Evaluation of

Thyroid Cancer Incidence in Wakefield, Massachusetts

1982-1997

TABLE OF CONTENTS

Evaluation of
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LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

At the request of Representative Brian M. Cresta, residents of Wakefield, and the Wakefield Board of Health, the Community Assessment Unit (CAU) of the Massachusetts Department of Public Health (MDPH) Bureau of Environmental Health Assessment (BEHA) conducted an investigation of thyroid cancer incidence in the town of Wakefield. In particular, concerns focused around a suspected elevation of thyroid cancer in more recent years and a possible relationship with both drinking water contamination and community swimming pools. Thus, the purpose of this investigation was to determine if unusual patterns of thyroid cancer exist at a smaller geographic level within the town of Wakefield and to establish whether future interventions or public health actions are warranted.

Epidemiological research into the causes of thyroid cancer has revealed few well-established risk factors for this disease. The most well established risk factor for thyroid cancer is exposure to radiation, including radiotherapy for the treatment of medical conditions such as cancer or thymic enlargement and fallout from nuclear weapons or power plant accidents (ACS 2000). Other factors that have been shown to result in an increased risk of thyroid cancer include medical conditions (i.e., goiter or defects in thyroid hormone metabolism) and specific hereditary conditions (i.e., Gardner's syndrome, familial polyposis and Cowden's disease). Aside from ionizing radiation, there have been no environmental exposures linked to the development of thyroid cancer. However, community members expressed concerns about a possible relationship with the public water supply and the public swimming pools. Although there is no evidence for a relationship between thyroid cancer and contamination of water supplies or chemicals used in swimming pools, these factors were addressed in this evaluation in response to community concern.

II. OBJECTIVES

The primary purpose of this investigation was to provide a descriptive evaluation of the incidence of thyroid cancer, in terms of the temporal (or time) and geographic distributions of this disease, in Wakefield and each of its census tracts (CTs 3351-3354). In addition, available information related to factors associated with the development of thyroid cancer, including risk factor information, demographic and other data were evaluated. Finally, the data were evaluated in relation to several environmental concerns expressed by the Wakefield Board of Health and residents of Wakefield.

This investigation is a descriptive evaluation of health outcome data for thyroid cancer. Although the results of a descriptive analysis cannot be used to establish a causal link between a particular risk factor and a disease, they can be useful in determining whether or not a common etiology (or cause) is likely and can serve to identify areas where further public health investigations or actions may be warranted. Such actions may include follow-up environmental investigations or public health interventions when an excess of well-established risk factors has been identified. Nevertheless, a descriptive evaluation of data helps to identify any patterns of risk factors that may exist, such as behaviors and opportunities for environmental exposures in a geographic context. In this report, the analysis of thyroid cancer is presented and discussed in the context of the available scientific and medical information for this disease.

The specific objectives of this investigation were as follows:

- To examine the incidence of thyroid cancer in Wakefield by smaller geographic areas and to determine if certain areas in the town may have higher or lower rates of thyroid cancer;

- To evaluate the geographic distribution and spatial patterns of individuals diagnosed with thyroid cancer in order to determine whether an atypical geographic pattern of cases exists in certain areas of Wakefield;

- To review available information for characteristics of the Wakefield population that could suggest risk factors for the development of thyroid cancer;

- To evaluate the temporal distribution of thyroid cancer diagnoses in Wakefield to determine if the incidence of this cancer has changed over time;

- To review existing environmental data for hazardous waste sites located in Wakefield and other sites of environmental concern to determine if a relationship with thyroid cancer incidence is likely;

- To interpret the results of this evaluation in the context of available scientific evidence on thyroid cancer and to provide a clearer understanding of any patterns of disease in order to decide whether further public health actions are warranted.

III. METHODS FOR ANALYZING CANCER INCIDENCE

A. Case Identification

The observed number of thyroid cancer cases in this evaluation was derived from cases reported to the Massachusetts Cancer Registry (MCR), a division of the MDPH Bureau of Health Statistics Research and Evaluation, as primary site thyroid cancer cases diagnosed among Wakefield residents from 1982 to 1997. Cases were selected for inclusion based on the home address of the patient as reported to the hospital or the reporting facility at the time of diagnosis.

The MCR began collecting information on Massachusetts residents diagnosed with cancer in the state in 1982. All newly diagnosed cancer cases are required by law to be reported to the MCR within six months of the date of diagnosis (M.G.L. c.111s.111B). The sixteen-year period 1982-1997 constitutes the period for which the most recent and complete cancer incidence data were available at the time of the analysis.

The term "cancer" is used to describe a variety of diseases associated with abnormal cell and tissue growth. Primary site (location in the body where the disease originated) and histology (tissue or cell type) classify the different cancer types. Epidemiological studies have revealed that different types of cancer are individual diseases with separate causes, risk factors, characteristics, and patterns of survival (Schottonfeld and Fraumeni 1996). Only primary site thyroid cancers were included in this evaluation. Thyroid cancer that occurs as the result of metastasis or the spread of a primary site cancer to another location in the body are not considered as a separate cancer and were, therefore, not included.

B. Calculation of Standardized Incidence Ratios (SIRs)

In order to determine whether an unusual occurrence of thyroid cancer exists in Wakefield, or census tract areas in Wakefield, cancer incidence data were analyzed by age and gender. These two criteria were used to compare the observed number of cancer cases in each census tract to the number that would be expected based on the incidence of thyroid cancer in Massachusetts as a whole. Standardized incidence ratios (SIRs) were calculated for thyroid cancer for the town of Wakefield and each of the four census tracts in Wakefield for the 16-year time period 1982-1997 and three smaller time periods (1982-1986, 1987-1992, and 1993-1997).

The census tract (CT) is the smallest geographic area for which cancer rates can be accurately calculated. Specifically, a CT is a smaller statistical subdivision of a city or town. Census tracts usually contain between 2,500 and 8,000 persons and are designed to be homogenous with respect to population characteristics (U.S. Department of Commerce 1990). Wakefield is composed of four CTs: 3351, 3352, 3353, and 3354. The geographic location and limits of Wakefield as well as the CTs are illustrated in Figure 1.

An SIR is an estimate of the occurrence of cancer in a population relative to what might be expected if the population had the same cancer experience as some larger comparison population designated as "normal" or average. Usually, the state as a whole is selected to be the comparison population. Using the state of Massachusetts as a comparison provides a stable population base for the calculation of incidence rates. As a result of the instability of incidence

rates based on a small number of cases, SIRs are not calculated when fewer than five cases are observed.

Specifically, an SIR is the ratio of the observed number of cancer cases to the expected number of cases multiplied by 100. An SIR of 100 indicates that the number of cancer cases that is observed in the population being evaluated is equal to the number of cancer cases expected based on the comparison or "normal" population. An SIR greater than 100 indicates that more cancer cases occurred than were expected and an SIR less than 100 indicates that fewer cancer cases occurred than were expected. Accordingly, an SIR of 150 is interpreted as 50% more cases than the expected number; an SIR of 90 indicates 10% fewer cases occurred than were expected.

Caution should be exercised, however, when interpreting an SIR because the interpretation depends on both the size and stability of the SIR. Two SIRs can have the same size but not the same stability. For example, an SIR of 150 based on four expected cases and six observed cases indicates a 50% excess in cancer, but the excess is actually only two cases and may be the result of chance or random variation in cancer incidence. Conversely, an SIR of 150 based on 400 expected cases and 600 observed cases represents the same 50% excess in cancer, but because the SIR is based upon a greater number of cases, the estimate is more stable. It is very unlikely that 200 excess cases of cancer would occur by chance alone.

