Massachusetts
Department
Of
Public Health

Evaluation of Cancer Incidence in Grafton, Massachusetts

1982-2000

Center for
Environmental Health,
Community Assessment
Program

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

At the request of concerned residents and the Grafton Board of Health, the Community Assessment Program (CAP) of the Massachusetts Department of Public Health (MDPH), Center for Environmental Health conducted an evaluation of cancer incidence for the town of Grafton. This evaluation was initiated based on community concerns about a suspected increase in the incidence of cancer, specifically among individuals living in the area surrounding the Wyman-Gordon Company, located in the northwest corner of the town.

This investigation provides a review of the pattern of ten cancer types in the town of Grafton and compares their incidence with the incidence of these cancers in the state of Massachusetts as a whole. Additionally, available information about risk factors, including environmental factors, related to the development of these cancers was evaluated. The town of Grafton is divided into four smaller geographic areas or census tracts (CTs) and cancer incidence rates were also evaluated for each census tract separately with a particular focus on CT 7383, where Wyman-Gordon is located. Cancer incidence data for Grafton were obtained from the Massachusetts Cancer Registry (MCR) for the years 1982 – 2000, the time period for which the most recent and complete data were available at the initiation of this analysis. In addition, two smaller time periods were evaluated, 1982 – 1990 and 1991 – 2000, to assess possible trends over time.

In addition to calculation of cancer incidence rates, a qualitative analysis of the geographic distribution of individuals diagnosed with each of the ten types of cancer was conducted by mapping their residence at time of diagnosis. This was done to determine if any patterns existed in a particular area of town or in relation to the Wyman-Gordon company site.

Finally, to further address resident concerns about the pattern of cancer near Wyman-Gordon and specific reports of individual diagnoses in the adjacent neighborhood, a qualitative evaluation of all cancer types was conducted for the streets immediately surrounding the facility.

WYMAN-GORDON COMPANY

The Wyman-Gordon Company is located on Worcester Street (Route 122) in North Grafton, Massachusetts (GZA 2003). The company has been in operation since 1945 and manufactures metal forgings used primarily in the military and aviation industry. Current operations are on a portion of a larger property located on approximately 232 acres in both Grafton and the adjacent town of Millbury. Multiple contamination areas have been identified on the Wyman-Gordon property and they are generally associated with previous site use (e.g. former waste management and disposal areas or accidental spill releases of hazardous materials). These contamination areas fall under the regulation of the Massachusetts Department of Environmental Protection (MDEP) and are at various stages of remediation (GZA 2003, 2004).

Community environmental concerns originally focused on the identification of nitrate and solvent contamination in private drinking water wells along Creeper Hill Road and Faulkner Road located north of the Wyman-Gordon property. Environmental investigations conducted at the site have identified contamination of groundwater with metals, nitrates, and volatile organic compounds (VOCs) including trichloroethylene (TCE) and tetrachloroethylene (PCE) (GZA 2003, 2004). Prior to 1994, residences and commercial buildings along Creeper Hill Road and Faulkner Road in Grafton were served by private water supply wells; however, in June 1994 they were connected to the municipal water supply (GZA 1994).

Community concerns have also focused on the presence of hazardous waste and radioactive materials on the property. Residents have reported to MDPH that children have frequented contaminated areas of the property and some individuals have voiced concern that basement flood water in area homes may have been contaminated. The nature of soil contamination varies with former site use throughout the property. Petroleum hydrocarbons, polychlorinated biphenyls (PCBs), VOCs, and metals have been identified in soil from a number of different release areas as well as in some pond sediment and wetland soils. Dioxin has been detected in soils where a former refuse burn

area was located (GZA 2003). Approximately 50,000 pounds of radioactive magnesium-thorium waste is buried in unlined trenches in the northeast corner of the Wyman-Gordon property along Creeper Hill Road. On- and off-site groundwater samples and exposure measurements taken directly above the disposal area have generally shown radiation is present at background levels (NRC 1993).

METHODS FOR ANALYZING CANCER INCIDENCE

A. Case Identification/Definition

Cancer incidence data (i.e., reports of new cancer diagnoses) for the years 1982 – 2000 were obtained for the town of Grafton from the MCR, a division of the Center for Health Information, Statistics, Research and Evaluation within the MDPH. Ten cancer types were evaluated in this investigation, including cancers of the bladder, stomach, thyroid, kidney, liver, lung and bronchus, and bone as well as leukemia, multiple myeloma and non-Hodgkin's lymphoma (NHL). [Coding for cancer types in this report follows the International Classification of Diseases for Oncology (ICD-O) system. See Appendix A for the incidence coding definitions used in this report for these cancer types.] These cancer types were selected for evaluation based on elevations that were observed at the town level in a preliminary review of cancer rates in Grafton, potential associations with contaminants of concern at the Wyman-Gordon Company site (primarily TCE, PCE, nitrates and radioactive waste), and/or resident concern over suspected elevations of some cancer types. Only cases reported to the MCR as a primary cancer for one of the ten cancer types and diagnosed among a resident of Grafton were included in the analysis. Cases were selected for inclusion based on the address reported to the hospital or reporting medical facility at the time of diagnosis.

The MCR is a population-based surveillance system that began collecting information on Massachusetts residents diagnosed with cancer in the state in 1982. All newly diagnosed cancer cases among Massachusetts residents are required by law to be reported to the MCR within six months of the date of diagnosis (M.G.L. c.111 s.111b). This information is kept in a confidential database. Data are collected on a daily basis and are reviewed for

accuracy and completeness on an annual basis. This process corrects misclassification of data (i.e., city/town misassignment). Once these steps are finished, the data for that year are considered "complete." Due to the volume of information received by the MCR, the large number of reporting facilities, and the six-month period between diagnosis and required reporting, the most current registry data that are complete will inherently be a minimum of two years prior to the current date. The 19-year period 1982 – 2000 constitutes the period for which the most recent and complete cancer incidence data were available from the MCR at the time of this analysis.[1]

The term "cancer" is used to describe a variety of diseases associated with abnormal cell and tissue growth. Epidemiologic studies have revealed that different types of cancer are individual diseases with separate causes, risk factors, characteristics and patterns of survival (Berg 1996). Cancers are classified by the location in the body where the disease originated (the primary site) and the tissue or cell type of the cancer (histology). Therefore, each of the cancer types reviewed in this report was evaluated separately. Cancers that occur as the result of the metastasis or the spread of a primary site cancer to another location in the body are not considered as separate cancers and therefore were not included in this analysis.

B. Calculation of Standardized Incidence Ratios (SIRs)

To determine whether elevated numbers of cancer cases occurred in Grafton, cancer incidence data were tabulated by gender according to eighteen age groups to compare the observed number of cancer cases to the number that would be expected based on the statewide cancer rate. Standardized incidence ratios (SIRs) were then calculated for the period 1982 – 2000 for each of the ten primary cancer types for Grafton as a whole as well as for each census tract (CT) within Grafton. SIRs were also calculated for two smaller time periods, 1982 – 1990 and 1991 – 2000, in order to evaluate patterns or trends in cancer incidence over time.

[1] The data summarized in this report are drawn from data entered on MCR computer files before June 21, 2004. The numbers presented in this report may change slightly in future reports, reflecting late reported cases, address corrections, or other changes based on subsequent details from reporting facilities.

In order to calculate SIRs, it is necessary to obtain accurate population information. The population figures used in this analysis were interpolated based on 1980, 1990, and 2000 U.S. census data for each CT in Grafton and for the town as a whole (U.S. DOC 1980, 1990, and 2000). Midpoint population estimates were calculated for each time period evaluated (i.e., 1986, 1991 and 1996). To estimate the population between census years, an assumption was made that the change in population occurred at a constant rate throughout the ten-year interval between each census.[2]

Because accurate age group and gender specific population data are required to calculate SIRs, the CT is the smallest geographic area for which cancer rates can be accurately calculated. Specifically, a CT is a smaller statistical subdivision of a county as defined by the U.S. Census Bureau. CTs usually contain between 2,500 and 8,000 persons and are designed to be homogenous with respect to population characteristics (U.S. DOC 1990).

According to the U.S. Census, the town of Grafton is subdivided into four census tracts (i.e., CTs 7381 – 7384). Four individuals for whom census tract designation was not possible were included in the town totals for Grafton. It is important to note that Grafton CT 7384 also encompasses areas of Shrewsbury and Westborough, as well as a part of Grafton (refer to Figure 1). According to the data from the 2000 Census, less than 400 individuals reside in the Grafton portion of CT 7384. This small population results in expected numbers calculated for the ten cancer types that are equal to or close to zero for this CT.

C. Interpretation of a Standardized Incidence Ratio (SIR)

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 a larger comparison population designated as "normal" or average. Usually, the state as a whole is selected to

[2] Using slightly different population estimates or statistical methodologies, such as grouping ages differently or rounding off numbers at different points during calculations, may produce results slightly different from those published in this report.

be the comparison population. Using the state of Massachusetts as a comparison population provides a stable population base for the calculation of incidence rates.

Specifically, an SIR is the ratio of the observed number of cancer cases in an area to the expected number of cases multiplied by 100. The population structure of each town is adjusted to the statewide incidence rate to calculate the number of expected cancer cases. The SIR is a comparison of the number of cases in the specific area (i.e., city/town or census tract) to the statewide rate. Comparisons of SIRs between towns or census tracts are not possible because each community has different population characteristics.

An SIR of 100 indicates that the number of cancer cases observed in the population being evaluated is equal to the number of cancer cases expected in 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 cancer cases than the expected number; an SIR of 90 indicates 10% fewer cancer cases than expected.

