Bone Cancer Incidence Rates in New York State: Time Trends and Fluoridated Drinking Water

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ABSTRACT

Background: Recent animal studies of the potential carcinogenicity of fluoride prompted an examination of bone cancer incidence rates.

Methods: Trends in the incidence of primary bone cancers, including the incidence of osteosarcomas were examined among residents of New York State, exclusive of New York City. Average annual osteosarcoma incidence rates in fluoridated and non-fluoridated areas were also compared.

Results: Among persons less than 30 years of age at diagnosis, bone cancer incidence among males demonstrated a significant increase since 1955, while incidence among females has remained unchanged. A significant decrease in bone cancer incidence rates since 1955 was observed among both males and females age 30 years and over at time of diagnosis. Osteosarcoma incidence rates have remained essentially unchanged since 1970, among both younger and older males and females. The average annual age adjusted incidence of osteosarcomas (1976–1987) in areas served by fluoridated water supplies was not found to differ from osteosarcoma incidence rates in non-fluoridated areas.

Conclusions: These data do not support an association between fluoride in drinking water and the occurrence of cancer of the bone. (*Am J Public Health* 1991;81:475–479)

Introduction

Artificial fluoridation of public drinking supplies has resulted in an ongoing debate concerning the potential health effects of this practice. Proponents have emphasized the benefits to dental health from the artificial fluoridation of drinking water, while opponents have suggested that a variety of adverse health outcomes, including cancer, can result from this exposure.

Interest in the potential carcinogenicity of fluoride has resurfaced as a result of recently released findings from a National Toxicology Program (NTP) study of rodents with life-long exposures to fluoride. That study reported an increased incidence of osteosarcomas among male rats ingesting a high fluoride diet. Although the significance of these findings is unclear, the study has raised renewed questions about the association between fluoridated drinking water and bone cancers, particularly osteosarcomas, in human populations.

Several studies which have compared cancer mortality in fluoridated and non-fluoridated areas have determined that cancer mortality is unrelated to fluoride levels in drinking water.[1–6] However, the relationship between cancer incidence and fluoridated water has not been thoroughly examined. We were able to identify only two previous studies of cancer incidence and fluoridated water supplies.[1,7] Using data from the Second and Third National Cancer Surveys, Hoover *et al*,[1] compared cancer incidence for a fluoridated (Denver) and nonfluoridated metropolitan area (Birmingham). No significant differences in overall cancer incidence were apparent, nor were significant differences in bone cancer incidence observed. Kinlen and colleagues[7] reported no differences in the incidence of bone cancers among areas in England and Wales, and the United States, Holland, and New Zealand, with high and low fluoride levels in drinking water. An additional study of exposure to fluoride among an occupational cohort reported an elevated cancer incidence among exposed workers, attributable to an excess of respiratory cancers.[8] It is not possible to rule out smoking as the cause of this respiratory cancer excess since information on smoking histories was unavailable. No cases of bone cancer were reported in this study of occupational fluoride exposure.

Widespread artificial fluoridation of drinking water supplies in New York State began primarily during the 1950s and early 1960s. By analyzing data in the New York State Cancer Registry, it is possible to compare current bone cancer incidence rates with rates prior to widespread fluoridation. This paper presents data on time trends in bone cancer incidence, including the incidence of osteosarcomas, among residents of New York State, exclusive of New York City, and compares average annual osteosarcoma incidence rates in fluoridated and nonfluoridated areas.

Methods

The New York State Cancer Registry has been operational since 1940, when

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cancer became a reportable disease in NYS. Beginning in 1973, this population-based registry expanded coverage to include the New York City area, thereby encompassing all of NYS. While physicians, laboratories, and hospitals are required to report cancer cases, most cases in the NYS Cancer Registry and other cancer registries are reported by hospital tumor registrars and medical record administrators. Based on the results of special studies of hospital records, it is estimated that over 95 percent of all cancer cases in New York State, exclusive of New York City, are reported to the registry.[9]

Analyses were restricted to primary malignancies of the bone occurring among residents of New York State, exclusive of New York City, between 1955 and 1987. The New York City area was excluded due to lack of cancer data before 1973. Bone malignancies were coded to International Classification of Diseases, Ninth Revision (ICD-9),[10] site 170. Site 170 includes cancers of the bone and articular cartilage, but excludes carcinomas of any type other than intraosseous or odontogenic. Three separate comparisons of bone cancer incidence were undertaken.