It is necessary to obtain accurate population information in order to calculate incidence rates. The population figures used in the analysis for the sixteen-year period of 1982-1997 were based on the 1990 U.S. Census data for each census tract in Wakefield (U.S. Department of Commerce 1990). For the calculation of incidence rates for the smaller time periods of 1982-1986 and 1987-1992, mid-year population estimates were calculated based on the 1980 and 1990 U.S. Census data (U.S. Department of Commerce 1980; U.S. Department of Commerce 1990). For the five-year period of 1993-1997, mid-year population estimates were calculated based on the 1990 and 2000 U.S. Census data (U. S. Department of Commerce 1990; U.S. Department of Commerce 2000). Since 2000 CT population totals by age and gender were not available at the time of this evaluation, the 1990 age and gender distribution were applied to the total population

in each CT for 2000. Furthermore, since some census tract boundaries in Wakefield were changed as a result of the 2000 census, CT population totals were adjusted in order to correspond with the census tract area comparable to the 1990 tract designations.

C. Calculation of 95% Confidence Interval

In addition to calculating SIRs, the statistical significance of each SIR was assessed. A 95% Confidence Interval (95% CI) was calculated for each SIR to determine if the observed number of thyroid cancer cases is significantly different from the expected number or if the difference may be due solely to chance (Rothman and Boice 1982). A 95% CI is a method of assessing the magnitude and stability of an SIR. Specifically, a 95% CI is the range of estimated SIR values that has a 95% probability of including the true SIR for the population. If the 95% CI range does not include the value 100, then the study population is significantly different from the comparison or "normal" population. "Significantly different" means there is a less than 5% chance that the observed difference between the number of observed and expected cancer cases is the result of random fluctuation in the number of observed cancer cases.

For example, if a confidence interval does not include 100 and the interval is above 100 (e.g., 105-130), then there is a statistically significant increase in the number of cancer cases. Similarly, if the confidence interval does not include 100 and the interval is below 100 (e.g., 45-96), then the number of cancer cases is statistically significantly lower than expected. If the confidence interval range includes 100, then the true SIR may be 100, and it cannot be concluded with sufficient confidence whether the observed number of cases is the result of chance or whether it reflects a real increase or decrease in the number of cases. Statistical significance was not assessed when fewer than five cases were observed.

In addition to indicating the significance of the SIR estimate, the width of the confidence interval also reflects the stability of the SIR estimate. For example, a narrow confidence interval (e.g., 103-115) allows a fair level of certainty that the calculated SIR is close to the true SIR of the population. A wide interval (e.g., 85-450) leaves considerable doubt about the true SIR,

which could be lower than or higher than the calculated SIR. A wide interval indicates an unstable statistic.

D. Determination of Geographic Distribution

In Wakefield, the geographic distribution of thyroid cancer cases was determined using available address information from the MCR indicating residence at the time of diagnosis. This information was mapped for each individual using a computerized geographic information system (GIS) (Environmental Systems Research Institute 1998). This allowed the assignment of a CT location for each case as well as a qualitative evaluation of the spatial distribution of cases at a smaller geographic level. The geographic distribution was assessed using a qualitative evaluation of the point pattern of cases within the town and within each CT. In instances where the address information was incomplete (i.e., did not include accurate street information for Wakefield), efforts were made to research cases using telephone books and town residential lists issued within two years of an individual's diagnosis year.

E. Evaluation of Characteristics of the Population

Through the evaluation of characteristics of the population, profiles can be constructed that may offer explanations for the observed patterns in the occurrence of thyroid cancer in Wakefield and its CTs. Age at diagnosis, gender, stage of disease, and histology (cancer cell type) are data regularly collected by the MCR for individuals diagnosed with cancer. However, information about personal risk factors that may also influence the development of thyroid cancer (e.g., family history and heredity, diet and iodine intake, and radiation to the head and neck) are not collected by the MCR or any other readily accessible source, and therefore, could not be evaluated in this investigation.

IV. RESULTS OF THYROID CANCER INCIDENCE ANALYSIS

A. Thyroid Cancer Incidence: 1982-1997

When evaluated for males and females together, the incidence of thyroid cancer in Wakefield was elevated but the difference between the observed and the expected number of

cases was not statistically significant (SIR=124, 95% CI=78-188). The elevation was based on 4 additional cases; there were 22 cases observed from 1982-1997 compared to 18 cases expected. Thyroid cancer in Wakefield for the years of 1982-1997 occurred more often than expected among males (SIR=118, 95% CI=43-257) and females (SIR=127, 95% CI=73-206) when compared to thyroid cancer incidence in the state of Massachusetts (Table 1). Although thyroid cancer incidence was elevated for males and females in the town, the incidence rates were not significantly elevated above the expected rate.

Thyroid cancer incidence for three of the four census tracts (CTs 3352, 3353, and 3354) in Wakefield could not be evaluated statistically because the number of cases that occurred in each CT was less than 5. However, the general pattern observed in these areas of town was that the number of individuals diagnosed with thyroid cancer was fewer than the number expected. In the remaining census tract (CT 3351) there was a statistically significantly elevated rate of thyroid cancer during the sixteen-year period of 1982-1997. These data are presented in Table 1. In CT 3351, which surrounds Lake Quannapowitt in the northern section of the town, 12 cases of thyroid cancer occurred where 4.6 cases were expected (SIR=262, 95% CI=135-458). Although this elevation is statistically significant, the large width of the confidence interval suggests instability in the resulting SIR because it is still based on a relatively small number of cases. Among males in this census tract, 3 cases occurred where slightly greater than one case was expected during 1982-1997. The incidence rate for females in CT 3351 was statistically significantly elevated (SIR=276, 95% CI=126-524). Nine cases of thyroid cancer occurred in women throughout the years of 1982-1997 in this area of Wakefield while slightly more than 3 cases were expected. Again because of the relatively small number of cases, the large width of the 95% CI suggests that this statistic may be somewhat unstable.

B. Thyroid Cancer Incidence: 1982-1986, 1987-1992, 1993-1997

Thyroid cancer incidence in Wakefield was examined for three smaller time periods (1982-1986, 1987-1992, and 1993-1997) to determine if the incidence of thyroid cancer had changed over time. Overall, the incidence rates for Wakefield, when compared to the state of

Massachusetts were not statistically significantly elevated for any of the time periods or for the total 16-years evaluated, 1982-1997. These data are presented in Table 2.

Incidence rates of thyroid cancer in Wakefield for the time periods 1982-1986 and 1987-1992 were greater than expected when compared to the incidence rates in the state of Massachusetts. However, the rates were not significantly elevated above the expected rate. During the period 1982-1986, 6 cases of thyroid cancer were observed in Wakefield overall when 4 were expected (SIR=140, 95% CI=51-305). For the 1987-1992 year period, 9 cases were observed when approximately 6 were expected (SIR=143, 95% CI=65-272). For the most recent year group, 1993-1997, the number of thyroid cancer cases was equal to the expected number. Among males and females combined, 7 cases occurred where approximately 7 cases were expected (SIR=100, 95% CI=40-205).

During all three time-periods, the incidence of thyroid cancer among males was approximately equal to expected. For females in Wakefield, thyroid cancer occurred more often than expected during the earlier time periods 1982-1986 and 1987-1992. However, during the most recent time period 1993-1997, thyroid cancer incidence among females in Wakefield was equal to expected (5 cases observed versus 5.1 cases expected). The majority of individuals diagnosed for all time periods were female and between the ages of 20-44. It is important to note that while the number of cases in females followed no consistent pattern by year group, the number of cases in males remained the same throughout all three time- periods evaluated. With the exception of CT 3351, SIRs were not calculated by CT for each specific time period because of the small number of cases. However in general, the number of observed cases by time period, for each CT was as expected, except for CT 3351. In CT 3351 the number of observed cases was higher than the expected for females for each time period.

Throughout the three time periods, no consistent pattern was observed for the incidence of thyroid cancer in females for CT 3351. The number of cases observed in females was higher than expected for the time periods 1982-1986 and 1987-1992, then leveled off to approximately the number of cases expected for the most recent time period evaluated, 1993-1997. Neither of

the elevations observed during the years 1982-1986 or 1987-1992 was statistically significant. These data are summarized in Table 3.