Caution should be exercised, however, when interpreting an SIR. The interpretation of an SIR depends on both the size and the 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. 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. As a result of the instability of incidence rates based on small numbers of cases, SIRs were not calculated when fewer than five cases were observed for a particular cancer type.

D. Calculation of the 95% Confidence Interval

To help interpret or measure the stability of an SIR, the statistical significance of each SIR was assessed by calculating a 95% confidence interval (95% CI) to determine if the observed number of cases is “significantly different” from the expected number or if the

difference may be due solely to chance (Rothman and Boice 1982). Specifically, a 95% CI is the range of estimated SIR values that have 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 less than a 5% chance that the observed difference (either increase or decrease) 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), there is statistically significant excess 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), the number of cancer cases is statistically significantly lower than expected. If the confidence interval range includes 100, the true SIR may be 100. In this case, it cannot be determined with certainty that the difference between the observed and expected number of cases reflects a real cancer increase or decrease or is the result of chance. It is important to note that statistical significance does not necessarily imply public health significance. Determination of statistical significance is just one tool used to interpret SIRs.

In addition to the range of the estimates contained in the confidence interval, the width of the confidence interval also reflects the stability of the SIR estimate. For example, a narrow confidence interval, such as 103–115, allows a fair level of certainty that the calculated SIR is close to the true SIR for the population. A wide interval, for instance 85–450, leaves considerable doubt about the true SIR, which could be much lower than or much higher than the calculated SIR. This would indicate an unstable statistic. Again, due to the instability of incidence rates based on small numbers of cases, statistical significance was not assessed when fewer than five cases were observed.

E. Evaluation of Cancer Risk Factor Information

Available information reported to the MCR related to risk factors for cancer development was reviewed and compared to known or established incidence patterns for the cancer

types evaluated in this report. This information is collected for each individual at the time of cancer diagnosis and includes age at diagnosis, stage of disease, smoking history and occupation. One or even several factors acting over time can be related to the development of cancer. For example, tobacco use has been linked to lung and bronchus, bladder, and kidney cancers. Other cancer risk factors may include lack of crude fiber in the diet, high fat consumption, alcohol abuse, and reproductive history. Heredity, or family history, is an important factor for several cancers. To a lesser extent, some occupational exposures, such as jobs involving contact with asbestos, have been shown to be carcinogenic (cancer causing). Environmental contaminants have also been associated with certain types of cancer. Available information from the MCR related to age and gender, as well as other factors related to the development of cancer such as smoking and occupation, was reviewed for those cancer types that had statistically significant elevations in incidence in Grafton. These cancer types included NHL and bladder cancer. However, information about personal risk factors such as family history, hormonal events, diet, and other factors that may also influence the development of cancer is not collected by the MCR, and therefore, it was not possible to evaluate them in this investigation.

F. Determination of Geographic Distribution of Cancer Cases

In addition to calculation of SIRs, address at the time of diagnosis for each individual diagnosed with one of the ten cancer types was mapped using a computerized geographic information system (GIS) (ESRI 2002). This allowed assignment of census tract location as well as an evaluation of the spatial distribution of individuals at a smaller geographic level (i.e., neighborhoods). The geographic pattern was determined using a qualitative evaluation of the point pattern of cancer diagnoses. In instances where the address information from the MCR was incomplete (i.e., did not include specific streets or street numbers), efforts were made to research those cases using telephone books issued within two years of an individual's diagnosis. For confidentiality reasons, it is not possible to include maps showing the locations of individuals diagnosed with cancer in this report.

[Note: MDPH is bound by law not to reveal the name or identifying information of an individual diagnosed with cancer and reported to the MCR.]

G. Cancer Incidence in the Wyman-Gordon Neighborhood

Specific information on several Grafton residents diagnosed with cancer was provided to the MDPH from residents along with concerns about the Wyman-Gordon Company. Although it is not possible to calculate incidence rates beyond the year 2000 (i.e., the year for which complete data are available), the MCR is a continual surveillance system for cancer and it is possible to review case reports for more recent years (i.e., 2001 – present). Therefore, to address specific community concerns about a suspected increase in cancer incidence in neighborhoods in close proximity to the Wyman-Gordon Company site, MCR data files for residents who had been diagnosed with any cancer type from 1982 to the present were reviewed qualitatively for this area of Grafton. Specifically, to determine whether any cancer type appeared to be concentrated within this area of North Grafton, place of residence at the time of diagnosis was mapped and evaluated for all individuals diagnosed with cancer in the area that is bordered to the north by the Shrewsbury town line, to the northwest by the city of Worcester, to the west by the town of Millbury, to the south by Interstate 90 and Hovey Pond to the east (see Figures 1 and 2). As previously stated, for confidentiality reasons, maps of the location of individuals diagnosed with cancer cannot be provided in this report.

RESULTS OF CANCER INCIDENCE ANALYSIS

The following sections present cancer incidence rates for Grafton and its individual census tracts during the 19-year time period 1982 – 2000. A focus was placed on census tract 7383 where the Wyman-Gordon Company site is located. To evaluate possible trends over time, these data were also analyzed by two smaller time periods, 1982 – 1990 and 1991 – 2000. SIRs were not calculated for some cancer types in smaller time periods due to the small number of observed cases (less than five). However, the expected number of cases was calculated during each time period, and the observed and expected

numbers of cases were compared to determine whether excess numbers of cancer cases were occurring.

H. Cancer Incidence in Grafton

Of the ten cancer types evaluated in the town of Grafton as a whole, the majority occurred approximately equal to or less than expected during the 19-year time period 1982 – 2000 (see Tables 1a through 10c). Specifically, cancers of the bone, kidney, liver, lung and bronchus, stomach, and thyroid occurred at about or below the rates expected among males and females combined during 1982 – 2000. Slight elevations were noted in the incidence of bladder cancer, leukemia, multiple myeloma, and NHL among males and females combined during this time period; however none of the elevations were statistically significant. When evaluated separately by gender, a statistically significant elevation of NHL was observed among males during 1982 – 2000. Several non-statistically significant elevations were also observed. Specifically, bladder cancer and multiple myeloma were elevated among males, and leukemia incidence was elevated among females. When evaluated by the two smaller time periods, 1982 – 1990 and 1991 – 2000, similar trends in cancer incidence were observed however, none of the cancers analyzed were consistently elevated over time. Results of the cancer incidence analyses for each of the ten cancer types evaluated for the town of Grafton as a whole are described in more detail below.

1. Bladder Cancer

During the 19-year time period 1982 – 2000, bladder cancer occurred slightly more often than expected among residents of Grafton. Specifically, there were 44 diagnoses among males and females combined compared to 40.6 expected (SIR = 108). The overall rate was due to an elevation in incidence among males in the town (36 diagnoses observed vs. 30.0 expected, SIR = 120). Females were diagnosed less often than expected (8 diagnoses observed vs. 10.6 expected, SIR = 76). See Table 1a.

As shown in Tables 1b and 1c, the incidence of bladder cancer appears to have decreased over time among both male and female residents of Grafton. During 1982 – 1990, statistically significant elevations in the incidence of bladder cancer were observed among males and females combined (34 diagnoses observed vs. 18.9 expected, SIR = 180, 95% CI = 125-252) and among males when evaluated separately by gender (29 diagnoses observed vs. 14.0 expected, SIR = 208, 95% CI = 139-299). During the most recent time period evaluated, 1991 – 2000, bladder cancer occurred about half as often as expected based on the statewide experience. Specifically, 10 individuals were diagnosed with bladder cancer compared to 21.2 diagnoses expected (SIR = 47). Moreover the incidence was statistically significantly lower than expected (95% CI = 23-87). Similar trends were observed among males and females when evaluated separately by gender. Males in Grafton were diagnosed statistically significantly less often than expected during 1991 – 2000 (7 diagnoses observed vs. 15.6 expected, SIR = 45, 95% CI = 18-93). Females were also diagnosed less often than expected during this time period (3 diagnoses observed vs. 5.6 expected).

2. *Bone Cancer*

There were no diagnoses of bone cancer diagnosed among residents of Grafton during the 19-year time period, 1982 – 2000, compared to 2.5 diagnoses expected (Tables 2a – 2c).

3. *Kidney Cancer*

The incidence of kidney cancer occurred as expected in the town of Grafton as a whole during the 19-year time period 1982-2000 (25 observed diagnoses vs. 25.2 expected, SIR = 99). This was also true when males and females were evaluated separately. Specifically, for males, the number of observed diagnoses was 16 versus 15.7 expected, and for females, nine diagnoses were observed versus 9.6 expected. Refer to Table 3a.

When cancer incidence was examined for the smaller time periods, no trends were apparent among individuals diagnosed with kidney cancer in the town as a whole. Slightly more individuals were diagnosed with kidney cancer than expected during the

1982 – 1990 time period (12 observed vs. 9.4 expected, SIR = 127). This was due to an elevation among females (6 diagnoses observed vs. 3.6 expected, SIR = 165). Neither elevation was statistically significant. Males were diagnosed at about the rate expected (6 diagnoses observed vs. 5.8 expected, SIR = 104). During the 1991 – 2000 time period, the incidence of kidney cancer among males and females combined was slightly below expected (13 diagnoses observed vs. 15.8 expected). Refer to Tables 3b and 3c.