The first comparison involved the calculation of average annual age-specific bone cancer incidence rates, between 1950 and 1987, for both males and females. Because of the distinct bimodal age pattern for bone cancers,[11] incidence rates were compared within two broad age categories: less than 30 years and 30 years and older at time of diagnosis. United States Census data were used to provide decennial (1960, 1970, 1980) population counts by age and sex for NYS,[12–14] while age- and sex-specific population estimates for intercensual years were furnished by the New York State Department of Health Bureau of Biometrics. Trends in incidence rates were evaluated by considering the slope of the regression line (t-test) using Statistical Analysis System (SAS) computer software.[15] Ninety-five percent confidence intervals for incidence rate ratios were calculated as described by Rothman.[16]

A second comparison involved the calculation of average annual age-specific osteosarcoma incidence rates, among males and females between 1970 and 1987. Histologic codes were assigned according to the Manual of Tumor Nomenclature and Coding[17] or more recently the International Classification of Diseases for Oncology.[18] Due to a different histologic classification scheme in use before 1970 it was not possible to distinguish histologic subtypes of bone cancers reported to the Registry prior to 1970. Trends in osteosarcoma incidence rates were also evaluated using the procedures described above.

Drinking water supplies in New York State contain no appreciable levels of naturally occurring fluoride. Thus, fluoridated water supplies are all artificially fluoridated. A third comparison evaluated average annual age-specific incidence rates for bone cancers and osteosarcomas, between 1976 and 1987, among males and females residing in fluoridated and nonfluoridated communities. Two metropolitan areas in New York State have maintained nonfluoridated drinking supplies: the City of Albany and Suffolk County.[19] Since less than 10 percent of the Nassau County population consumes fluoridated water, this metropolitan area was also considered to be nonfluoridated for the purposes of this study. Together, the 1980 population of these nonfluoridated areas (Albany, Suffolk County, Nassau County) was 2,707,540.[13] Since the nonfluoridated areas are urbanized communities, osteosarcoma incidence rates in these areas were compared with incidence in two groups of fluoridated communities: 1) counties located within standard metropolitan statistical areas (i.e. urbanized areas), and 2) counties not located within standard metropolitan statistical areas. Residents of nonmetropolitan areas are less likely to be served by a public water supply. Since these incidence rates were based on a limited number of cases (due to the infrequent occurrence of osteosarcomas), the standard error (SE) of each incidence rate was estimated by dividing the rate by the square root of the number of cases upon which it is based.[20]

Results

Between 1955 and 1987, 3,166 bone cancers were diagnosed among residents of New York State, exclusive of New York City (1,824 males, 1,292 females). About one-third (n = 1,100) of these cases occurred among persons less than 30 years of age at diagnosis (652 males, 448 females); 2,016 cases occurred among persons ages 30 and over at time of diagnosis (males 1,172, females 844).

Trends in Bone Cancer Incidence Rates

For bone cancers among persons less than 30 years of age at diagnosis, the slope of the regression line was significant among males ($p = 0.002$) with an observed increase in bone cancer incidence of 54 percent during the 1955–87 period. Among females (<30 years), bone cancer incidence increased 44 percent; however, the slope of the regression was not significant at the 5 percent level ($p = 0.07$). Further exploration of trends in bone cancer incidence among persons less than 30 years of age at time of diagnosis reveals that, relative to the period 1955–63, a significant increase in bone cancer incidence among males occurred only after 1969, while among females incidence was not significantly increased until the 1983–87 period (Table 1).

Bone cancer incidence rates among persons age 30 years and over at diagnosis show a significant decrease among both males (44 percent decrease, $p = 0.0001$) and females (33 percent decrease, $p = 0.0001$). Relative to incidence during the period 1955–1963, bone cancer incidence rates among males were significantly decreased during the period 1970–75 and thereafter (Table 1). Among females age 30 years and older at diagnosis, significant decreases in bone cancer incidence rates did not occur until after 1975.

Trends in Osteosarcoma Incidence Rates

Among persons less than 30 years of age at time of diagnosis, 196 and 113 osteosarcomas were diagnosed among males and females, respectively, between 1970 and 1987. While there was some variation in annual osteosarcoma incidence rates, between 1970 and 1987, among persons less than 30 years of age at diagnosis, the slope of the regression line was not significant among either males (16 percent increase, $p = 0.71$) or females (18 percent increase, $p = 0.45$). As shown in Table 2, osteosarcoma incidence rates did not differ significantly during three six-year periods between 1970 and 1987.

Between 1970 and 1987, 135 osteosarcomas were diagnosed among males and 103 osteosarcomas were diagnosed among females age 30 years or older at time of diagnosis. Based on the slope of the regression line, osteosarcoma incidence rates have been stable among both males (16 percent decrease, $p = 0.58$) and females (24 percent increase, $p = 0.29$) over 30 years of age at diagnosis. Osteosarcoma incidence rates did not differ significantly during three six-year periods between 1970 and 1987 (Table 2).