C. Analysis of Geographic Distribution

Place of residence at the time of diagnosis was geocoded and mapped for each individual diagnosed with thyroid cancer in Wakefield to assess any possible geographic pattern among cases. In addition to quantitatively determining census-tract-specific incidence ratios when possible, a qualitative evaluation was conducted to determine whether thyroid cancer cases appeared to be concentrated in some areas within the town or in a particular CT.

In Wakefield, 22 individuals were diagnosed with thyroid cancer during the 16 years of 1982-1997. In the area surrounding Lake Quannapowitt (CT 3351), a statistically significant elevation occurred. Twelve of the 22 cases occurred in CT 3351 with the majority of these individuals being female. Most of the individuals diagnosed with thyroid cancer in CT 3351 were located on the east side of Lake Quannapowitt (Figure 1). The concentration of cases in that area appears consistent with the pattern of population-density in that CT. Ten cases of thyroid cancer were diagnosed in the remaining three CTs. In CTs 3352 (north of Crystal Lake) and 3353 (eastern half of the town), the geographic distribution of thyroid cancer generally mimics the distribution of population density within Wakefield

No identifiable pattern emerged with respect to the smaller spatial distribution of cases when evaluated by age or year of diagnosis. That is, in no area within Wakefield or its CTs did cases of thyroid cancer appear concentrated in patterns by age or the year of diagnosis. Further, residence locations of cases in more recent years of diagnosis did not reveal a specific spatial pattern, nor was there a change in age of diagnosis by year. In fact, the seven cases diagnosed during the most recent year group of 1993-1997 appeared uniformly distributed throughout the town of Wakefield and were not concentrated in any particular CT area.

V. RESULTS OF RISK FACTOR INFORMATION

In order to better understand the patterns of thyroid cancer incidence in Wakefield, factors that are thought to contribute to an individual's risk were evaluated. However, some risk factors, such as heredity, dietary consumption of iodine, and historical radiation treatments could not be evaluated because information related to these factors for individuals with thyroid cancer was not available. Data on risk factors that was provided in MCR records were evaluated including gender and age information, occupational information, and information associated with the type of thyroid cancer diagnosis.

A. Gender and Age

Of the 22 individuals diagnosed with thyroid cancer in Wakefield during the years 1982-1997, 16 were female (73%) and 6 were male (27%). The gender distribution of thyroid cancer cases closely follows the expected distribution when compared to that in Massachusetts (Figure 2). In Massachusetts, 71% of thyroid cancer cases were diagnosed in females and 29% were diagnosed in males. In the United States, the American Cancer Society (ACS) estimates that 18,400 thyroid cancer cases will be diagnosed in 2001 with 74% in females and 26% in males (ACS 2001).

When evaluating the gender distribution of thyroid cancer in Wakefield by time period, the gender distribution closely follows that in Massachusetts (Figure 3). For the time period 1982-1986, 67% of female and 33% of male thyroid cancer cases occurred in Wakefield whereas 66% of female and 34% of male thyroid cancer cases occurred in the state of Massachusetts. Similarly, for the time period 1987-1992, female and male thyroid cancer cases in Wakefield were 78% and 22% while in Massachusetts they were 72% and 28%, respectively. For the most recent period evaluated (1993-1997), 71% female and 29% male thyroid cancer cases occurred in Wakefield while 73% female and 27% male thyroid cancer cases occurred in the state of Massachusetts.

The incidence rates for thyroid cancer were calculated and adjusted by age according to six age categories: 0-19, 20-44, 45-64, 65-74, 75-84, 85+. Age group-specific SIRs were used to

evaluate thyroid cancer in Wakefield in comparison to age group-specific rates for the state of Massachusetts as a whole. In the town, the incidence rates were not statistically significant by age categories or by gender. In general, the observed distribution of cases by age showed that the highest percentage of cases occurred in individuals who were between 20 and 64 years of age for both Wakefield (73%) and Massachusetts (76%). Specifically in Wakefield, 59% of the cases occurred in the 20-44 year age group whereas in Massachusetts, 46% of cases were within that age group.

B. Stage and Type of Diagnosis

The greatest percentage of thyroid cancer cases that occurred during the sixteen-year period of 1982-1997 were diagnosed at a localized or regional stage (84%); this is similar to Massachusetts as a whole where 85% of thyroid cancers were diagnosed at the local or regional stage. This indicates that the localized tumors were present at the site of the thyroid gland and have not metastasized, or spread, to any other areas in the body (i.e., to the nearby lymph nodes or to other organs). When tumors have already metastasized at the time of diagnosis, the cancer is considered to be at a more advanced stage. Diagnosis at a young age or diagnosis with a more aggressive type of thyroid tumor is often an indication of an environmental cause, usually previous high-dose radiation treatment or radioactive exposure (Pacini et al., 1997). However, few of the individuals diagnosed with thyroid cancer in Wakefield showed lymph node metastases. In addition, all thyroid cancers diagnosed in Wakefield between the years of 1982-1997 were in individuals over the age of 20. Thus, the staging and age distributions of the cases are not consistent with a pattern of thyroid cancer related to environmental sources, such as high-dose radiation (Pacini et al., 1997).

Regardless of etiology (i.e., cause) most thyroid tumors are diagnosed as the slower growing type known as papillary carcinoma. In Wakefield, 17 of the 22 cases diagnosed during the years of 1982-1997 were papillary carcinomas (77%). Of the remaining cases, 14% were diagnosed as follicular carcinoma, 5% were medullary, and 5% were adenocarcinomas (Figure 4). This distribution by histology follows a similar pattern to histology types of thyroid cancer in the state and nationally. In Massachusetts, 75% of thyroid cancers diagnosed were papillary,

15% were follicular, 4% were medullary, and 6% were of other types. In the US, it is estimated that 70-80% of thyroid tumors are papillary and 10-15% are follicular (American Thyroid Association 1996). The distribution of cases of thyroid cancer in the town of Wakefield as a whole, showed no unusual pattern according to the type or stage at diagnosis when evaluated by geographic location, gender, or by year of diagnosis.

C. Occupation

Available occupational data for cases was evaluated with respect to suspected risk factors for thyroid cancer. Occupations such as being a paper or pulp-maker, hospital-based nurse or attendant, dentist or hygienist, or lab technician and nuclear engineer have been associated with a higher incidence of thyroid cancer, however none has been proven to increase one's risk of the disease (Fincham et al., 2000). Suspected exposures that are common to some of these occupations include ionizing radiation, wood dust, hydrocarbons and carcinogenic solvents (i.e., acetone, xylene, methlethylketone, and trichloroethylene) (Fincham et al., 2000; Wingren and Axelson 1997).

In Wakefield, three individuals reported occupations thought to be associated with higher incidence of thyroid cancer and five were reported as retired or with unknown occupations. The remaining 14 individuals had reported occupations that were not thought to be associated with an increased risk for thyroid cancer. However, from the available information, it was not possible to assess individual occupational exposure to established or suspected risk factors for thyroid cancer. Furthermore, because of the small number of cases with similar occupations, the role of specific occupations in any one individual's diagnosis of thyroid cancer could not be reliably evaluated.

VI. COMMUNITY ENVIRONMENTAL CONCERNS AND CANCER INCIDENCE

Wakefield residents and the Wakefield Board of Health (BOH) have raised a number of concerns regarding environmental factors in the town and the potential relationship to increased

thyroid cancer incidence. Specifically, the concerns focused on the locations of water supplies and chemicals used in community swimming pools. It should be noted that there is no evidence linking thyroid cancer with exposures commonly found at a swimming pool. Also, concerns were expressed regarding how environmental factors may have impacted a potential elevation of thyroid cancer incidence in the more recent years (i.e., 1995-2000). The following sections discuss the distribution of thyroid cancer cases relative to opportunities for exposure from the various sources of concern.

A. Public Water Sources & Community Swimming Pool

According to the Massachusetts Water Resources Authority (MWRA), 85% of the 2.5 million gallons of water used in the town of Wakefield comes from the MWRA supply. The water supply sources for Wakefield include the Quabbin Reservoir, located 65 miles west of Boston, and the Wachusett Reservoir, located 35 miles west of Boston (MWRA 1999). The "High Service Area" of Wakefield, constituting the western half of the town (i.e., CTs 3351 and 3352), receives 100% of its water from the MWRA supply during normal operating conditions (Department of Public Works 2000). Crystal Lake, a high-quality surface-water body supplies the remaining 15% of the water for Wakefield. Water from Crystal Lake is obtained through a system set up by the local Broadway Treatment and Pumping Facility.