4. Leukemia

The incidence of leukemia was slightly elevated in the town of Grafton as a whole during 1982 – 2000 (25 diagnoses observed vs. 22 expected, SIR = 114). The observed elevation was largely due to an increase in diagnoses among residents of CT 7382, as discussed in Section IV.B of this report, but was not statistically significant. This is not the census tract where the Wyman-Gordon facility is located. Leukemia was diagnosed more often than expected among males and females combined during the earlier time period 1982 – 1990, (15 diagnoses observed vs. 8.6 expected, SIR = 175), but the elevation did not reach the level of statistical significance (95% CI = 98-289). In the more recent time period (1991 – 2000), the incidence of leukemia in Grafton occurred less often than expected for males, and at about the rate expected among females. Specifically, there were four diagnoses observed among males compared to 7.6 expected. Among females, there were 6 diagnoses observed and 5.9 expected. See Tables 4b – 4c.

There are four major types of leukemia: acute lymphoid leukemia (ALL), acute myeloid leukemia (AML), chronic lymphoid leukemia (CLL), and chronic myeloid leukemia (CML). There are also several rare types of leukemia (e.g., hairy cell leukemia, myelomonocytic leukemia). In adults, the most common types are AML and CLL. Leukemia is the most common type of childhood cancer, accounting for more than 30% of all cancers diagnosed in children. The majority of these cases are of the ALL type (ACS 2003). The various subtypes of leukemia are thought to represent different diseases and occur with different frequencies in the population. In the state of Massachusetts during the time period 1982–2000, 34% of all leukemia cases were AML, 26% were CLL, 13% were ALL, 11% were CML, and 16% were other histology types.

Of the 25 individuals diagnosed with leukemia in Grafton during 1982 – 2000, 32% were diagnosed with the AML sub-type, 28% were diagnosed with CLL, 16 % were diagnosed with ALL, 12% were diagnosed with CML, and 12% were diagnosed with other types of leukemia. This distribution is similar to that seen statewide.

5. *Liver Cancer*

The incidence of liver cancer occurred slightly less than expected for the town of Grafton, when compared to the state for the overall time period, 1982 – 2000 (5 diagnoses observed vs. 6.2 expected, SIR = 81) (see Table 5a).

One diagnosis occurred during the first time period 1982 – 1990, which was slightly less than expected (1 diagnosis observed vs. 2 expected). The majority of individuals diagnosed with liver cancer during the most recent time period 1991 – 2000 were males (4 individuals observed vs. 4.2 expected). Refer to Tables 5a – 5c for a summary of this information.

6. *Lung and Bronchus Cancer*

During the 19-year time period, 1982 – 2000, the incidence of lung and bronchus cancer occurred at approximately the rates expected in the town of Grafton. Specifically, among males and females combined, 156 diagnoses were observed whereas 157.5 were expected (SIR = 99) (Table 6a). Lung and bronchus cancer also occurred near the rates expected when males and females were evaluated separately. Specifically, among males, 91 diagnoses were observed whereas 94.5 would be expected (SIR = 96). Among females, 65 diagnoses were observed versus 63.0 expected (SIR = 103).

The incidence of lung and bronchus cancer also occurred as expected for the two smaller time periods. In the earlier time period, 1982 – 1990, 65 individuals were diagnosed while 65.3 diagnoses were expected (SIR = 100). This trend is consistent among both males and females and within the most recent time period. From 1991 – 2000, 91 individuals were diagnosed and 91.3 diagnoses were expected (SIR = 100) (see Tables 6b – 6c).

7. *Multiple Myeloma*

The incidence of multiple myeloma in the town of Grafton occurred slightly more often than expected for the time period 1982 – 2000 (12 diagnoses observed versus 9.2 expected, SIR = 130) (refer to Table 7a). This was due to an elevation that occurred among males during this time period (7 diagnoses observed vs. 4.8 expected, SIR = 145). Neither elevation was statistically significant. Females experienced multiple myeloma at approximately the rate expected during 1982 – 2000 (5 diagnoses observed vs. 4.4 expected).

For the earlier time period (i.e., 1982 – 1990), the incidence of multiple myeloma occurred at the rate expected for the town of Grafton as a whole (4 diagnoses observed vs. 3.9 expected). However, all four individuals diagnosed with multiple myeloma were males and no females were diagnosed during this time period, compared to two diagnoses each expected among males and females. More females were diagnosed with multiple myeloma than expected during the most recent time period, 1991 – 2000 (5 diagnoses observed vs. 2.5 expected, SIR = 200), but this elevation was not statistically significant. Males were diagnosed at the rate expected during this time period (3 diagnoses observed vs. 2.8 expected) (see Table 7b and 7c).

8. *Non-Hodgkin's Lymphoma*

The incidence of NHL was elevated in the town of Grafton as a whole during 1982 – 2000. Specifically, 45 individuals were diagnosed with NHL compared to 38.6 expected (SIR = 117) (see Table 8a). Moreover, males in Grafton experienced a statistically significant elevation in the incidence of this cancer type (31 diagnoses observed vs. 20.8 expected, SIR = 148, 95% CI = 101-211). The overall elevation observed during 1982 – 2000 was largely attributed to a statistically significant elevation in the incidence of this cancer type among males during the more recent time period 1991 – 2000 (24 diagnoses observed vs. 13.0 expected, SIR = 185, 95% CI = 118-275). The incidence of NHL was about as expected during the earlier time period, 1982 – 1990 (13 diagnoses observed vs. 14.5 expected). The number of females diagnosed with NHL was less than expected

during 1982 – 2000 and during the two smaller time periods evaluated (see Tables 8a – 8c).

9. Stomach Cancer

Stomach cancer occurred slightly less than expected in the town of Grafton during 1982 – 2000 based on the statewide cancer experience (18 diagnoses observed vs. 21.0 expected, SIR = 86). When evaluated separately by gender, stomach cancer occurred approximately equal to the rate expected among males, and less often among females than expected during this time.

When the smaller time periods were evaluated in comparison to the state, the number of observed diagnoses for males and females combined was equal to or lower than expected. During the first time period, 1982 – 1990, seven individuals were diagnosed with stomach cancer whereas 9.9 diagnoses were expected. The incidence for males and females combined was as expected in the later time period (i.e., 1991 – 2000). Specifically, eleven individuals were diagnosed with stomach cancer and 10.9 diagnoses were expected during this time period. The incidence of stomach cancer in Grafton appears to have increased slightly over time among males while remaining constant over time among females (see Tables 9a – 9c).

10. Thyroid Cancer

The incidence of thyroid cancer in Grafton was consistent with what would be expected for the time period 1982 – 2000. Specifically, 12 individuals were diagnosed with thyroid cancer versus 12.3 expected (SIR = 98). Females were diagnosed (8 diagnoses observed vs. 8.9 expected) more than males (4 diagnoses observed vs. 3.4 expected) during this time period. However, this is consistent with the statewide incidence patterns for this cancer type (see Table 10a).

Overall during 1982 – 1990, two diagnoses were observed compared to about four diagnoses expected. During 1991 – 2000, ten individuals were diagnosed with this

cancer type compared to 8.6 expected. The observed elevation was not statistically significant (see Tables 10b – 10c).

I. Cancer Incidence in Grafton Census Tracts

In general, with some exceptions noted below, residents of most Grafton census tracts experienced cancer approximately at or near the rates expected during 1982 – 2000 and during the smaller time periods evaluated in this report. Census tract 7384 had no observed cases of cancer of any of the cancer types examined, which is what would be expected based on comparison to the state. As previously noted, CT 7384 contains portions of Shrewsbury and Westborough and the number of individuals residing in the Grafton portion of this census tract is small.

1. Bladder Cancer

During the 19-year time period 1982 – 2000, there were slight elevations in the incidence of bladder cancer among residents of CTs 7381 and 7382. These were due to increased elevations among males in each of these CTs. In CT 7382, 21 males were diagnosed with bladder cancer compared to 14.8 expected (SIR = 142). This elevation was not statistically significant. The incidence of bladder cancer was below the rate expected in CT 7383 (where Wyman-Gordon is located) for the overall time period (8 diagnoses observed vs. 11.2 expected). Additionally, incidence was approximately at or below expected for females in CTs 7381, 7382 and 7383 as well as for males in CT 7383. See Table 1a.

A statistically significant elevation in the incidence of bladder cancer was observed for males and females combined in CT 7382 during the earlier time period 1982 – 1990 (19 diagnoses observed vs. 9 expected, SIR = 212, 95% CI 127-330). This elevation was due to a statistically significant elevation among males during this time (16 diagnoses observed vs. 6.6 expected, SIR = 243, 95% CI = 139-394). Bladder cancer was also slightly elevated among males in CTs 7381 and 7383 during 1982 – 1990, although neither elevation was statistically significant. There were fewer diagnoses of bladder

cancer than expected in the more recent time period, 1991 – 2000, in each of Grafton's four census tracts (see Tables 1b – 1c).

2. Bone Cancer

As noted above, there were no diagnoses of bone cancer among residents of Grafton during 1982 – 2000. See Tables 2a – 2c.

3. Kidney Cancer

Kidney cancer generally occurred about as expected in Grafton CTs 7381, 7382, 7383, and 7384 during 1982 – 2000 (see Table 3a). When males and females were evaluated separately, slightly more males were diagnosed with kidney cancer than expected in CTs 7381 and 7382. Specifically, in CT 7381, five males were diagnosed with kidney cancer, while 3.3 diagnoses were expected (SIR = 151). In CT 7382, nine diagnoses were observed and 8.0 were expected (SIR = 113). Neither elevation was statistically significant. In CT 7383, where Wyman-Gordon is located, the incidence of kidney cancer occurred at the rate expected among males and females combined during 1982 – 2000 and during each of the two smaller time periods. However, when evaluated separately by gender, the incidence of kidney cancer was slightly lower than expected among males and slightly greater than expected among females. Specifically, between 1982 – 2000, the incidence of kidney cancer among males was 2 diagnoses versus 4.4 expected and among females, 5 diagnoses versus 2.5 expected in CT 7383. Similar trends occurred in both smaller time periods (see Table 3b and 3c).

