] Unweighted averages of annual age-adjusted rates which are adjusted to the U.S. population in 1950.

Sites are numbered according to the seventh revision (1955) of the International Classification of Diseases.

Table 3—Analysis of Linear Regression for Annual Age-Adjusted Cancer Incidence Rates By Primary Site and Sex, Connecticut, 1935-65

ICD NO.	Primary Site	Sex	1935-1950 b	1935-1950 r^2	1950-1965 b	1950-1965 r^2	Δb
151	Stomach	M	−0.61[2]	0.60	−0.68[1]	0.84	−0.07
		F	−0.55[2]	0.65	−0.36[1]	0.86	0.19
153	Large Intestine	M	0.52[1]	0.88	0.26[3]	0.47	−0.26[3]
		F	0.54[1]	0.74	0.06	0.05	−0.48[2]
154	Rectum	M	0.31[3]	0.40	−0.22[4]	0.34	−0.53[2]
		F	0.14	0.21	−0.20[4]	0.29	−0.34[3]
162.1	Lung and Bronchus	M	1.27[1]	0.94	1.31[1]	0.86	0.04
		F	0.07	0.21	0.29[1]	0.78	0.22[2]
170	Breast	F	0.42[4]	0.27	0.38	0.22	−0.04
171	Cervix Uteri	F	0.02	0.00	1.01[1]	0.85	0.99[1]
172	Corpus Uteri	F	0.31[3]	0.53	0.31[2]	0.61	0.00
175.0	Ovary	F	0.10	0.07	−0.01	0.00	−0.11
177	Prostate	M	0.47[3]	0.55	0.38[3]	0.41	−0.09
181.0	Bladder	M	0.46[2]	0.56	0.36[3]	0.53	−0.10
		F	0.06	0.11	0.09[4]	0.33	0.03

[1] $P < .0001$
[2] $0.0001 < P < 0.001$
[3] $0.001 < P < 0.01$
[4] $0.01 < P < 0.05$

b - coefficient of annual linear regression.
r^2 - square of the coefficient of correlation.
$\Delta b = b_{1950\text{-}65} - b_{1935\text{-}50}$

and 1950-65 were not significantly different. Male rates remained approximately twice as large as female rates over the entire study period.

Mortality rates for stomach cancer were only slightly lower than incidence rates (Table 4 and Figure 1).

Figure 1—Age-Adjusted Incidence and Mortality Rates per 100,000 for Cancer of the Stomach by Sex and Period of Diagnosis: Connecticut, 1935-1965

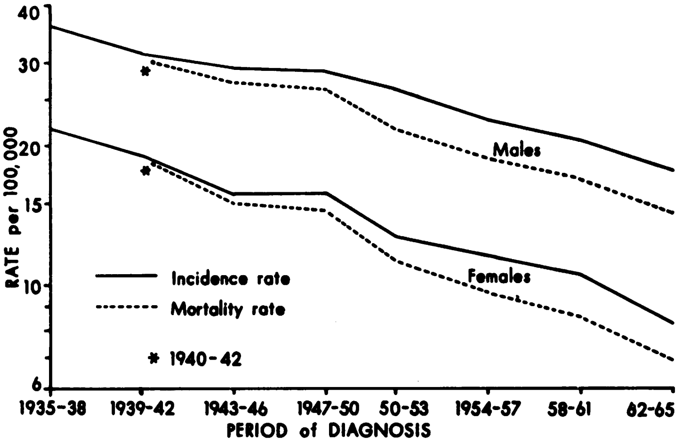
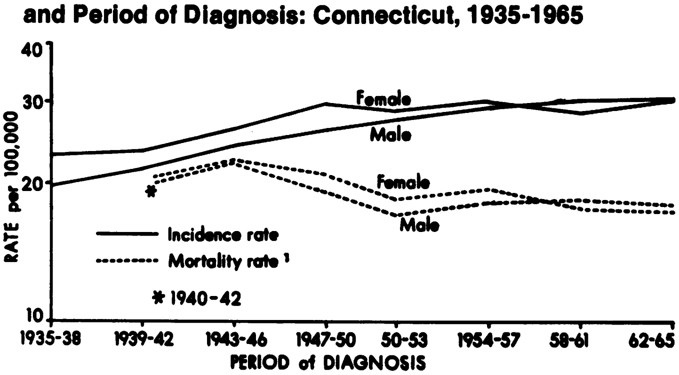
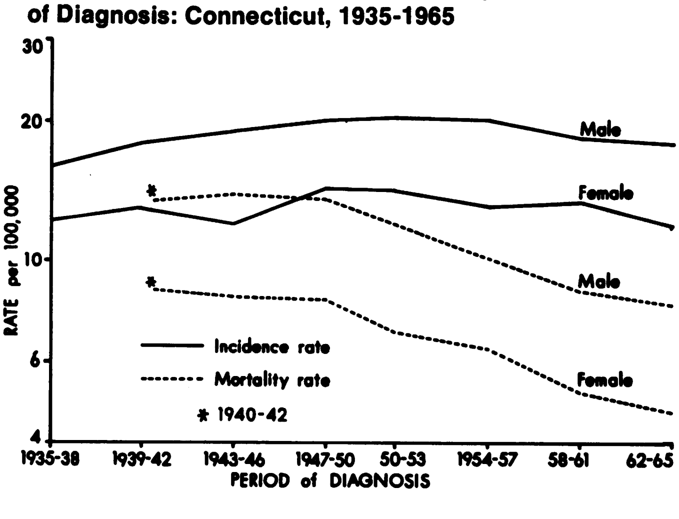


