Cancer Incidence and Trihalomethane Concentrations in a Public Drinking Water System

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Abstract: Four thousand two hundred fifty-five cases of esophageal, stomach, colon, rectal, bladder, and pancreatic cancer reported from Erie County, NY between 1973 and 1976 were analyzed in terms of their relationship to type of water source, level of trihalomethane (THM) and various social and economic parameters. Among white males, a significant positive correlation existed between pancreatic cancer incidence rates and THM level. No other significant correlations were observed. This research lends little or no support to the hypothesis that THM levels which meet present standards are related to the incidence of human cancer. (*Am J Public Health* 70:523-525, 1980.)

Introduction

Epidemiologic and experimental studies have supported the hypothesis of a positive relationship between halomethanes, by-products of the chlorination process, found in public drinking water and cancer occurrence. Chlorine, a halogen added to water as a control of microbial contamination, readily reacts with naturally occurring humic substances to form various trihalomethane (THM) species. A comprehensive review of the literature regarding these substances and their cancer causing potential has recently been reported elsewhere.[1] In general, previous epidemiologic research, necessarily ecological, has been based on cancer mortality rather than incidence, has considered large and diverse geographic areas, and has inferred trihalomethane level through indirect measurement. In the present research, we sought to determine whether directly measured THM levels, in a geographically limited area, are related to the incidence of cancer. We have utilized existing health and environmental monitoring data.

Methods

This investigation considered 4,255 cases of esophageal, stomach, colon, rectal, bladder, and pancreatic cancers reported from Erie County to the New York State Tumor Reg-

istry between 1973 and 1976. Two hundred seventy-eight patients (6.1 per cent) with incomplete residential data were not included in the analysis. The dependent variables in our analyses were the age-adjusted incidence rates by census tract for each site for the total population and each sex-color subgroup. Census tracts with observed rates greater than three standard deviations above the mean of all tracts were eliminated from specific analyses as outliers. Also eliminated were census tracts with unstable populations such as those with large hospitals or universities. There were nine such tracts out of a total of 218. The New York State Bureau of Public Water Supply and the Erie County Department of Health provided information on water quality. Several tract-specific indicators were constructed from 1970 census information to control for socioeconomic factors which might confound possible water quality-disease relationships.

The data were studied by correlations and multiple regressions of the water quality measures and control variables on the age-adjusted incidence rates. Initial observation suggested that the variables for prefiltration chlorine dose, chloroform, and total trihalomethane were highly intercorrelated ($r \geq .90$) and were likely to be measuring the same ecologic phenomena. For this reason, only total trihalomethane was included in the multivariate analyses. Only those variables suspected on the basis of previously published reports to be involved in the etiology of a given site of disease were included in the particular multiple regression. Thus, for example, the proportion of bluecollar employment was considered in the case of bladder cancer but not in other diseases.

Results

In Table 1, the zero-order relationships between cancer incidence and both the water quality and control variables for the total population are presented. While surface water was significantly associated with the incidence of cancers of the esophagus and pancreas, actual levels of THM were not significantly associated with incidence of any site of cancer studied here.

To control for interrelationships between the independent variables which might mask greater effects of the water quality variables on incidence rates, the regressions represented in Table 2 were performed. These analyses indicate that the relationships suggested in the previous Table are undiminished by controlling for possible confounding by other variables. With respect to water quality, the type of source was a significant predictor of esophageal and pancreatic cancer incidence; however, no significant effects for varying THM concentrations were observed.

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TABLE 1—Pearson Correlation Coefficients, Age-Adjusted Cancer Incidence Rates with Social, Economic, and Water Quality Variables, Total Population

Variable	Esophagus	Stomach	Colon	Rectum	Bladder	Pancreas
¹Socioeconomic Status	−.32*	−.10	.13	.08	—	—
²Mobility	−.04	−.10	−.02	.09	−.08	−.06
Per Cent Nonwhite	.34*	−.02	—	—	—	−.01
³Occupation	—	—	—	—	.23*	—
⁴Urbanicity	—	—	—	—	.04	—
⁵Water Source Type	−.16*	−.07	−.06	−.01	.02	−.16*
⁶Total THM	.06	.09	.06	.09	.13	.11

*all values greater than .14 p < .05.

1) measured by median family income, per cent of population employed, and median years of education completed.

$$2) \quad \frac{\text{number of persons moving into a census tract before 1959}}{\text{total number of persons reporting year moved into tract}} \times 100$$

3) number of individuals reporting high exposure potential occupations

$$\frac{\text{(craftsmen, kindred workers, operatives, laborers, and service workers)}}{\text{total number of individuals reporting occupation}}$$

$$4) \quad \frac{\text{number of persons reporting urban residence}}{\text{total number of persons reporting urban or rural residence}} \times 100$$

Urban residence was designated as living in a city within the Standard Metropolitan Statistical Area.

5) Surface (lake, river, reservoir), ground (well, spring).