4. Leukemia

The incidence of leukemia was slightly elevated with respect to the state in one Grafton census tract (CT 7382) during the overall time period 1982 – 2000 (15 diagnoses observed vs. 11.2 expected, SIR = 134). However, this increase was not statistically significant (see Table 4a). The observed elevation was largely due to an increase during the 1982 – 1990 time period, which was also not statistically significant (8 diagnoses observed vs. 4.2 expected, SIR = 191). During the most recent time period, the incidence of leukemia in CT 7382 occurred at the rate expected. Additionally, these individuals

were diagnosed with different sub-types, which as previously mentioned, are thought to represent different diseases and occur with different frequencies in the population. In CT 7383, leukemia occurred approximately at or below the rates expected during 1982 – 2000 and the two smaller time periods. Refer to Tables 4b and 4c.

5. Liver Cancer

The incidence of liver cancer occurred at or slightly below what would be expected in all Grafton census tracts during the 19-year time period, 1982 – 2000. One individual was diagnosed with liver cancer in the town of Grafton as a whole during the earlier time period 1982 – 1990. This individual lived in CT 7383 at the time of diagnosis. Four diagnoses were reported in the later time period, with three individuals residing in CT 7382 and one in CT 7383. No diagnoses of liver cancer occurred in CT 7381 during either time period. Refer to Tables 5a – 5c for a summary of these data.

6. Lung and Bronchus Cancer

Lung and bronchus cancer occurred approximately as expected during 1982 – 2000 in each of the Grafton census tracts (see Table 6a). During the earlier time period 1982 – 1990, both CTs 7381 and 7383 had a lower incidence of lung and bronchus cancer than expected. Specifically, in CT 7381, there were 10 observed diagnoses versus 15.7 expected (SIR = 64). In CT 7383, where Wyman-Gordon is located, 18 individuals were diagnosed with lung and bronchus cancer compared to 18.8 diagnoses expected (SIR = 96). The SIR for lung and bronchus cancer was elevated in CT 7382 (37 diagnoses observed vs. 30.8 expected, SIR = 120). However, this elevation was not statistically significant. In contrast to trends observed during the first time period, lung and bronchus cancer was slightly elevated among males and females in CT 7381 during 1991 – 2000. Specifically, in CT 7381, there were 25 individuals diagnosed with lung and bronchus cancer versus 18.9 expected, SIR = 132. This elevation was not statistically significant. In CT 7383, lung and bronchus cancer occurred about as expected during 1991 – 2000 (25 diagnoses were observed versus 23.8 expected, SIR = 105). Refer to Tables 6a – 6c.

7. *Multiple Myeloma*

During the 19-year time period 1982 – 2000, no individuals were diagnosed with multiple myeloma in CT 7383, where Wyman-Gordon is located, compared to about 2.5 diagnoses expected. Multiple myeloma was slightly elevated in both census tracts 7381 and 7382 among males and females combined during the overall time period (refer to Table 7a). However, neither of these elevations was statistically significant.

During the 1982 – 1990 time period, four males and no females were diagnosed with multiple myeloma. Two of the males lived in CT 7381 and two lived in CT 7382. During the more recent time period 1991 – 2000, the incidence of multiple myeloma was slightly elevated with respect to the state rate among both males and females combined in census tracts 7381 and 7382. These elevations were not statistically significant. See Tables 7b and 7c.

8. *Non-Hodgkin's Lymphoma*

As previously stated, the town of Grafton had a statistically significant elevation in the incidence of NHL among males from 1982 – 2000 (31 diagnoses observed vs. 20.8 expected, SIR = 149, 95% CI 101-211). This elevation was largely due to non-statistically significant elevations in the incidence of this cancer type among males in CTs 7381, 7382 and 7383. In CT 7381, six males were diagnosed with NHL, while 4.4 diagnoses were expected (SIR = 136). In CT 7382, 15 males were diagnosed with NHL from 1982 – 2000 whereas 10.7 were expected (SIR = 140). In CT 7383, where Wyman-Gordon is located, there were 10 diagnoses observed among males versus 5.7 expected, SIR = 176. Females in each of these census tracts were diagnosed with NHL approximately as or less often than expected during 1982 – 2000 (see Table 8a).

During the earlier 1982 – 1990 time period, the number of individuals diagnosed with NHL was approximately equal to the number of expected in all Grafton census tracts. In the most recent time period, 1991 – 2000, a statistically significant elevation was observed in CT 7383 among males (8 diagnoses observed vs. 3.3 expected, SIR = 243,

95% CI 105-479). Slight elevations were also noted among males and females combined in CTs 7381 and 7382 during this time period. See Tables 8b and 8c.

9. Stomach Cancer

Stomach cancer occurred slightly less often than expected in Grafton CTs 7381 and 7382 and approximately as expected in CT 7383, where Wyman-Gordon is located, during the 19-year time period 1982 – 2000 (refer to Table 9a). Specifically, in CT 7381, among males and females combined, there were three diagnoses observed versus 4.9 expected. In CT 7382, nine diagnoses were observed and 10.4 were expected (SIR = 86). Six stomach cancer diagnoses were observed among residents of CT 7383, while 5.7 were expected (SIR = 105). See Table 9a.

When incidence was evaluated by smaller time periods, no diagnoses of stomach cancer were reported in CT 7381 during 1982-1990. The number of observed diagnoses of stomach cancer in the other census tracts was approximately equal to what was expected. During the more recent time period 1991 – 2000, stomach cancer occurred about as expected in all census tracts (see Tables 9b and 9c).

10. Thyroid Cancer

Thyroid cancer occurred about as expected in Grafton CTs 7381, 7382 and 7383 during the 19-year time period 1982 – 2000 (Table 10a). When evaluated by gender, the incidence of thyroid cancer occurred about as expected for males and females separately. No males were diagnosed with thyroid cancer during the 19-year time period in CT 7383, where Wyman-Gordon is located. The incidence among females occurred about as expected in this census tract between 1982 – 2000 (3 diagnoses observed vs. 2.2 expected).

During the earlier time period 1982 – 1990 no males were diagnosed with thyroid cancer in Grafton as a whole. Two females were diagnosed during this time period, one in CT 7382 (vs. two expected) and one in CT 7383 (vs. one expected). Although the number of individuals diagnosed with thyroid cancer increased town-wide from the earlier time

period to the later time period, this cancer type generally occurred approximately as expected when evaluated by census tract.

J. Review of Cancer Risk Factor Information

Studies have generally shown that different cancer types have different causes, patterns of incidence, risk factors, latency periods (period between exposure and development of disease), characteristics, and trends in survival. Available information from the MCR related to age and gender, as well as other factors related to the development of cancer such as smoking and occupation, was reviewed for those cancer types that had statistically significant elevations in incidence in Grafton, specifically, bladder cancer and NHL. Information for both of these cancer types was compared to known or established incidence trends to assess whether any unexpected patterns exist among these cases. For detailed information regarding risk factors associated with these cancer types please refer to Appendix B.

Tobacco use is a known or suggested causal risk factor in several types of cancer, including bladder cancer. Personal history of smoking for individuals diagnosed with this cancer type in Grafton during the years 1982 – 2000 was reviewed. However, results of smoking status analysis should be interpreted with caution because of the number of individuals for which smoking status was unknown.

In some studies, an association has been found with exposures to specific occupations and an increase in incidence of bladder cancer and NHL. Therefore, occupational information as reported by the MCR at the time of diagnosis was reviewed for individuals diagnosed with these two cancer types in Grafton to determine the role that occupational factors may have played in the development of these cancers. It should be noted, however, that occupational data reported to the MCR are generally limited to job title and often do not include specific job duty information that could further define exposure potential for individuals. Further, these data are often incomplete as occupational information can be reported as unknown, at home, or retired.

1. *Bladder Cancer*

To better characterize the incidence patterns of bladder cancer in Grafton, available data on individual risk factors from the MCR was reviewed. This section describes the review of information related to age and gender, smoking, and occupation.

a) *Age and Gender*

Age and gender are important risk factors in the development of bladder cancer. The risk of bladder cancer increases with age and the average age of diagnosis is 68-69 years. Furthermore, according to the American Cancer Society (ACS), males are more likely to develop bladder cancer than females. During 1982 – 2000, the observed age and gender distribution of individuals diagnosed with bladder cancer in Grafton was consistent with this trend, as the average age of diagnosis among Grafton residents was approximately 69 years and 82% of individuals diagnosed were males.