Figure 2—Age-Adjusted Incidence and Mortality Rates per 100,000 for Cancer of the Large Intestine by Sex and Period of Diagnosis: Connecticut, 1935-1965



[1]Includes small intestine, 1940-1948

Figure 3—Age-Adjusted Incidence and Mortality Rates per 100,000 for Cancer of the Rectum by Sex and Period of Diagnosis: Connecticut, 1935-1965



The small differential between incidence and mortality rates has increased somewhat over time.

Cancer of the Large Intestine

The incidence of cancer of the large intestine showed a highly significant increase over the first half of the study period for both sexes (Tables 2 and 3 and Figure 2). The rates for males continued to increase significantly over the second half of the study period, although at a slower rate, while the female rates remained at a nearly constant level. Incidence rates for males and females have been at similar levels, with rates for females slightly higher than males except for the most recent years of the study period.

Mortality rates for cancer of the large intestine reached a peak around 1945 for both sexes, then decreased to levels in the early 1950s that have changed only slightly (Table 4 and Figure 2).

Rectal Cancer

The incidence of rectal cancer increased slightly during the years 1935-50 then decreased slightly during the years 1950-65 for both sexes (Table 2 and Figure 3). The differences in the regression coefficients, which were positive in the first half and negative in the second half of the study period, were highly significant for males and significant for females (Table 3). Male rates were about half again as large as female rates during the entire study period.

Mortality rates for cancer of the rectum were relatively constant during the 1940s, then decreased steadily during the subsequent years under study, and at a more rapid rate than the incidence rates (Table 3 and Figure 3).

Lung Cancer

The incidence of lung cancer among males increased over time more rapidly than for any other primary site under investigation (Table 2 and Figure 4). The large positive slopes of the regression lines for the first and second halves of the study period were both highly signficant and of about equal magnitude (Table 2).

For females, the incidence rate showed a highly significant increase in the second half of the study period (Table 3). Since the early 1940s, the rate of increase for female lung cancer has been rather constant and since the late 1950s has even surpassed the rate of increase for male lung cancer (Figure 4). Since the early 1950s, male incidence rates for lung cancer have been at least 6 times as large as the rates for females.

Mortality rates for lung cancer closely paralleled incidence rates, testifying to the particularly poor prognosis for this disease.

Female Breast Cancer

The incidence of breast cancer among women increased somewhat over time, but the pattern was irregular (Table 2 and Figure 5). The coefficient of linear regression was significant in the first half of the study period and, although of nearly the same magnitude in the second half, it was not significant (Table 3). Linear regression was able to account for only about one-quarter of the total variation in the rate in each half of the study period.

Mortality rates for breast cancer, after a decrease from 1940-42 to 1943-46, have been nearly constant since the mid 1940s (Table 4 and Figure 5).

Uterine Cancer

The incidence of uterine cervix cancer (including carcinoma in situ) was relatively constant over the first half of the study period but showed a highly significant increase during the second half of the study period (Tables 2 and 3 and Figure 6). For the most part the increase represented increased numbers of in situ cases, undoubtedly reflecting to a great part the increased use of Pap screening throughout the state. In situ tumors accounted for 62% of all cervical cancer in 1962-65 as compared with only 15% in 1950-53.