TABLE 1—Rate Ratios by Sex and Age at Diagnosis for Bone Cancer Incidence Rates per Million among Residents of New York State, Exclusive of New York City, 1955–87

	<30 Years at Diagnosis							
	Males				Females			
Year of Diagnosis	No.	Rate	RR*	(95% CI)**	No.	Rate	RR	(95% CI)
1955–1963	116	6.1	1.00		91	4.8	1.00	
1964–1969	111	7.3	1.20	(0.93, 1.56)	86	5.7	1.19	(0.88,1.60)
1970–1975	132	8.2	1.34	(1.04, 1.72)	88	5.5	1.15	(0.86,1.54)
1976–1981	156	10.0	1.64	(1.29, 2.10)	85	5.6	1.17	(0.87,1.57)
1982–1987	137	9.4	1.54	(1.22, 1.97)	98	6.9	1.44	(1.09,1.94)
t-test for trend:*** p = 0.002							p = 0.07	
	30+ Years at Diagnosis							
	Males				Females			
Year of Diagnosis	No.	Rate	RR	(95% CI)	No.	Rate	RR	(95% CI)
1955–1963	392	19.8	1.00		245	11.4	1.00	
1964–1969	253	18.2	0.92	(0.78, 1.08)	181	11.7	1.03	(0.84,1.24)
1970–1975	204	14.3	0.72	(0.61, 0.86)	154	9.4	0.82	(0.68,1.01)
1976–1981	150	10.1	0.51	(0.42, 0.61)	125	7.2	0.63	(0.51,0.79)
1982–1987	173	11.0	0.56	(0.46, 0.66)	139	7.6	0.67	(0.54,0.82)
t-test for trend: p = 0.0001							p = 0.0001	

*RR, rate ratio relative to 1955–1963 period.
**95% confidence interval.
***t-test for trend using annual incidence rates between 1955 and 1987.

TABLE 2—Rate Ratios by Sex for Osteosarcoma Incidence Rates per Million among Residents of New York State, Exclusive of New York City, 1970–87

	<30 Years at Diagnosis							
	Males				Females			
Year of Diagnosis	No.	Rate	RR*	(95% CI)**	No.	Rate	RR	(95% CI)
1970–1975	61	3.8	1.00		35	2.2	1.00	
1976–1981	71	4.6	1.21	(0.86,1.70)	41	2.7	1.23	(0.78,1.93)
1982–1987	64	4.4	1.16	(0.84,1.64)	37	2.6	1.18	(0.77,1.87)
t-test for trend:*** p = 0.71							p = 0.45	
	30+ Years at Diagnosis							
	Males				Females			
Year of Diagnosis	No.	Rate	RR	(95% CI)	No.	Rate	RR	(95% CI)
1970–1975	45	3.2	1.00		28	1.7	1.00	
1976–1981	48	3.2	1.00	(0.68,1.54)	36	2.1	1.24	(0.75,1.98)
1982–1987	42	2.7	0.84	(0.56,1.28)	39	2.1	1.24	(0.79,1.95)
t-test for trend: p = 0.58							p = 0.29	

*RR, rate ratio relative to 1970–1975 period.
**95% confidence interval.
***t-test for trend using annual incidence rates between 1970 and 1987.

Bone Cancer, Osteosarcoma Incidence and Fluoridated Drinking Water

As shown in Table 3, average annual sex- and age-specific bone cancer and osteosarcoma incidence rates (1976–87) did not differ between areas with and without fluoridated drinking water supplies.

Discussion

Although changes in bone cancer incidence since 1955 are evident, these changes have not been consistent between age groups or between the two genders. Bone cancer incidence rates among males less than 30 years at diagnosis have increased since 1955, while no statistically significant change in incidence was observed among females in this age group. Among persons ages 30 years and older, significant decreases in bone cancer incidence were noted among both males and females since 1955. Incidence increases, which have occurred, have been re-

TABLE 3—Age- and Sex-specific Incidence Rates per Million for Bone Cancers and Osteosarcomas among Residents of New York State, Exclusive of New York City, 1975–87, by Age at Diagnosis

	Bone Cancer Incidence								
	Nonfluoridated Areas			Fluoridated SMSA* Counties			Fluoridated NonSMSA Counties		
Age at Diagnosis	No.	Rate	(SE)**	No.	Rate	(SE)	No.	Rate	(SE)
<30 years									
males	75	9.7	(1.12)	158	9.0	(0.71)	60	11.3	(1.46)
females	51	6.7	(0.94)	110	6.4	(0.61)	22	4.3	(0.92)
30+ years									
males	98	12.4	(1.25)	181	10.4	(0.78)	44	9.0	(1.36)
females	64	7.0	(0.87)	162	8.0	(0.62)	38	6.7	(1.12)