For the earlier 1982 – 1990 time period, there was a statistically significant elevation in the incidence of bladder cancer among males in the town as a whole. The average age of diagnosis for males during this time was 69 years. Similar trends were observed in Grafton census tracts where elevations in this cancer type were observed. Among males in CT 7382 where a statistically significant elevation in the incidence of bladder cancer was observed during this time period, the average age of individuals diagnosed was 72 years.

b) *Smoking History*

Because cigarette smoking is the most well-established risk factor for the development of bladder cancer, smoking history was reviewed for each individual diagnosed with this cancer type in Grafton, including CT 7382 where a statistically significant elevation in bladder cancer incidence occurred among males. Approximately 25-60% of all bladder cancers can be attributed to tobacco use (Johansson and Cohen, 1997). Of the 44 individuals diagnosed with bladder cancer in Grafton during 1982 – 2000, 72% of those

with known smoking history were current/former smokers (n = 28). This is a larger percentage than the 67% of individuals diagnosed with bladder cancer in Massachusetts during the same time period with known smoking history who were current/former smokers. Therefore, smoking appears to have played a greater role in the incidence of bladder cancer among residents of Grafton in comparison to the state as a whole.

c) Occupation

Occupational exposure to certain chemicals common in the dye industry (e.g., aromatic amines) is associated with the development of bladder cancer. A higher risk of bladder cancer has also been observed among aromatic amine manufacturers as well as among workers in the rubber, leather, textiles, printing, and paint products industries (ACS, 2000; Silverman et al., 1996). A review of occupational information reported to the MCR for individuals diagnosed with bladder cancer in Grafton during 1982 – 2000 indicated that three individuals had an occupation where job exposures thought to increase the risk of bladder cancer might have been possible. No one else reported working jobs in which occupational exposures related to bladder cancer would have been likely. However, occupation was unknown or reported as retired or "at home" for 23% of individuals in Grafton diagnosed with bladder cancer during 1982 – 2000. Therefore, although the information reviewed suggests the possibility that occupational exposures may have contributed to the development of bladder cancer among some individuals, it is difficult to determine what role, if any, occupational exposures played in the incidence of bladder cancer in Grafton overall.

2. NHL

The exact causes of NHL are unknown, however, a number of risk factors have been associated with this disease. Besides age, gender and race, the most important risk factors for NHL include conditions that suppress the immune system and viral infections (Scherr and Mueller, 1996). Certain occupational exposures have also been suggested as having an increased risk of NHL. Previous chemotherapy combined with radiation has been associated with the development of NHL (Schottenfeld and Fraumeni, 1996). Ionizing

radiation has induced lymphomas in animals. One study of Japanese atomic bomb survivors found an elevation of NHL in persons who were under 25 years of age at exposure; however, this excess did not appear until 14 to 16 years after exposure. Certain therapeutic radiation treatments have also been associated with the development of NHL (Schottenfeld and Fraumeni, 1996).

In order to better understand the pattern of NHL incidence in Grafton, available information from the MCR related to risk factors for individuals diagnosed with this cancer were evaluated. Such information included individual case information relating to age at diagnosis, histology (cancer cell type), and occupation. The information was compared to established incidence trends to determine whether an atypical pattern of NHL might exist. As previously stated, one or even several factors acting over time can be related to the development of cancer. However, information about personal risk factors that may also influence the development of NHL (e.g., conditions that suppress the immune system, exposure to the Epstein-Barr Virus) are not collected by the MCR or any other readily accessible source, and therefore, could not be evaluated in this investigation.

a) Age and Gender

NHL can affect people of all ages, although the incidence of NHL increases with age. In Massachusetts, incidence rates of NHL begin to increase in the 45 to 64 year age group and are highest in the 75 to 84 year age group. The majority of individuals (approximately 78%) diagnosed with NHL between the years 1982 – 2000 in Grafton were aged 50 and older and the average age of diagnosis was approximately 62 years. In CT 7383, where a statistically significant elevation occurred in the incidence of NHL among males during the later time period, 75% were over 50 years old at diagnosis and the average age at diagnosis for males was approximately 64 years old.

In addition, all types of NHL occur more frequently among males compared to females (NCI, 1996b). Review of gender of individuals diagnosed with NHL in Grafton between the years 1982 – 2000 was consistent with this trend; approximately 69% were males.

b) *Histology*

In general, each diagnosis of cancer is classified by its histology, which is the tissue or cell type of the cancer. Tumors that develop as a result of NHL consist of abnormal, malignant lymphoid cells – either T cells or, more commonly, B cells – originating in the lymphoid tissue. Lymphoid tissue is found in many places throughout the body. As a result, there are many different kinds of NHL that can originate almost anywhere in the body. The various subtypes of NHL are thought to represent different diseases with different causes, clinical characteristics, survival rates and response to treatments (Hauke and Armitage, 2000; Scherr and Mueller, 1996).

Specific information related to histology was reviewed for each individual in Grafton who had been diagnosed with NHL to determine if any similarities existed, which could suggest a common pattern related to these cancers. In addition, a recent study examined the patterns and trends of NHL subtypes in the U.S. population, using six major NHL sub-types that included: small lymphocytic, follicular, diffuse, high-grade, peripheral T-cell and not otherwise specified (NOS) (Groves et al, 2000). The NOS sub-type represents a category of malignant lymphomas that includes cases for which more detailed classification is not available. The distribution of NHL diagnoses in Grafton was examined using these six major subtypes and compared to the distribution of all Massachusetts residents diagnosed with NHL from 1982 – 2000. A comparison of the distribution of NHL cases by subtype is presented in Table 11.

The distribution of NHL diagnoses by sub-type in Grafton was generally consistent with the distribution in Massachusetts. The diffuse sub-type represented the most common type among Grafton residents with 60% diagnosed with this sub-type during 1982 – 2000. The percentage of individuals with the diffuse and small lymphocytic sub-types of NHL in Grafton was greater than observed in the state (see Table 11). Specifically, the percentage of individuals in Grafton with the diffuse type of NHL was 60% while the state percentage was 44.1%. The percentage of individuals in Grafton diagnosed with the small lymphocytic type of NHL was 13% compared to the state percentage of 9%. The

percentage of individuals with each other sub-type of NHL was less than the state distribution percentages.

In CT 7383, where a statistically significant elevation of NHL was observed among males during the 1991 – 2000 time period, six of the eight individuals (75%) were diagnosed with the diffuse NHL sub-type. The two remaining individuals were diagnosed with two different sub-types.

c) Occupation

The exact causes of NHL remain unknown but some occupations have been associated with an increased risk of developing this cancer type, specifically occupations related to agriculture and farming. Farmers, herbicide and pesticide applicators, and grain workers appear to have the most increased risk due to more intense and prolonged exposures to chemicals than would be experienced by the general public (Tatham et al., 1997; Zahm, 1990 and 1993). Occupational information as reported to the MCR, at the time of diagnosis was reviewed for all residents of Grafton who were diagnosed with NHL during the 19-year time period of 1982 – 2000. Review of this information revealed that approximately 18% of individuals reported their occupation as retired or at home. An additional 9% did not have an occupation listed or their occupation was unknown at the time of diagnosis. Of the remaining 73%, the majority of individuals indicated a job title that did not suggest an association with possible exposures related to the development of NHL or did not have specific enough information to determine whether their occupation may be associated with exposures that could possibly increase the risk of NHL. Occupations where exposures possibly related to an increased risk of NHL may have occurred were reported for two individuals in Grafton.

d) Previous Cancer Diagnoses

As mentioned above, patients who are treated with radiation therapy and/or chemotherapy for other cancers have a slight risk of developing secondary NHL later in life. Review of data from the MCR identified seven individuals (16%) diagnosed with

NHL in Grafton during 1982 – 2000 who had a previous cancer diagnosis reported to the MCR. These patients may have received treatment for their initial cancer that could have contributed to their subsequent NHL diagnosis (e.g., radiation therapy or chemotherapy). However, because medical records were not readily available, it is not possible to determine whether these individuals actually received radiation therapy or chemotherapy for their cancer.

K. Geographic Distribution of the Cancer Incidence in Grafton

In addition to determining census tract-specific incidence rates for each of the ten cancer types, a qualitative evaluation was conducted to determine whether the individuals diagnosed with these cancers appeared to be spatially concentrated in any one area of Grafton during the time period evaluated in this report, 1982 – 2000. Specifically, place of residence at the time of diagnosis was mapped for all individuals diagnosed with cancers of the bladder, stomach, thyroid, kidney, liver, lung and bronchus, and bone as well as leukemia, multiple myeloma and NHL to assess any possible geographic concentration of cases.

In general, review of the geographic distribution of cancer diagnoses in Grafton revealed no apparent spatial patterns at the neighborhood level that could not be attributed to factors such as areas of higher population density. For example, although a statistically significant elevation of bladder cancer among males was observed in both CT 7382 and the town as a whole during the 1982 – 1990 time period, the diagnoses were fairly evenly distributed throughout the town and seemed to coincide closely with the pattern of population. A similar trend was observed when looking at the distribution of residences of males diagnosed with NHL in the later time period when a statistically significant elevation occurred town-wide and in CT 7383. Specifically, the distribution of individuals diagnosed with NHL varied geographically and no atypical patterns were noted that would suggest the presence of a common factor.

L. Cancer Incidence in Neighborhoods near Wyman-Gordon

To further address the concerns of residents living in close proximity to the Wyman-Gordon Company, an analysis of all types of cancer diagnosed in this neighborhood was completed for the years 1982 to the present. The company is located in the northwestern portion of Grafton bordering the town of Millbury and the city of Worcester. For this evaluation, the pattern of all cancer diagnoses was reviewed for the area that is bordered to the east by Hovey Pond and Northgate Court, to the south by Interstate 90 (Massachusetts Pike), to the west by the Millbury town line and to the north by Flint Pond (see Figure 2). Thirty different streets, in part or whole, are included in this area. In general, our review found no atypical pattern of cancer in the neighborhood surrounding the Wyman-Gordon Company site. From 1982 – present, a total of 18 different types of cancer were diagnosed among residents of this area, representing the occurrence of many different of diseases.