Regardless of the source, the Massachusetts Department of Environmental Protection (MDEP) regulates all public water in the town of Wakefield for safety. This means that only highly regulated MDEP certified laboratories are acceptable for testing all primary water for contaminants. Contaminants are defined as chemicals or water quality parameters (i.e., nitrate, nitrite, volatile organic compounds, coliform bacteria, lead, copper, arsenic, several pesticides and herbicides, and asbestos) which EPA has identified as a health risk from excessive exposure and for which EPA has set a Maximum Contaminant Level (MCL). If a substance is present below the MCL then it is considered to be at a level safe for drinking water. In addition, MDEP requires that water be tested for secondary contaminants. These are substances that may present aesthetic problems for water quality but are not generally regarded as a health risk (i.e., pH, turbidity, total dissolved solids).

No association between contaminants found in drinking water and thyroid cancer has been established. Information from the Safe Drinking Water Violation Report for the town of Wakefield did not give any indication of problems with the public water supply for the town during the period of interest (EPA 2001). Similarly, discussions with the Department of Public Works in Wakefield did not identify any historical problems with the town's drinking water supply. From the available information, no known substances that are established risk factors for thyroid cancer have been documented in the Wakefield water supply.

Community concerns also focused on possible exposures from the community swimming pool. However, based on a thorough review of the scientific and medical literature there is no evidence that chemicals used in the maintenance of swimming pools increase a person's risk of developing thyroid cancer. Furthermore, information is not available to assess an individual's time spent in the town pool or other swimming pools. There did not appear to be a concentration of thyroid cancer cases in the area of the town swimming pool (Figure 1).

B. MDEP 21E Sites

Information regarding sites in the town of Wakefield reported to the Massachusetts Department of Environmental Protection (MDEP) in 1994 or earlier as potential releases of oil and/or other hazardous materials was reviewed. It has been reported that there is a 4 to 20 year latency period between exposure to a potentially harmful substance and the development of thyroid cancer (Mangano 1996; Schimpff 1979). Therefore, in order to focus on potential past exposure consistent with this latency period, only historical MDEP site releases were reviewed. Releases that occurred after 1994 are unlikely to be related to thyroid cancer incidence during the period of 1982-1997. The reported sites were mapped and the proximity of these sites to thyroid cancer cases was assessed. Under Chapter 21E (also known as State Superfund) of the Massachusetts General Laws (M.G.L.) enacted in 1983, the MDEP investigates potentially hazardous sites in the state and conducts or oversees cleanup of these sites. These sites are regulated according to M.G.L. Chapter 21E and the Massachusetts Contingency Plan (MCP) 310 CMR 40.0000.

A total of 40 hazardous waste sites or reported potential release areas were identified by MDEP as located in Wakefield prior to 1995. The locations of these sites are shown in Figure 5. All 21E sites are classified by the type of contamination present; that is, sites may be listed as having petroleum contamination (i.e., gasoline, diesel, and fuel oils), hazardous contamination (i.e., metal, organic compounds, volatile organic compounds, and pesticides) or both. In Wakefield, 20 sites contained petroleum contamination, 7 sites contained hazardous materials, 10 sites contained both, and 3 sites had contamination types that were undetermined. There has been no proven association between petroleum or other hazardous material contamination and a diagnosis of thyroid cancer (Sathiakumar et al., 2001).

Most of the 21E sites were located in close proximity to the 1890 Boston & Maine Railroad Route and were centralized towards the middle of the town where all four CTs meet. Sixteen sites were located in CT 3351, where an elevation in thyroid cancer was observed among females, while the remaining sites were scattered throughout the other three Wakefield CTs. Although the majority of the sites were located in CT 3351, 9 were positioned in the southern part of the CT, south of Lake Quannapowitt. In contrast, the majority of the individuals diagnosed with thyroid cancer in CT 3351 resided in the northern portion of this CT, east of the lake. The MDEP 21E sites located in the remaining CTs (3352, 3353, and 3354) showed no pattern in relation to the spatial distribution of cases of thyroid cancer in Wakefield. Overall, review of the geographic distribution of cases of thyroid cancer in relation to MDEP 21E sites in Wakefield did not demonstrate any spatial correlation.

VII. DISCUSSION

During the 16-year period 1982-1997, the incidence of thyroid cancer was not statistically significantly elevated in Wakefield when compared to the state of Massachusetts. Incidence rates overall in the town were not statistically significant for males, females, or both combined. Census tract analysis revealed that thyroid cancer was statistically significantly

elevated in one census tract (CT 3351) located in the northern portion of the town. This was primarily the result of the significantly elevated incidence among females in this area. The incidence of thyroid cancer in CT 3351 for males was not significantly elevated. However, thyroid cancer incidence in CT 3351 revealed an expected 3 to 1 ratio for women to men. Specific rates for CTs 3352, 3353, and 3354 could not be evaluated statistically because of the small number of cases that occurred in these areas; however, in general fewer cases were observed than were expected in these three CTs.

No increasing trend in incidence of thyroid cancer in Wakefield was observed over time when evaluated by smaller time periods (1982-1986, 1987-1992, and 1993-1997). Throughout each time period the number of individuals diagnosed with thyroid cancer showed a slight increase from the years of 1982-1986 to 1987-1992, then decreased to the rate that was expected during the 1993-1997 year period. This change was due to a decrease in the number of female cases as the number of cases diagnosed among Wakefield males remained consistent for all three year-periods. However, it is important to note that during the years 1998 to the present there were a total of three cases of thyroid cancer diagnosed in Wakefield. Although the more recent MCR data is not yet complete, this information along with the decreased number of cases diagnosed during the 1987-1992 to 1993-1997 time periods may indicate that a downward trend in incidence of thyroid cancer may be occurring in Wakefield.

In order to further evaluate the geographic distribution of cases of thyroid cancer in the town, a total of 40 hazardous waste sites (i.e., 21E sites) documented in Wakefield by the Massachusetts Department of Environmental Protection (MDEP) were mapped. When analyzing the spatial distribution of the 21E sites with respect to residences of individuals diagnosed with thyroid cancer, no consistent pattern emerged. Residences did not appear concentrated around any particular 21E site. It should be noted that this evaluation only qualitatively describes the geographic pattern of thyroid cancer cases in relation to locations of community concern and potentially hazardous sites in Wakefield. Information regarding the nature and extent of contamination as well as the potential for individual exposure to nearby sites is not readily available and therefore could not be evaluated in this report. Also, no pattern emerged when

evaluating the spatial distribution of cases when analyzed by age or year of diagnosis with respect to 21E sites.

Overall in 2001, the American Cancer Society estimates that a total of 13,700 new cases of thyroid cancer will occur in women and 4,700 new cases will occur in men, a 3 to 1 ratio (ACS 2001). Other reports estimate a 2 to 3-fold increased risk for thyroid cancer in women compared to men (NCI 1997). The reason for this higher incidence in women is unknown. This pattern is reflected in the distribution of cases of thyroid cancer by gender in Wakefield with 73% of cases being female and 27% being male for the years of 1982-1997.