	Osteosarcoma Incidence								
	Nonfluoridated Areas			Fluoridated SMSA* Counties			Fluoridated NonSMSA Counties		
Age at Diagnosis	No.	Rate	(SE)**	No.	Rate	(SE)	No.	Rate	(SE)
<30 years									
males	34	4.4	(0.75)	75	4.3	(0.43)	26	4.9	(0.96)
females	24	3.2	(0.64)	44	2.5	(0.38)	10	2.0	(0.62)
30+ years									
males	26	3.3	(0.64)	50	2.9	(0.41)	14	2.9	(0.77)
females	22	2.4	(0.51)	45	2.2	(0.33)	8	1.5	(0.51)

*SMSA = Standard Metropolitan Statistical Areas.
**SE = standard error.

stricted to more recent time periods among the cohort of persons born after the initiation of widespread artificial fluoridation of water supplies suggesting that any potential association with fluoride must be differential by age. The increased bone cancer risk observed in younger persons could be consistent with lifelong exposures to fluoride including exposures at times when growth rates for skeletal tissue are at a peak. However, other findings from this study do not support an association between exposure to fluoridated water and bone cancers. The incidence of bone cancers and osteosarcomas was not found to differ between areas with and without fluoridated drinking water supplies.

The potential specificity of effect from fluoride exposure was also examined by evaluating trends in the incidence of osteosarcomas. The incidence of osteosarcomas reveal no significant changes among either males or females, in either age group, since 1970. An examination of osteosarcoma incidence, between 1976 and 1987, in areas which have remained nonfluoridated did not indicate any significant differences compared to areas supplied by fluoridated water sources.

The limited secular increases observed in the number of bone cancer cases and osteosarcoma cases suggest that any potential effect of fluoride is probably minimal. Among population subgroups demonstrating incidence increases, the estimated annual increase in rates of bone cancers and osteosarcomas was 1–2 percent. Despite the ubiquitous nature of fluoride exposures, bone cancer and osteosarcomas remain as relatively infrequent cancers.

As with most previous studies of potential health effects resulting from exposure to fluoridated drinking water, the present study utilizes an ecological design and lacks precise measures of exposures to fluoridated drinking water, and other fluoride sources, at an individual level. Further, this study has not attempted to account for population mobility and movement between fluoridated and nonfluoridated areas. While most fluoridation of water supplies occurred during the 1950s and 1960s, some communities across New York State have initiated fluoridation of drinking water supplies at later times.

Although these data do not demonstrate consistent shifts in the incidence of bone cancers or osteosarcomas, recent increases in bone cancer incidence relative to the 1955–63 period are evident, particularly among younger persons. At this time it is not possible to establish an association between fluoride and bone cancer incidence. The potential role of fluoride in the incidence of bone cancers might be more thoroughly investigated using an analytic study design allowing more careful assessment of residential history to minimize misclassification of exposure to fluoridated drinking water and an examination of fluoride exposure from sources other than drinking water. □

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Federal Hazardous Waste Law Plagued by Ambiguities, says Report

A portion of the 1986 federal law requiring each of the 50 states to ensure the availability of hazardous waste treatment or disposal facilities over the next 20 years has been plagued by ambiguities, unanswered policy questions, and at least one lawsuit, according to a report to the US Environmental Protection Agency (EPA) by a Tufts University researcher. The report by Sharon N. Green, senior environmental research analyst at Tufts' Center for Environmental Management (CEM), recommends that Congress reassess the need for hazardous waste treatment and disposal facilities, given uncertainties about waste generation and management over the next 20 years.

The report cites data from 13 Northeast states projecting an 18 percent decline in hazardous waste generation by the year 2009, based on economic forecasting, waste reduction programs, expected new regulations, and contaminated site cleanups.

In her report, Green suggests a 15-point set of recommendations, including that the goals of the current provision be clarified to explicitly address waste reduction, facility siting, and attaining geographic equity for waste management services.

Other recommendations in the report, released in December 1990, include:

- Congress should consider state and federal roles in providing hazardous waste management services, given that responsibility for waste generation and management currently rests with the private sector.
- Congress should reconsider the appropriateness of threatening non-complying states with the loss of federal funds for hazardous waste cleanup projects.
- EPA should provide additional guidance to states in preparing hazardous waste projections.
- Data collection and planning methods among the states should be standardized.

"Capacity assurance planning probably will become a viable public policy only if significant revisions are made to the structure and function of the provision and implementation process," Green concludes in the report.