The most commonly reported diagnoses included cancers of the lung and bronchus, breast, prostate, and colon/rectum. These are the four most common types of cancer diagnosed among men and women in Massachusetts and this pattern is consistent with national and statewide trends in cancer incidence (ACS, 2002b). Together, these cancer types represented more than half (59%) of the cancer diagnoses in this area. There were also a number of other cancer types diagnosed among residents of this area of Grafton over the 22 year period reviewed including cancers of the bladder, bone, cervix, esophagus, kidney, liver, oral cavity and pharynx, ovary, pancreas, thyroid, and uterus as well as Hodgkin's disease, leukemia, melanoma of the skin, and Non-Hodgkin's Lymphoma. However, the types of cancer that occurred varied in nature and there was no specific pattern or geographic concentration of any one cancer type within this neighborhood. Also, the years of diagnosis for these individuals varied throughout the 22 years reviewed, indicating no apparent trend or pattern in the time of diagnosis.

The majority of cancer types diagnosed among residents of the neighborhood surrounding the Wyman-Gordon Company site are predominantly associated with non-environmental factors such as family history, smoking, diet, and other lifestyle behaviors.

Because the MCR collects some information related to risk factors (e.g., smoking history) for individuals diagnosed with cancer, this data was reviewed to better characterize the incidence patterns of cancer in this area of Grafton. This included a review of age at diagnosis, gender, smoking history, and occupation.

Age is an important risk factor in many cancers. Different cancers occur with different frequencies among the various age groups, and most cancer types occur more frequently in older populations (i.e., age 50 and over). The average age at diagnosis among individuals in this neighborhood with any type of cancer was 64 and the majority of individuals (86%) were age 50 or older when they were diagnosed. Review of the age and gender pattern among these individuals indicates that the incidence of cancer in this area is consistent with established prevalence patterns of disease in the general population. Because cigarette smoking is also an important risk factor in the development of several cancer types, including cancers of the lung and bronchus, oral and pharynx, esophagus, colon/rectum, bladder, kidney, stomach, and pancreas, smoking history was reviewed for each individual in the Wyman-Gordon Company site area who had been diagnosed with a smoking related cancer. Of the 44 individuals with a smoking-related cancer, 26 (59%) reported being current or former smokers at the time of diagnosis, nine were non-smokers, and smoking history was unknown for nine individuals. Therefore, it is likely that smoking played a role in the development of cancer among some residents of the neighborhood surrounding the Wyman-Gordon Company. In addition, some occupational exposures, such as jobs involving contact with chemicals, have been associated with an increased risk for developing certain types of cancer. A review of occupation as reported to the MCR showed that some of the individuals diagnosed with cancer in this area of Grafton worked in jobs that could be related to an increased risk for developing their cancer. Finally, analysis of the geographic distribution of place of residence for individuals diagnosed with cancer did not reveal any atypical spatial patterns that would suggest an association with a common factor in the town of Grafton as a whole or in the neighborhoods surrounding the Wyman-Gordon Company.

The diagnoses of several individuals who were reported to the CEH by residents who expressed concerns about cancer and the Wyman-Gordon Company could not be confirmed through the MCR. There are several possible reasons for this. Some of these individuals may have been diagnosed prior to 1982 when the MCR began collecting information on individuals in the state diagnosed with cancer. It is also possible that some individuals resided at an address at the time of their diagnosis other than the one reported to the CEH by residents concerned about the Wyman-Gordon Company. Finally, some of these individuals may have actually been diagnosed with non-invasive cancer types (i.e., benign tumors) or other pre-cancerous or non-cancerous conditions. Such individuals would not be included in the MCR data files.

DISCUSSION AND CONCLUSIONS

According to American Cancer Society statistics, cancer is the second leading cause of death in Massachusetts and the United States. Not only will one out of three people develop cancer in their lifetime, but this tragedy will affect three out of every four families. For this reason, cancers often appear to occur in "clusters," and it is understandable that someone may perceive that there are an unusually high number of cancer cases in their surrounding neighborhoods or towns. Upon close examination, many of these "clusters" are not unusual increases, as first thought, but are related to such factors as local population density, variations in reporting or chance fluctuations in occurrence. In other instances, the "cluster" in question includes a high concentration of individuals who possess related behaviors or risk factors for cancer. Some, however, are unusual; that is, they represent a true excess of cancer in a workplace, a community, or among a subgroup of people. A suspected cluster is more likely to be a true cancer cluster if it involves a large number of cases of one type of cancer diagnosed in a relatively short time period rather than several different types diagnosed over a long period of time (i.e., 20 years), a rare type of cancer rather than common types, and/or a large number of cases diagnosed among individuals in age groups not usually affected by that cancer. These types of clusters may warrant further public health investigation.

Based on the information reviewed in this report, there does not seem to be an atypical pattern of cancer in the town of Grafton as a whole, or in any of the census tracts or the neighborhood surrounding the Wyman-Gordon Company site. As mentioned previously, the ten cancer types evaluated were chosen based on town-wide elevations observed in previously published MCR reports, potential associations with contaminants of concern at the Wyman-Gordon Company site, and/or resident concern. Although there were elevations in some cancer types during certain time periods, in general, the incidence of cancer occurred about as expected when compared to the state as a whole. When elevations did occur, the majority were not statistically significant. In addition, it does not appear that any one environmental factor played an important role in the occurrence of cancer during this time.

There was a statistically significant elevation in the incidence of bladder cancer among males in Grafton during the earlier time period, 1982 – 1990. However, based on the information reviewed, it appears that the incidence of bladder cancer has decreased over time. Specifically, in the most recent time period evaluated, the incidence of bladder cancer occurred statistically significantly below the rate expected. A review of available information on smoking status for individuals diagnosed with bladder cancer indicated that more Grafton residents diagnosed with bladder cancer were current or former smokers compared to the state as a whole. A statistically significant elevation in the incidence of NHL among males occurred during the later time period in CT 7383, where Wyman-Gordon is located. As mentioned previously, risk factors for this cancer type include age, occupation, and radiation exposure. In addition, recent studies suggest that their may be a link between NHL and drinking water contaminated with nitrates (Ward et al., 1996). In 1993, a nitric acid spill occurred at the Wyman-Gordon Company site that released 2,500 gallons of nitric acid into the groundwater. Testing of private wells on Creeper Hill and Faulkner Roads showed contamination of nitrate in these wells. The private wells were closed and residents were connected to town water in 1994. Although NHL was statistically elevated among males in CT 7383 during the more recent time period, none of the individuals diagnosed with NHL had an address located on Creeper Hill and Faulkner Roads at the time of diagnosis. Therefore, based on the locations of individuals diagnosed with NHL in this census tract and the short period of time that the

contaminated private wells were in use, it is very unlikely that the 1993 nitric acid spill at the Wyman-Gordon company site played a role in the elevation of NHL in this CT.

In general, the analysis of the geographic distribution of place of residence for individuals diagnosed with cancer did not reveal any atypical spatial patterns that would suggest a common factor (environmental or non-environmental) is related to the incidence of cancer in the town of Grafton during the 19-year time period 1982 – 2000. Moreover, no unusual concentrations of individuals diagnosed with cancer (including cancer types with a potential association with exposure to nitrates and VOCs) were observed in the vicinity of the Wyman-Gordon Company.

Based on the results of this investigation, the MDPH does not recommend any further evaluation of cancer incidence in Grafton in relation to the Wyman-Gordon Company at this time. However, the MDPH will continue to monitor the incidence of all cancer types in the town through city/town cancer incidence reports published by the Massachusetts Cancer Registry.

REFERENCES

American Cancer Society. 2000. Bladder Cancer. Available at: http://www3.cancer.org/cancerinfo/.

American Cancer Society (ACS). 2002b. Lung Cancer. Available at: http://www.cancer.org.

Berg JW. 1996. Morphologic classification of human cancer. In: Cancer Epidemiology and Prevention. Schottenfeld D and Fraumeni JF Jr (eds). New York: Oxford University Press, 1996:28-44.

Environmental Systems Research Institute (ESRI). 2002. ArcGIS, Arcview license, ver. 8.3, Redlands, California.

Groves FD, Linet MS, Travis LB and Devesa SS. 2000. Cancer Surveillance Series: Non-Hodgkin's Lymphoma Incidence by Histologic Subtype in the United States From 1978 through 1995. J Nat Canc Inst 92 (15): 1240-51.

GZA 2004. GZA GeoEnvironmental, Inc. Phase II – Comprehensive Site Assessment Risk Characterization Eastern Area RTN 2-00535. February, 2004.

GZA 2003. GZA GeoEnvironmental, Inc. Risk Assessment Scope of Work Wyman-Gordon Company West Side Risk Characterization Grafton/Millbury, Massachusetts RTN 2-00535. August, 2003.

GZA 1998. GZA GeoEnvironmental, Inc. Preliminary Assessment – Bonny Brook and Flint Pond. Wyman-Gordon Company North Grafton, Massachusetts. June, 1998.

GZA 1994. GZA GeoEnvironmental, Inc. Addendum 2 – Work Plan for Additional Studies VOC and Nitrate Water Study. Wyman-Gordon North Grafton Plant. October, 1994.

Hauke RJ and Armitage JO. 2000. A New Approach to Non-Hodgkin's Lymphoma. Internal Medicine 39(3): 197-208.

Johansson SL and Cohen SM. 1997. Epidemiology and etiology of bladder cancer. Semin Surg Oncol 13:291-298.

NCI. 1996b. Cancer Rates and Risks. 4th ed. National Cancer Institute, National Institutes of Health, Publication No. 96-691.

NRC 1990. Letter from U.S. Nuclear Regulatory Commission to Defense Logistics Agency. May 13, 1993.

Rothman K and Boice J. 1982. Epidemiological Analysis with a Programmable Calculator. Boston: Epidemiology Resources, Inc. 1982.