A rising trend in the incidence rate of cancer of the uterine corpus was significant in the first period and highly significant in the second (Table 3). However, the increase may be more apparent than real because tumors which for-

Table 4—Age-Adjusted Mortality Rates Per 100,000 By Primary Site, Sex and Period of Diagnosis, Connecticut, 1940-1965[1]

ICD NO.	Primary site	Sex	Period of Diagnosis 1940-42	1943-46	1947-50	1950-53	1954-57	1958-61	1962-65
151	Stomach	M	29.9	27.1	26.2	21.6	18.6	16.8	14.3
		F	18.2	14.9	14.4	11.3	9.7	8.6	6.9
153	Large intestine[2]	M	19.8	21.9	19.1	17.1	18.1	18.4	17.9
		F	20.5	22.3	20.9	18.5	19.4	17.6	17.4
154	Rectum	M	13.4	13.9	13.6	12.0	10.2	8.6	8.0
		F	8.6	8.3	8.2	7.0	6.4	5.2	4.7
162,163	Lung and bronchus[3]	M	13.0	16.2	23.4	28.1	33.7	38.2	41.1
		F	3.5	4.2	4.5	5.0	4.7	5.7	6.4
170	Breast	F	31.9	27.7	29.0	28.0	28.3	26.3	27.9
171-174	Uterus	F	22.1	20.0	17.9	15.3	13.6	11.5	9.7
175	Ovary[4]	F	10.0	8.5	10.0	9.8	10.2	9.5	9.3
177	Prostate	M	20.3	16.9	17.7	17.2	16.1	16.2	15.5
181	Bladder[5]	M	7.6	6.8	8.6	8.0	7.4	7.3	6.2
		F	2.9	3.2	2.9	2.4	2.5	2.3	2.0

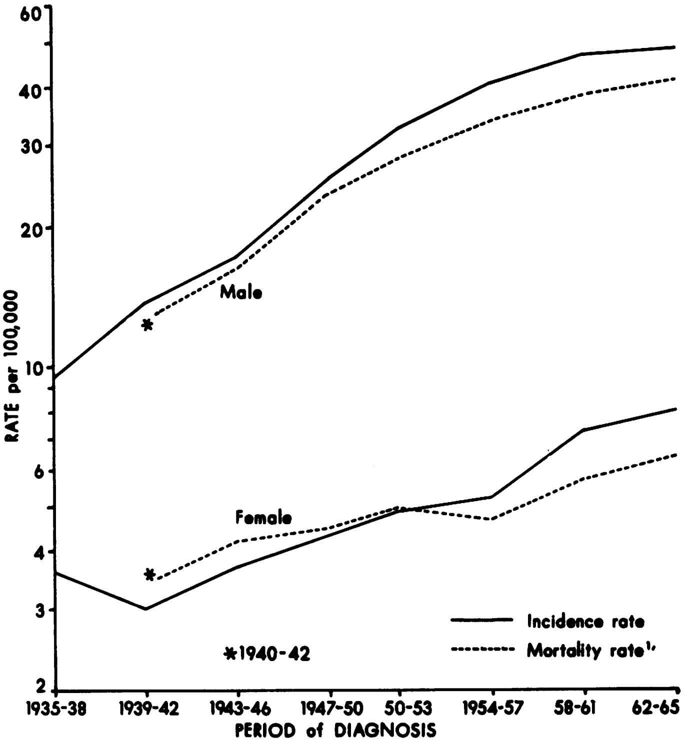
[1] Unweighted averages of annual age-adjusted rates which are adjusted to the U.S. population in 1950.
[2] Includes small intestine 1940-1948.
[3] Includes trachea and cases unspecified primary or secondary.
[4] Includes fallopian tube and broad ligament 1949-1965.
[5] Includes other urinary organs except kidney 1949-1965.

Table 5—Age-Adjusted Incidence Rates Per 100,000 By Primary Site, Sex and Period of Diagnosis, Connecticut and Alameda County, California, 1960-1965[1]

ICD No.	Primary Site	1960-62 Conn.	1960-62 Alameda County Calif.[2]	1963-65 Conn.	1963-65 Alameda County Calif.[2]
		Males			
151	Stomach	20.3	17.2	16.8	16.5
153	Large Intestine	29.2	26.1	30.6	27.7
154	Rectum	17.1	17.8	18.5	17.7
162.1	Lung and Bronchus	46.4	49.8	48.5	55.4
177	Prostate	39.3	39.0	38.0	50.5
181.0	Bladder	19.5	20.7	22.5	20.5
		Females			
151	Stomach	10.1	8.2	7.9	8.5
153	Large Intestine	28.4	25.8	30.4	27.2
154	Rectum	11.6	11.5	12.1	10.9
162.1	Lung and Bronchus	7.0	7.9	8.4	9.6
170	Breast	66.2	69.2	69.4	73.1
172	Corpus Uteri	14.7	19.3	17.1	19.9
175.0	Ovary	14.1	14.5	12.5	12.2