The risk of developing thyroid cancer may be influenced by a number of factors, although many people with thyroid cancer possess no apparent risk factors. Also, many individuals with one or more risk factors never develop the disease. Epidemiological studies have found few well-established risk factors for this cancer type. The best-established risk factor is exposure to ionizing radiation (ACS 2000). It has been shown that radiation treatment to the head and neck as a child increases the risk for developing this disease. Particularly, the risk for thyroid cancer increases as the age of exposure to ionizing radiation decreases (Ron et al., 1995). Exposure to radioactive fallout from nuclear weapons or power plant accidents also increases risk for thyroid cancer (NCI 1997). The presence of other medical conditions, such as goiter or defects in thyroid hormone metabolism, has also shown some association with thyroid cancer (Correa and Chen 1995). In some areas of the world, an elevated incidence of papillary and follicular type thyroid cancers has occurred where people's diets are low in iodine (Franceschi et al., 1990). However, the level of iodine intake has not been proven to have a causal relationship with thyroid cancers. It was not possible to analyze individual exposure to radiation, other related medical conditions, and dietary habits for each individual in Wakefield because such information was not available. However, it is important to note that no known source of ionizing radiation exists in Wakefield. The Radiation Control Program at the MDPH has no documentation of a history of radioactive leakage or unusual radiation levels in Wakefield.

For most head and neck cancers, tobacco and alcohol have been established as risk factors. However, neither of these factors has been correlated with thyroid cancer. Thus, these behaviors were not evaluated in this report. Although, specific hereditary or genetic conditions such as Gardner's syndrome, familial polyposis, specific gene mutations, and Cowden's disease have been associated with higher risk for thyroid cancer, information on these predisposing conditions was not available for evaluation.

Occupations that have been associated with an increased risk of thyroid cancer include being a pulp and paper maker, hospital-based nurse or attendant, dentist or hygienist, or lab technician and nuclear engineer. Employees in these occupations may be exposed to things such as ionizing radiation, wood dust, solvents (e.g., acetone, xylene), formaldehyde, glues, preservatives and pesticides which may contribute to the increased risk of thyroid cancer (Fincham et. al., 2000). However, the suspected link between these exposures and an increased risk for thyroid cancer has not been proven. Further, the majority of individuals diagnosed with thyroid cancer in Wakefield were not reported to be employed in these occupations.

Overall, it is estimated that of all the radiation an average person is in contact with, approximately 82% originates from sources that occur naturally (Radiation and Health Physics 2000). Naturally occurring radiation refers to radiation from three sources: the earth's soil, outside the earth's atmosphere, and the body's own internal tissues. Other sources of potential radiation exposure include x-rays (11% of exposure), radiation treatment in medicine (4%), and other man-made radioactive substances. Given this, it is extremely difficult to separate the natural and man-made sources of radiation exposure when assessing the impact on human health. It becomes substantially more difficult to assess one's environmental radiation exposure when attempting to attribute an observed health effect to one specific cause. This is particularly difficult when ionizing radiation and chemicals, from both naturally occurring sources and human activities, are acting simultaneously (IAEA Bulletin 2000). Individual exposure levels due to these various sources of radiation could not be assessed from the available information on cases of thyroid cancer in Wakefield.

Thyroid cancer may develop as either benign (non-cancerous) or malignant (cancerous) thyroid tumors; only malignant tumors are reported to the MCR and, hence, included in this evaluation. The four main histology types of malignant thyroid cancer are papillary, follicular, medullary, and anaplastic. These differ in the type of cells in which the tumors are found, the extent of metastasis (spread of tumor cells throughout the body), and the aggressiveness of growth of the tumors. In the U.S., papillary carcinoma is the most frequently diagnosed type (73%) followed by follicular adenocarcinoma (16%) and medullary carcinoma (6%). In areas known to harbor unusual levels of radiation from radioactive fallout, papillary carcinoma tends to be a higher majority of cases (i.e., up to 95%) while follicular adenocarcinomas fall to an observed level of 5% of total cases (Pacini et al., 1997). Accordingly, papillary and follicular carcinomas accounted for 77% and 14% of thyroid cancer cases in Wakefield for the years of 1982-1997, respectively. This suggests that the diagnoses of thyroid cancer in Wakefield do not follow a pattern related to exposures to high-dose radiation.

The majority of thyroid cancers in Wakefield were diagnosed at a localized or regional stage of disease, so the data may also suggest that Wakefield residents have access to health care and therefore are diagnosed at earlier stages. Also, 91% of the thyroid cancers were categorized as the more common and slower growing subtypes of thyroid cancer, papillary carcinoma and follicular adenocarcinoma. Thus, it can be determined that the majority of thyroid cancers in Wakefield, diagnosed during the years of 1982-1997, were not of a rare subtype or a more aggressively growing histology that is more likely related to an environmental influence.

Thyroid cancers occur in people of all ages, however diagnoses of certain types typically occur in specific age groups. Papillary and follicular thyroid cancer, the more commonly observed types, are found most often in people ages 30-50 years of age (ACS 2000). A similar pattern was observed in Massachusetts with 76% of cases diagnosed while between the ages of 20 and 64. The age distribution seen in Wakefield is consistent with this pattern; 50% of individuals diagnosed with these types of thyroid cancer were between 30 and 50 years of age.

In response to concerns raised by residents and the Wakefield Board of Health, MDPH/BEHA investigated the public water sources and the potential relationship to any increased thyroid cancer incidence. All water utilized in Wakefield, either for drinking or use in swimming pools, was obtained from one of two sources: the MWRA supply or Crystal Lake. According to the Massachusetts Water Resources Authority (MWRA) and the Wakefield Department of Public Works, no contaminants or chemicals have been detected at any level outside of water quality parameters set by EPA. Thus, it is unlikely that town water supplies would have contributed to an increase in the diagnosis of thyroid cancers in Wakefield during the years of 1982-1997.

VIII. CONCLUSIONS

- Thyroid cancer incidence in Wakefield was not significantly elevated compared to Massachusetts for any of the four time periods evaluated (1982-1997, 1982-1986, 1987-1992, and 1993-1997).

- At the census tract level, a significantly elevated incidence of thyroid cancer was found in CT 3351, located in the northwest quadrant of the town near Lake Quannapowitt, for the years of 1982-1997. However, rates for all other CTs (3352, 3353, and 3354) were lower than expected.

- No consistently increasing trend emerged when evaluating incidence rates of thyroid cancer in Wakefield throughout the time periods of 1982-1986, 1987-1992, and 1993-1997. The patterns suggest that the incidence of thyroid cancer in Wakefield may be decreasing in more recent years. Any change in incidence was due to diagnoses among females since the number of males diagnosed with thyroid cancer in Wakefield remained the same throughout all year periods.

- Consistent with incidence rates observed statewide and nationwide, the majority of individuals diagnosed with thyroid cancer in Wakefield were women. Similarly, the majority of cases occurred in individuals between the ages of 30 and 50.

- The majority of thyroid cancer cases diagnosed in Wakefield were the more common and slowly growing subtypes, papillary and follicular. This suggests that thyroid cancer in Wakefield is not likely related to exposure to high-dose radiation.

- Residences of individuals at the time of diagnosis were not concentrated in any particular area of Wakefield. In general, the incidence of cases was consistent with the population density of the town.

- Individuals diagnosed with thyroid cancer in Wakefield were not employed in occupations that are believed to increase one's risk for the disease.

- There is no reported contamination of the Wakefield drinking water supply during the time period under evaluation. In addition, no documentation exists to link the incidence of thyroid cancer to contamination in either of the town's major water supplies, the Quabbin Reservoir or Crystal Lake.

- Available information indicates no correlation between the distribution of case residences and potentially hazardous sites (i.e., 21E Sites) in Wakefield. In addition, there does not appear to be a concentration of cases in the area of the YMCA swimming pool.

IX. SUMMARY AND RECOMMENDATIONS

Although thyroid cancer was not significantly elevated in the town of Wakefield overall, there was a statistically significant elevation in thyroid cancer incidence among females in CT 3351 between 1982-1997. However, evaluation of the geographic distribution as well as the distribution of available risk factor information (i.e., age, gender and occupation) did not reveal any unusual patterns of incidence in Wakefield. Unfortunately, information for some of the most well established risk factors (ionizing radiation exposure and hereditary conditions) for thyroid cancer is not available at the individual level; therefore, these factors could not be evaluated in this report. Because of this, the MDPH recommends that each person, with the help of their physician, evaluate their individual risk for developing thyroid cancer from information on family medical history or past radiation treatments. Individuals who are concerned about their potential risk for this cancer should discuss their concerns with their physician. In addition, the Community Assessment Unit of the Massachusetts Department of Public Health will continue to monitor the incidence of thyroid cancer in Wakefield through the Massachusetts Cancer Registry.