6) The amount of THM compounds measured in water samples taken at the treatment plants in July 1978 (range 0-71 ppb, mean 46 ppb).

We repeated these analyses for White males only, White females only and for nonwhites. The only difference evident in these analyses not found in the total population analyses was the finding of a significant correlation (r = .16) between THM concentrations and pancreatic cancer among White males. This relationship persisted (b = .17) when this group was analyzed by the same multiple regression procedure employed above.

Discussion

We have regarded an association as a relationship having the probability of occurring by chance alone of less than five per cent. Applying this standard, this research has re-

vealed positive associations between surface water as a water supply source and the incidence of esophageal and pancreatic cancer, and between THM concentrations and the incidence of pancreatic cancer among White males. These positive findings, however, must be regarded as tentative for a number of reasons. The surface water-esophageal cancer link has been reported previously,[1] but only ten per cent of the census tracts investigated here received ground water and the relationship may be confounded in a number of ways which we have not been able to control. The absence of any association of this variable with the majority of other sites studied also casts doubt on the meaning of those associations.

Perhaps, the positive association between THM concentrations and pancreatic cancer among White males

TABLE 2—Standardized Regression Coefficients, Age-Adjusted Cancer Incidence Rates with Social, Economic, and Water Quality Variables, Total Population

Variable	Esophagus	Stomach	Colon	Rectum	Bladder	Pancreas
Socioeconomic Status	−.18*	−.03	.14	.09	—	—
Mobility	−.04	−.12	−.01	−.08	−.06	−.06
Per Cent Nonwhite	.26*	−.07	—	—	—	−.02
Occupation	—	—	—	—	.20*	—
Urbanicity	—	—	—	—	.02	—
Water Source Type	−.13*	−.06	−.07	−.03	.03	−.15*
Total THM	.07	.09	.06	.07	.11	.10
R	.40*	.14	.15	.13	.29*	.12
R square	.16	.02	.02	.02	.08	.01

*p ≤ .05
R = multiple correlation coefficient
R square = variance explained

should be investigated more fully; however, the absence of association between THM concentrations and incidence of other cancers and the additional problem of lack of association between THM concentrations and pancreatic cancer in any other sex- or race-specific group raises doubts as to the validity of this finding. Since ecological studies are theoretically biased toward Type I error, there is the distinct possibility that this finding is a spurious product of confounding by unmeasured variables.

Concurrent with the Type I bias, is a lower probability of missing a true association. Given a sound methodology, this no-effect phenomenon could be due to the modest range of THM values (71 ppb) or to factors actually inhibiting the disease process; an actual association might be masked by a competing risk, (e.g., the population has a high incidence of another disease which diminishes the susceptibility pool for these cancers, or a competing exposure, or the environmental "noise" in Erie County is too great to allow the surfacing of a modest THM effect).

One must also add that information gathered from disease registries is subject to biases such as differences in pathological diagnosis, and incomplete reporting or noncompliance, and that the site-specific age-adjusted incidence rates by census tract are subject to substantial variability since many rates are based on few cases and the occurrence of one or two tumor cases in a particular census tract greatly influences the incidence rate. Furthermore, use of adjusted rates glosses over associations that may be present in specific categories. Measurements of the independent variables were taken after the appearance of the diseases and, although chlorination practices in Erie County have not changed appreciably in four decades, this theoretically does not account for the long latency period usually associated with cancer. Patterns of population migration out of Erie County have not been quantified and differential migration by water quality could be a source of bias due to incomplete cohort followup.

On the other hand, this research does not present methodology inferior to previous research reporting positive associations, and in some ways it may be considered more refined.

REFERENCE
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Evaluation of Utilization of Laboratory Tests In a Hospital Emergency Room

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Abstract: Visits to a metropolitan teaching hospital emergency room were evaluated for laboratory test utilization and quality of care by chart review. Of 630 tests, 197 (32 per cent), clustered in 44 out of 476 (9 per cent) patient visits, were considered unnecessary. The number of tests per visit showed a strong negative correlation with the necessity of tests and with the quality of care. Results suggest the usefulness of identifying a subgroup of patients with excessive tests and implementing measures to alter testing behavior for this subgroup. (Am J Public Health 70:525–528, 1980.)

The hospital emergency room (ER) has become an increasingly important source of ambulatory care for the community, often for patients with self-limited and non-urgent problems or for the "worried well."[1-4] There appears also to be a marked increase in the number of laboratory tests obtained in the ER, as in other areas of medical practice.[5-6] The phenomenon of excessive laboratory testing, well documented in hospitalized patients,[7-11] has received less attention in the ER setting. In this communication we report an analysis of utilization of laboratory tests in a metropolitan hospital ER.

Methods

We reviewed the charts of every fifth adult visit over a three-week period to the ER of a 700-bed teaching hospital. Without reference to the results of the tests, a panel of six reviewers (three senior resident physicians and three attending physicians in the Department of Medicine) evaluated each test performed with respect to: 1) necessity of the test