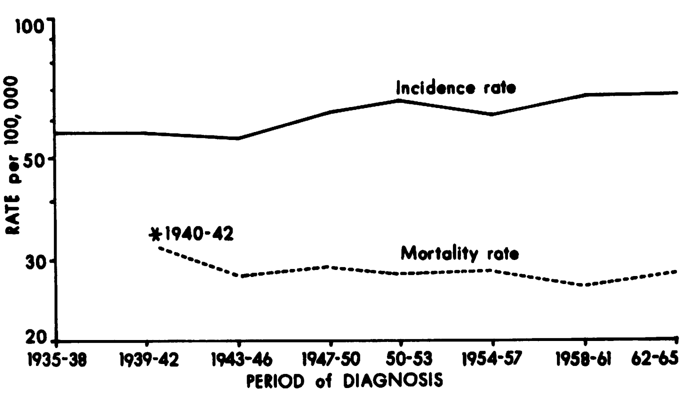
[1] Age-adjusted to the U.S. population in 1950.
[2] White population only.

Figure 4—Age-Adjusted Incidence and Mortality Rates per 100,000 for Cancer of the Lung and Bronchus by Sex and Period of Diagnosis: Connecticut 1935-1965



[1]Includes trachea and deaths unspecified primary or secondary

Figure 5—Age-Adjusted Incidence and Mortality Rates per 100,000 for Cancer of the Female Breast by Period of Diagnosis: Connecticut, 1935-1965



merly occupied the category of "uterus, not otherwise specified" appear to have been designated as uterine corpus in later years. When the two rates are combined little change in the rate is noted throughout the period.

Mortality for total uterine cancer decreased steadily from 1940 through 1965 (Table 4 and Figure 6). This reflects in part a decline in the incidence rate of invasive cervical cancer.

Ovarian Cancer

The incidence of ovarian cancer varied somewhat but showed an essentially level trend throughout the study

Figure 6—Age-Adjusted Incidence and Mortality Rates per 100,000 for Cancer of the Uterus by Period of Diagnosis: Connecticut, 1935-1965

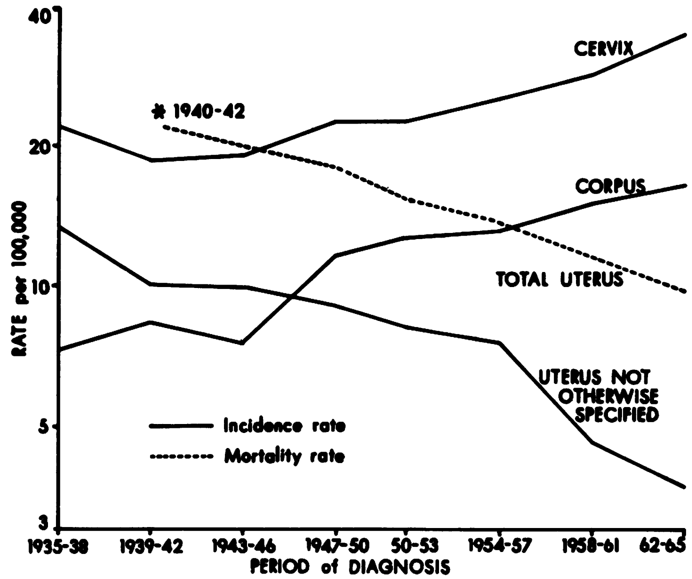
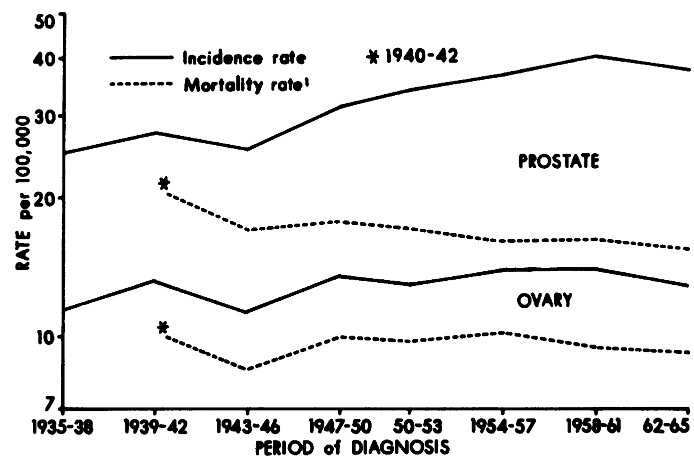


Figure 7—Age-Adjusted Incidence and Mortality Rates per 100,000 for Cancer of the Ovary and Prostate by Period of Diagnosis: Connecticut, 1935-1965



[1]Ovary includes fallopian tube and broad ligament deaths, 1949-1965

period (Table 2 and Figure 7). Mortality had the same irregularly level pattern throughout.