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Figure 1:
Location of Census Tract Boundaries in Wakefield, MA

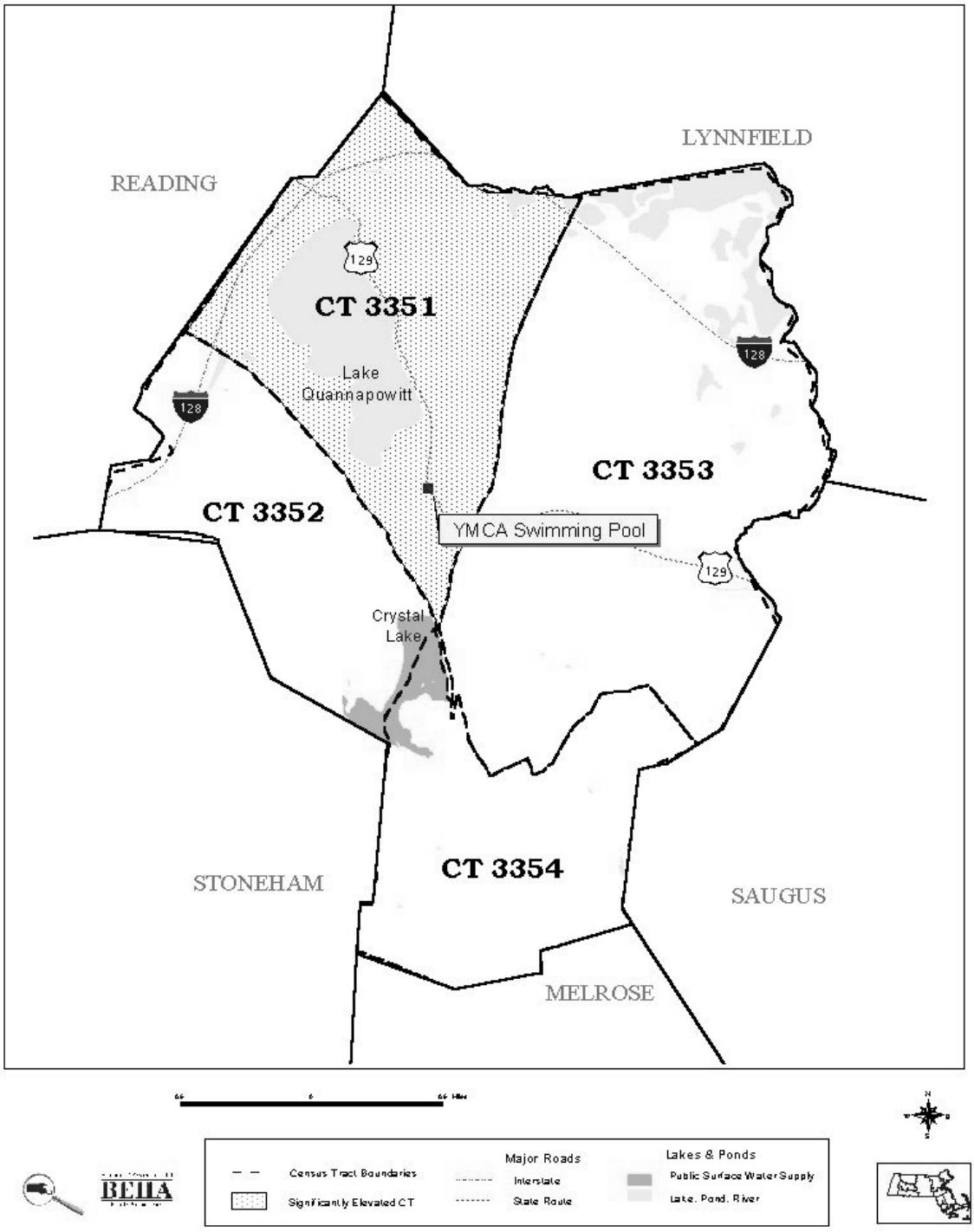
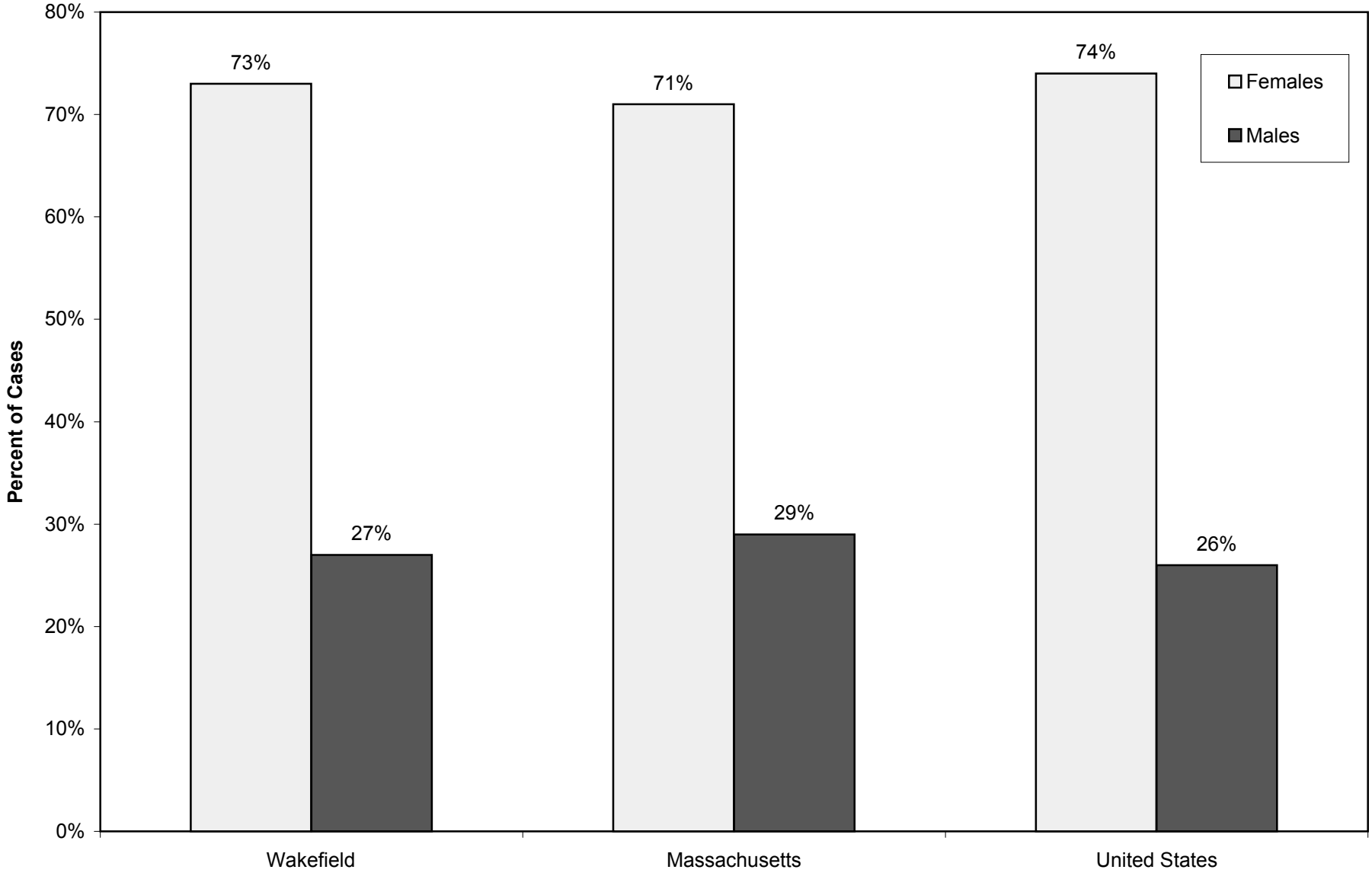
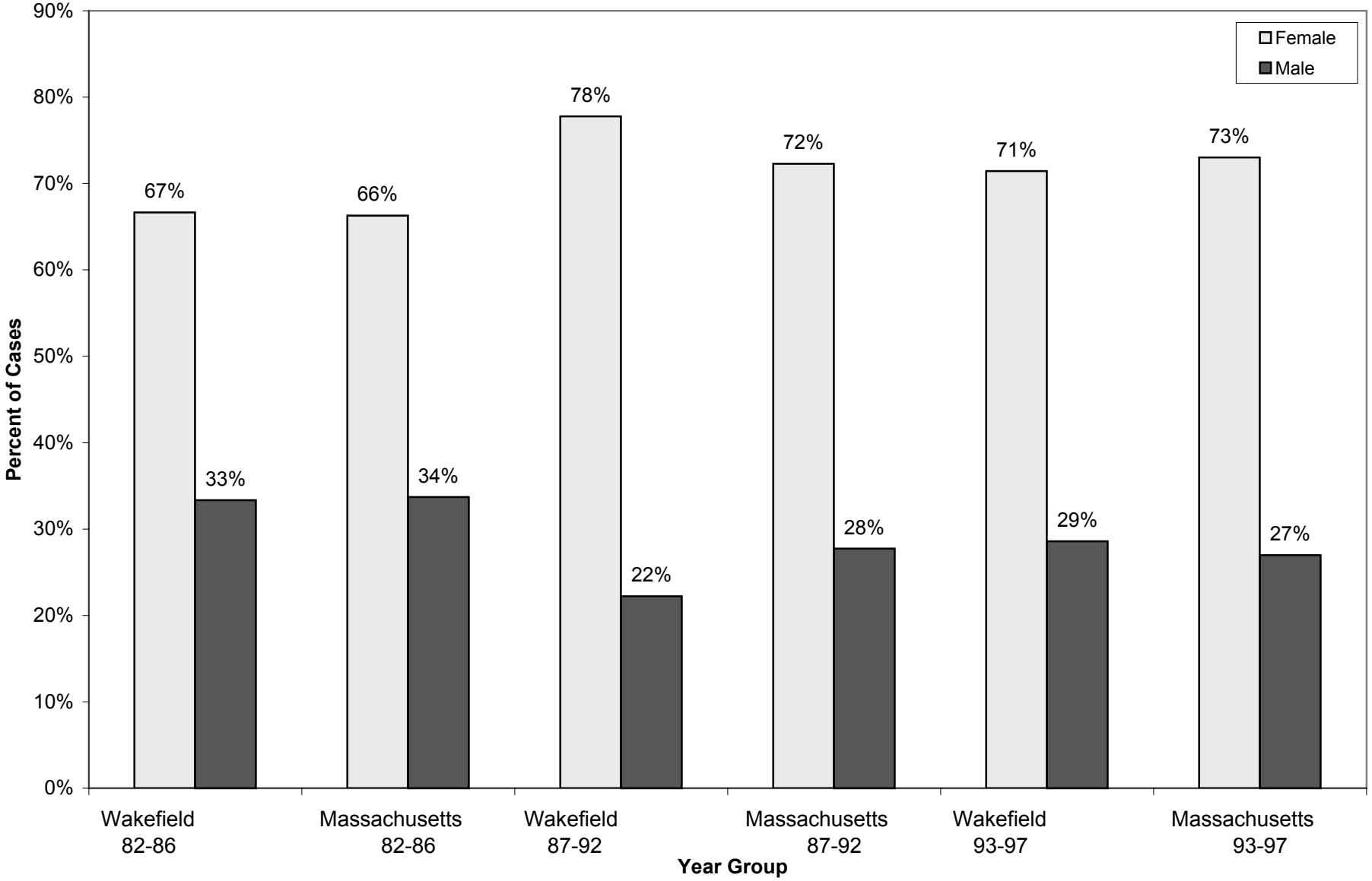