Scherr PA and Mueller NE. Non-Hodgkin's Lymphomas. 1996. In: Cancer Epidemiology and Prevention. 2nd Ed, edited by Schottenfeld D, Fraumeni. JF. New York: Oxford University Press: 1996.

Schottenfeld, D., and J.F. Fraumeni. 1996. Cancer Epidemiology and Prevention. 2nd ed. New York: Oxford University Press, 1996.

Silverman D, Morrison A, and Devesa S. Bladder Cancer. 1996. In: Cancer Epidemiology and Prevention. 2nd Ed, edited by Schottenfeld D, Fraumeni. JF. New York: Oxford University Press: 1996.

Tatham L, Tolbert P, and Kjeldsberg C. 1997. Occupational risk factors for subgroups of non-Hodgkin's lymphoma. Epidemiology 8(5): 1551-8.

U.S. Department of Commerce (U.S. DOC). 1980. Census of Population: General Population Characteristics, Massachusetts. U.S. Department of Commerce, Washington, DC: US Gov't Printing Office.

U.S. DOC. 1990. Census of Population: General Population Characteristics, Massachusetts. U.S. Department of Commerce, Washington, DC: US Gov't Printing Office.

U.S. DOC. 2000. Census of Population: General Population Characteristics, Massachusetts. U.S. Department of Commerce, Washington, DC: US Gov't Printing Office.

Ward MH, Mark SD, Cantor KP, Weisenburger DD, Correa-Villasenor A, Zahm SH. 1996. Drinking water nitrate and the risk of non-Hodgkin's lymphoma. Epidemiology 7(6):465-71.

Zahm SH, Weisenburger DD, Babbit PA, Saal RC, Vaught JB, Cantor KP, et al. 1990. A case-control study of non-Hodgkin's lymphoma and the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) in Eastern Nebraska. Epidemiology 1(5): 349-56.

Zahm SH, Weisenburger DD, Saal RC, Vaught JB, Babbit PA, and Blair A. 1993. The role of agricultural pesticide use in the development of non-Hodgkin's lymphoma in women. Archives of Environmental Health 48(5): 353-8.

Figure 1
Location of 1990 Census Tracts in Grafton, Massachusetts

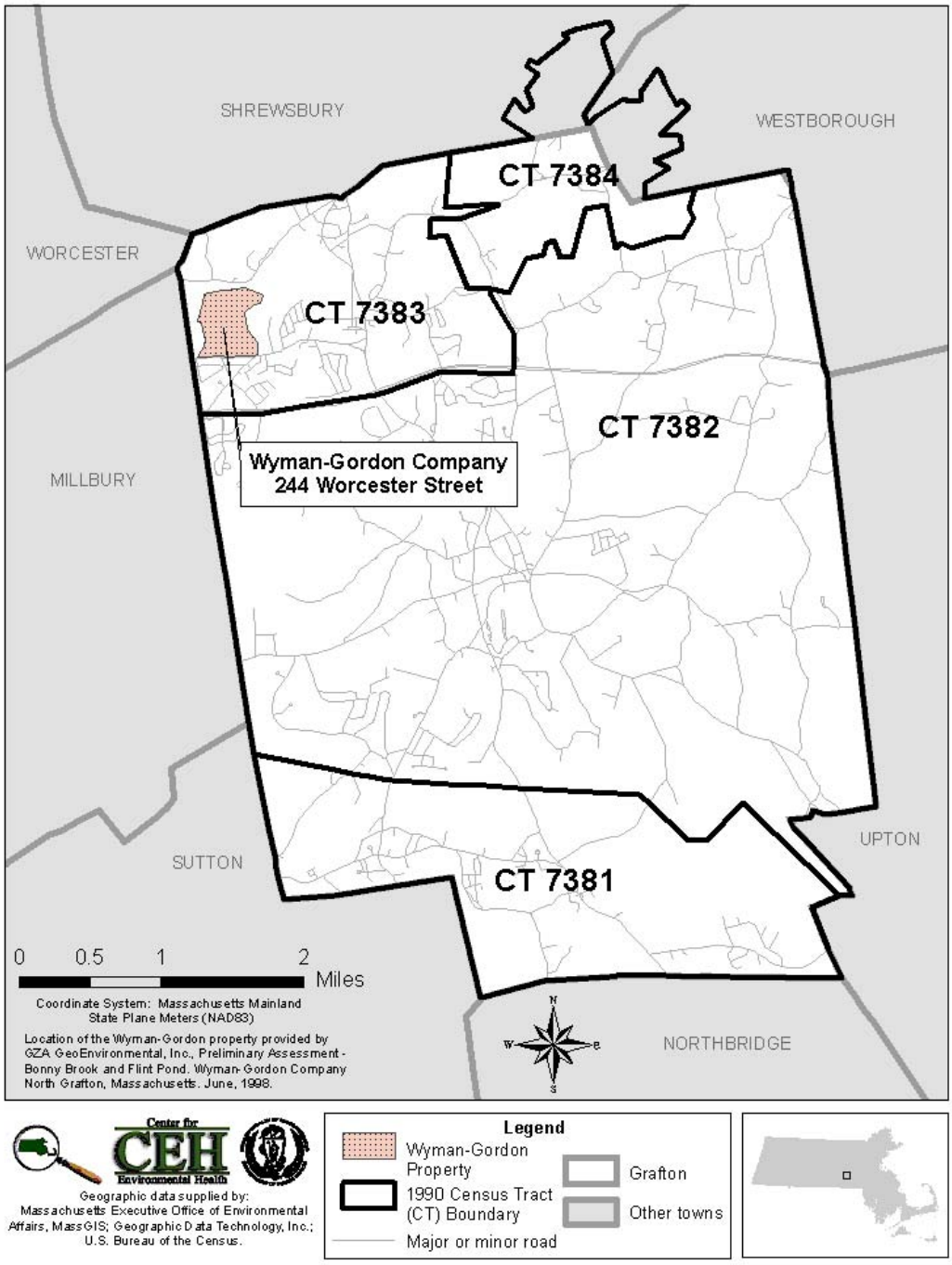
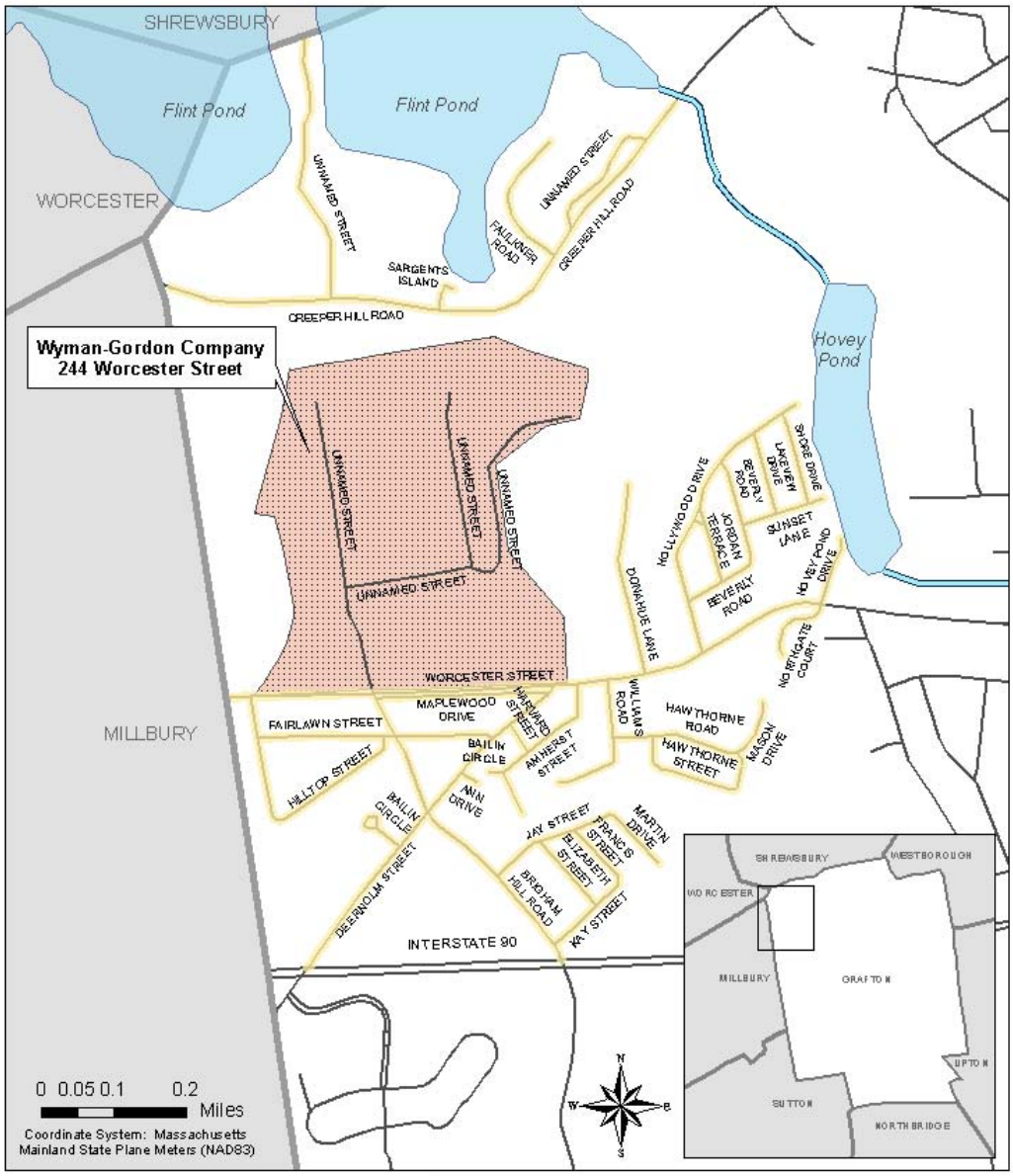


Figure 2
Area of Concern in Grafton, Massachusetts



Center for CEH Environmental Health

Geographic data supplied by:
Massachusetts Executive Office of Environmental Affairs, MassGIS;
Geographic Data Technology, Inc.; U.S. Bureau of the Census.