Cancer of the Prostate

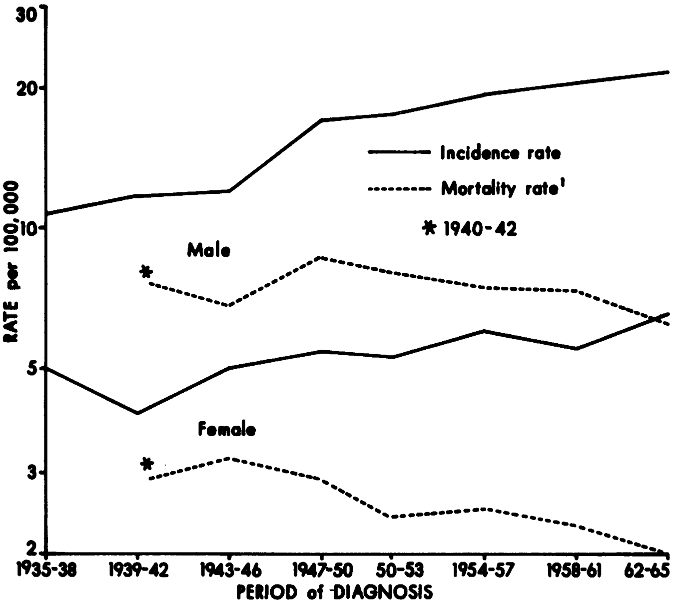
There was a significant increase in the incidence of cancer of the prostate in the periods 1935-50 and 1950-65 (Tables 2 and 3 and Figure 7).

A moderate decline occurred in the mortality rates during the study years (Table 4).

Cancer of the Bladder

A highly significant rise in the incidence of cancer of the bladder in males occurred in the period 1935-50

Figure 8—Age-Adjusted Incidence and Mortality Rates per 100,000 for Cancer of the Bladder by Sex and Period of Diagnosis: Connecticut, 1935-1965



Includes other urinary organs except kidney, 1949-1965

(Tables 2 and 3 and Figure 8). Significant increases were noted in both sexes for the second study period, 1950-65.

Despite the upturn in the incidence rates, mortality rates for both males and females declined in the period 1950-65.

Connecticut and California

It is of interest to compare Connecticut incidence rates with those from other areas in the United States. However, valid comparisons are difficult to make because not all sources reporting cancer incidence rates use the same procedures and definitions for the collection and analysis of the data. Accordingly, the only comparison made is with the data from Alameda County, California, for the years 1960-1965.[1] The total population of Alameda County was 955,000 in 1962 with about 84% white and the total Connecticut population in the same year was 2,663,000 with about 96% white. Accordingly, only data for the white population of Alameda County is used in the comparison. The Alameda County and the Connecticut registries generally use the same criteria for inclusion and exclusion of cases and the methodologies in the collection, coding, and analysis of the data are similar. Because the Alameda County registry does not include any in situ cancers, data for cancer of the cervix is not included in the comparison.

Table 5 shows that for most sites there was marked similarity in the incidence rates from the two registries for the 1960-62 and 1963-65 time periods.

California had a higher incidence of cancer of the lung and bronchus in males for both periods with a marked increase over the Connecticut rate in the second period. The rate of cancer of the prostate was also greatly increased in California as compared to Connecticut in the second period despite similar percentages of cases diagnosed at autopsy and by means of the death certificate only in each state.

Incidence rates for cancer in females did not vary greatly between registries.

Discussion

The decrease in the incidence of stomach cancer with no apparent cause raises the question of whether the decrease is a real one or is due to more accurate diagnoses in the later years of study. It has been pointed out by Gordon, Crittendon and Haenszel with respect to stomach cancer mortality rates, that if the latter was actually the case, the most likely possibility would be the erroneous assignment of intestinal cancers to the stomach.[2] Only 21% of stomach cancers and 38% of large intestinal cancers were microscopically confirmed in 1935-39 while in 1965, the corresponding figures were 75% and 90%. The opportunity for more accurate diagnoses with the passage of time is apparent.