Figure 2:
Thyroid Cancer By Gender
Wakefield, Massachusetts, and the United States
1982-1997



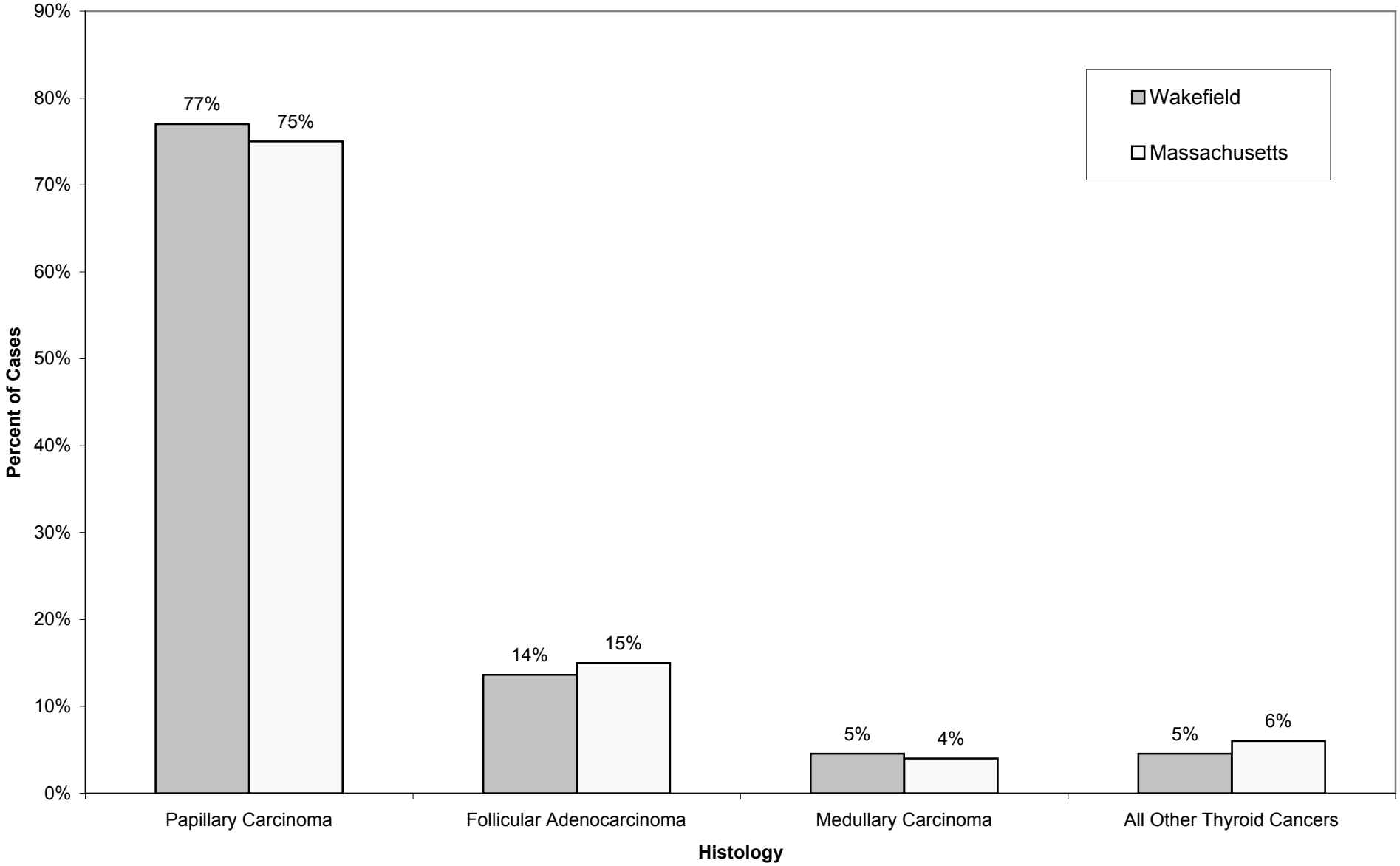
Data Source: Massachusetts Cancer Registry, Bureau of Health Statistics, Research and Evaluation, Massachusetts Department of Public Health and The American Cancer Society