Changes in the incidence rates for these two sites were only in part compensating, however. Furthermore, the hypothesis of compensating changes in the incidence of stomach and large intestine is not supported by changes in the age-specific rates of these two sites. The present authors therefore conclude that the decrease in incidence of stomach cancer cannot in large part be explained by increased incidence of large intestine cancer due to incorrect case assignments in the earlier years. This conclusion is similar to that reached by Gordon, Crittendon and Haenszel concerning stomach cancer mortality.[3]

Although deaths from cancer of the small intestine were included with those from cancer of the large intestine in computing mortality rates for the years 1940-48, this is unlikely to account for the higher rates found during the first half of the study period. In subsequent years only 2% of all deaths from intestinal cancer were assigned to the small intestine.

For several of the major sites including large intestine, breast, prostate, bladder and uterus there were contrasting trends in the incidence and mortality rates from the early 1940s to the 1960s with the former rate rising and the latter rate decreasing.

Mortality rates are influenced by changes in rates of survival as well as by changes in incidence rates. Although it is difficult to evaluate the effects of changes in survival rates on mortality rates because of time and other factors, at least some of the decline in breast, colon, uterine, prostate and bladder cancer mortality can be attributed to improvement in survival rates which occurred for cases diagnosed in the 1940s and 1950s.[4]

The incidence rates for cancer of the rectum and of the ovary showed little net change from the first period of diagnosis, 1935-38, to the latest period, 1962-65. However, rectal cancer and, to a lesser extent, ovarian cancer increased in the intervening periods of diagnosis.

Although the incidence rate for male cancer of the lung and bronchus rose in each period of diagnosis, the percentage increases in the rate have been progressively smaller since the 1947-50 period. The incidence rate curve continues to rise but at a decreasing rate. By contrast, the upward curve for females shows no sign of levelling off.

Summary

During the period 1950-65, there were statistically significant average annual increases in the age-adjusted incidence rates for cancer of the large intestine, bronchus and lung, prostate and bladder among males; for cancer of the bronchus and lung, cervix, corpus and bladder among females; and significant decreases in cancer of the stomach and rectum among both sexes. The increases for cancer of the bronchus and lung, cervix and corpus and the decrease for stomach cancer were all highly significant. The increase in cancer of the corpus was associated with a decline in the incidence of uterine cancer "not otherwise specified." Female breast cancer also showed a rising trend in the 1950-65 period.

For the most part, the incidence rate trends in 1950-65 represented continuations of the trends in the 1935-50 period for the 10 sites studied. Cancer of the large intestine showed a highly significant increase for both sexes in the 1935-50 period as did bladder cancer among males. Cancer of the rectum, which increased for both sexes and cervical cancer, which was nearly stable, displayed markedly different trends in the 1935-50 diagnosis period as compared to the later period.

While mortality rates generally followed the trends in the incidence rates, there were decreases in the mortality rates for large intestine, breast, uterine, bladder and prostatic cancer in spite of increased incidence rates for these sites.

A comparison of the Connecticut data with that from Alameda County, California showed many similarities. There were differences noted for cancer of the prostate and lung and bronchus in males.

References

1. California Tumor Registry. Unpublished cancer incidence data. Berkeley, Calif.: State of Calif. Dept. of Public Health, 1970.
2. Gordon, T.; Crittendon, M.; and Haenszel, W. Cancer Mortality Trends in the United States, 1930-1955. In: End Results and Mortality Trends in Cancer. N.C.I. Monograph No. 6. Washington, D.C.: U.S. Dept. of Health Education and Welfare, 1961.
3. Ibid.
4. Eisenberg, H.; Sullivan, P.D.; and Connelly, R. R. Cancer in Connecticut, Survival Experience, 1935-1962. Hartford, Conn.: Conn. State Dept. of Health, 1968.

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Erratum

The paper Oral Contraceptive Use in Patients with Thromboembolism following Surgery, Trauma, or Infection, by G. R. Greene, M.D., M.P.H., and P. E. Sartwell, M.D., M.P.H., Vol. 62, No. 5, was supported by the Food and Drug Administration, Contract Number FDA 67-10; the Family Planning Evaluation Activity of the Epidemiology Program, Center for Disease Control, Atlanta, Georgia; and the Population Council, through Grant Number M68.06.