Figure 3:
Thyroid Cancer by Gender and Year Group
Wakefield vs. Massachusetts
1982-1986, 1987-1992, 1993-1997



Data Source: Massachusetts Cancer Registry, Bureau of Health Statistics, Research and Evaluation, Massachusetts Department of Public Health

Figure 4:
Thyroid Cancer by Histology
Wakefield, Massachusetts, and the United States
1982-1997



Data Source: Massachusetts Cancer Registry, Bureau of Health Statistics, Research and Evaluation; Massachusetts Department of Public Health

Figure 5:
MDEP 21-E Sites in Wakefield, MA

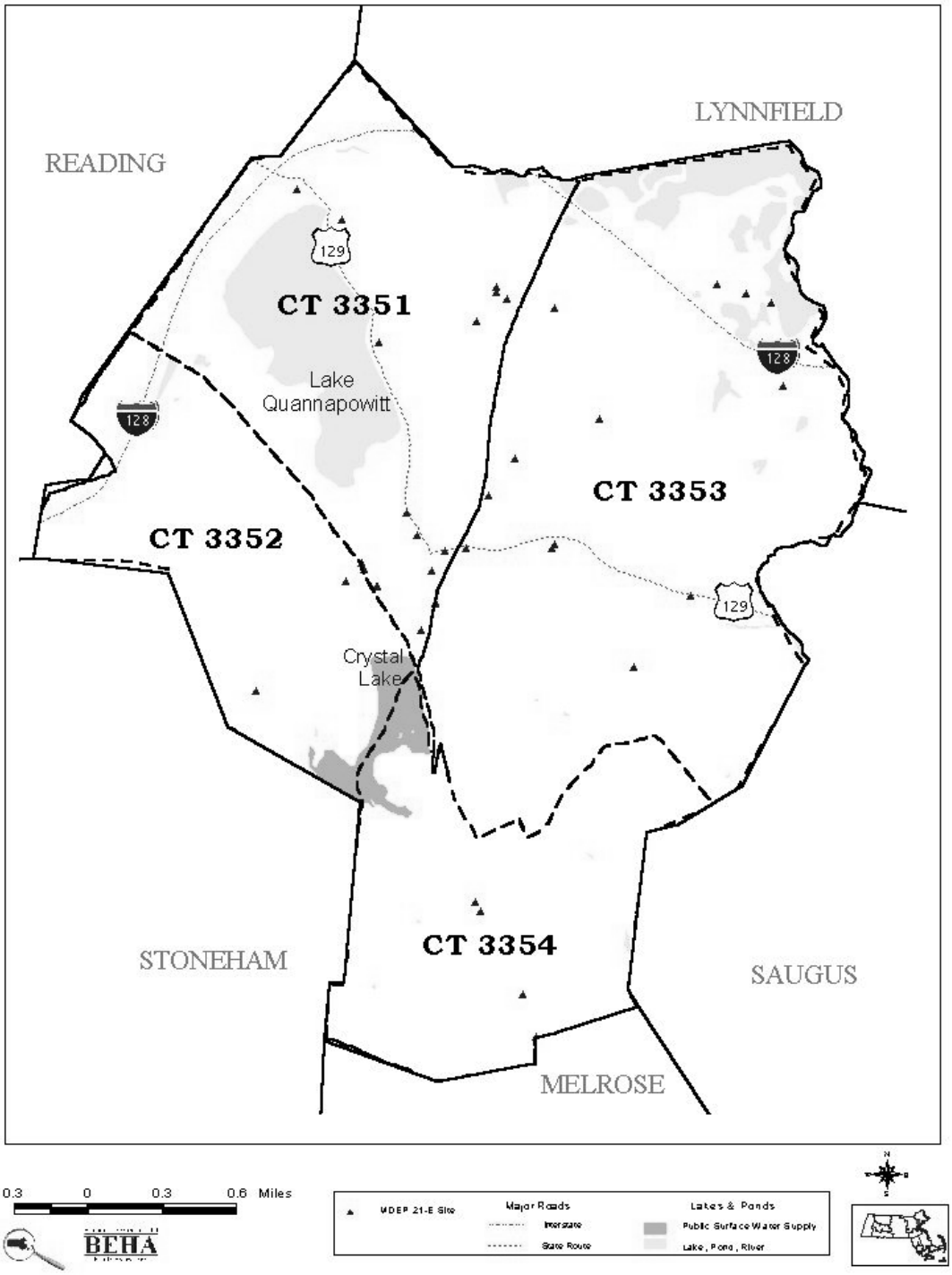


Table 1

Thyroid Cancer Incidence in Wakefield, MA
1982-1997

Census Tract	Total					Male					Female				
	Obs	Exp	SIR	95 % CI		Obs	Exp	SIR	95 % CI		Obs	Exp	SIR	95 % CI	
3351	12	4.6	262 *	135	-- 458	3	1.3	NC	NC		9	3.3	276 *	126	-- 524
3352	4	4.2	NC	NC		2	1.2	NC	NC		2	3.0	NC	NC	
3353	4	5.5	NC	NC		1	1.6	NC	NC		3	3.9	NC	NC	
3354	2	3.4	NC	NC		0	1.0	NC	NC		2	2.4	NC	NC	
Total	22	17.7	124	78	-- 188	6	5.1	118	43	-- 257	16	12.6	127	73	-- 206

Notes:

Expected number of cases presented are rounded to the nearest tenth.

SIRs are calculated based on the exact number of expected cases.

SIRs and 95% Confidence Interval are not calculated when fewer than 5 cases are observed.

Obs = Observed number of cases

Exp = Expected number of cases

SIR = Standardized Incidence Ratio

NC = Not Calculated

95% CI = 95% Confidence Interval

* Indicates statistical significance (P<.05)

Data source and analysis: Massachusetts Cancer Registry, Bureau of Health Statistics, Research and Evaluation, Mass. Dept. of Public Health

Table 2

Thyroid Cancer Incidence in Wakefield, MA
1982-1986, 1987-1992, 1993-1997

Year Group	Total				Male				Female			
	Obs	Exp	SIR	95 % CI	Obs	Exp	SIR	95 % CI	Obs	Exp	SIR	95 % CI
1982-1986	6	4.3	140	51 -- 305	2	1.4	NC	NC	4	2.8	NC	NC
1987-1992	9	6.3	143	65 -- 272	2	1.7	NC	NC	7	4.5	154	62 -- 318
1993-1997	7	7.0	100	40 -- 205	2	1.9	NC	NC	5	5.1	97	31 -- 227

Notes:

Expected number of cases presented are rounded to the nearest tenth.
SIRs are calculated based on the exact number of expected cases.
SIRs and 95% Confidence Interval are not calculated when fewer than 5 cases are observed.
Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
NC = Not Calculated
95% CI = 95% Confidence Interval
* Indicates statistical significance (P<.05)
Data source and analysis: Massachusetts Cancer Registry, Bureau of Health Statistics, Research and Evaluation, Mass. Dept. of Public Health

Table 3

Thyroid Cancer Incidence in Wakefield, MA
Census Tract 3351
1982-1986, 1987-1992, 1993-1997

Year Group	Total				Male				Female			
	Obs	Exp	SIR	95 % CI	Obs	Exp	SIR	95 % CI	Obs	Exp	SIR	95 % CI
1982-1986	4	1.1	NC	NC	1	0.4	NC	NC	3	0.8	NC	NC
1987-1992	5	1.6	307	99 -- 717	1	0.4	NC	NC	4	1.2	NC	NC
1993-1997	3	1.8	NC	NC	1	1.5	NC	NC	2	1.3	NC	NC

Notes:

Expected number of cases presented are rounded to the nearest tenth.
SIRs are calculated based on the exact number of expected cases.
SIRs and 95% Confidence Interval are not calculated when fewer than 5 cases are observed.
Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
NC = Not Calculated
95% CI = 95% Confidence Interval
* Indicates statistical significance (P<.05)
Data source and analysis: Massachusetts Cancer Registry, Bureau of Health Statistics, Research and Evaluation, Mass. Dept. of Public Health