Legend

- Study street selection
- Wyman-Gordon Property
- Lake or pond
- River or stream
- Major or minor road
- Grafton
- Other towns

Location of the Wyman-Gordon property provided by GZA GeoEnvironmental, Inc., Preliminary Assessment - Bonny Brook and Flint Pond. Wyman-Gordon Company North Grafton, Massachusetts. June, 1998.

TABLE 1a
Bladder Cancer Incidence
Grafton, MA
1982-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	11	9.4	117	59 -- 210	8	6.8	118	51 -- 232	3	2.6	NC	NC -- NC
7382	25	20.0	125	81 -- 184	21	14.8	142	88 -- 217	4	5.2	NC	NC -- NC
7383	8	11.2	71	31 -- 140	7	8.5	83	33 -- 170	1	2.8	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	44	40.6	108	79 -- 146	36	30.0	120	84 -- 166	8	10.6	76	33 -- 149

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 1b
Bladder Cancer Incidence
Grafton, MA
1982-1990

Census Tract	Total					Males					Females				
	Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI	
7381	9	4.7	193	88	366	7	3.4	205	82	421	2	1.2	NC	NC	NC
7382	19	9.0	212 *	127	330	16	6.6	243 *	139	394	3	2.4	NC	NC	NC
7383	6	5.2	115	42	250	6	3.9	153	56	333	0	1.3	NC	NC	NC
7384	0	0.0	NC	NC	NC	0	0.0	NC	NC	NC	0	0.0	NC	NC	NC
Town Total	34	18.9	180 *	125	252	29	14.0	208 *	139	299	5	4.9	101	33	236

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 1c
Bladder Cancer Incidence
Grafton, MA
1991-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	2	4.4	NC	NC -- NC	1	3.1	NC	NC -- NC	1	1.3	NC	NC -- NC
7382	6	11.1	54	20 -- 117	5	8.2	61	20 -- 142	1	2.9	NC	NC -- NC
7383	2	5.6	NC	NC -- NC	1	4.2	NC	NC -- NC	1	1.4	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	10	21.2	47	* 23 -- 87	7	15.6	45	* 18 -- 93	3	5.6	NC	NC -- NC

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 2a
Bone Cancer Incidence
Grafton, MA
1982-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	0	0.5	NC	NC -- NC	0	0.3	NC	NC -- NC	0	0.2	NC	NC -- NC
7382	0	1.3	NC	NC -- NC	0	0.7	NC	NC -- NC	0	0.6	NC	NC -- NC
7383	0	0.6	NC	NC -- NC	0	0.3	NC	NC -- NC	0	0.3	NC	NC -- NC
7384	0	0.1	NC	NC -- NC	0	0.1	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	0	2.5	NC	NC -- NC	0	1.3	NC	NC -- NC	0	1.1	NC	NC -- NC

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 2b
Bone Cancer Incidence
Grafton, MA
1982-1990

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	0	0.2	NC	NC -- NC	0	0.1	NC	NC -- NC	0	0.1	NC	NC -- NC
7382	0	0.6	NC	NC -- NC	0	0.3	NC	NC -- NC	0	0.3	NC	NC -- NC
7383	0	0.3	NC	NC -- NC	0	0.2	NC	NC -- NC	0	0.1	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	0	1.1	NC	NC -- NC	0	0.6	NC	NC -- NC	0	0.5	NC	NC -- NC

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 2c
Bone Cancer Incidence
Grafton, MA
1991-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	0	0.3	NC	NC -- NC	0	0.1	NC	NC -- NC	0	0.1	NC	NC -- NC
7382	0	0.7	NC	NC -- NC	0	0.4	NC	NC -- NC	0	0.3	NC	NC -- NC
7383	0	0.3	NC	NC -- NC	0	0.2	NC	NC -- NC	0	0.1	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	0	1.3	NC	NC -- NC	0	0.7	NC	NC -- NC	0	0.6	NC	NC -- NC

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 3a
Kidney Cancer Incidence
Grafton, MA
1982-2000

Census Tract	Total					Males					Females				
	Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI	
7381	6	5.6	108	39	-- 235	5	3.3	151	49	-- 352	1	2.2	NC	NC	-- NC
7382	12	12.8	94	48	-- 164	9	8.0	113	51	-- 214	3	4.8	NC	NC	-- NC
7383	7	6.9	101	40	-- 208	2	4.4	NC	NC	-- NC	5	2.5	198	64	-- 461
7384	0	0.0	NC	NC	-- NC	0	0.0	NC	NC	-- NC	0	0.0	NC	NC	-- NC
Town Total	25	25.2	99	64	-- 146	16	15.7	102	58	-- 166	9	9.6	94	43	-- 179

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 3b
Kidney Cancer Incidence
Grafton, MA
1982-1990

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	3	2.2	NC	NC -- NC	2	1.3	NC	NC -- NC	1	0.9	NC	NC -- NC
7382	6	4.5	132	48 -- 288	4	2.8	NC	NC -- NC	2	1.7	NC	NC -- NC
7383	3	2.7	NC	NC -- NC	0	1.7	NC	NC -- NC	3	1.0	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	12	9.4	127	66 -- 223	6	5.8	104	38 -- 226	6	3.6	165	60 -- 359

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 3c
Kidney Cancer Incidence
Grafton, MA
1991-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	3	3.2	NC	NC -- NC	3	1.9	NC	NC -- NC	0	1.3	NC	NC -- NC
7382	6	8.6	69	25 -- 151	5	5.4	92	30 -- 215	1	3.2	NC	NC -- NC
7383	4	4.0	NC	NC -- NC	2	2.5	NC	NC -- NC	2	1.5	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	13	15.8	82	44 -- 140	10	9.9	102	49 -- 187	3	6.0	NC	NC -- NC

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 4a
Leukemia Incidence
Grafton, MA
1982-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	4	4.9	NC	NC -- NC	3	2.8	NC	NC -- NC	1	2.2	NC	NC -- NC
7382	15	11.2	134	75 -- 221	6	6.4	94	34 -- 204	9	4.8	188	86 -- 356
7383	4	5.8	NC	NC -- NC	3	3.4	NC	NC -- NC	1	2.4	NC	NC -- NC
7384	0	0.1	NC	NC -- NC	0	0.1	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total†	25	22.0	114	73 -- 168	13	12.6	103	55 -- 176	12	9.4	128	66 -- 223

† Cases for which census tract designation was not possible are included in the town total.

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 4b
Leukemia Incidence
Grafton, MA
1982-1990

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	3	2.0	NC	NC -- NC	2	1.2	NC	NC -- NC	1	0.9	NC	NC -- NC
7382	8	4.2	191	82 -- 376	4	2.4	NC	NC -- NC	4	1.8	NC	NC -- NC
7383	3	2.3	NC	NC -- NC	2	1.3	NC	NC -- NC	1	0.9	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total†	15	8.6	175	98 -- 289	9	4.9	182	83 -- 346	6	3.6	166	61 -- 361

† Cases for which census tract designation was not possible are included in the town total.

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 4c
Leukemia Incidence
Grafton, MA
1991-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	1	2.8	NC	NC -- NC	1	1.5	NC	NC -- NC	0	1.3	NC	NC -- NC
7382	7	7.3	96	38 -- 197	2	4.1	NC	NC -- NC	5	3.2	158	51 -- 369
7383	1	3.3	NC	NC -- NC	1	1.9	NC	NC -- NC	0	1.4	NC	NC -- NC
7384	0	0.1	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total†	10	13.5	74	35 -- 136	4	7.6	NC	NC -- NC	6	5.9	102	37 -- 221

† Cases for which census tract designation was not possible are included in the town total.

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 5a
Liver Cancer Incidence
Grafton, MA
1982-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	0	1.4	NC	NC -- NC	0	1.0	NC	NC -- NC	0	0.4	NC	NC -- NC
7382	3	3.1	NC	NC -- NC	3	2.3	NC	NC -- NC	0	0.8	NC	NC -- NC
7383	2	1.7	NC	NC -- NC	2	1.3	NC	NC -- NC	0	0.4	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	5	6.2	81	26 -- 189	5	4.6	110	35 -- 256	0	1.6	NC	NC -- NC

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 5b
Liver Cancer Incidence
Grafton, MA
1982-1990

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	0	0.5	NC	NC -- NC	0	0.3	NC	NC -- NC	0	0.1	NC	NC -- NC
7382	0	1.0	NC	NC -- NC	0	0.7	NC	NC -- NC	0	0.3	NC	NC -- NC
7383	1	0.6	NC	NC -- NC	1	0.4	NC	NC -- NC	0	0.2	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	1	2.0	NC	NC -- NC	1	1.4	NC	NC -- NC	0	0.6	NC	NC -- NC

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 5c
Liver Cancer Incidence
Grafton, MA
1991-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	0	0.8	NC	NC -- NC	0	0.6	NC	NC -- NC	0	0.2	NC	NC -- NC
7382	3	2.3	NC	NC -- NC	3	1.7	NC	NC -- NC	0	0.5	NC	NC -- NC
7383	1	1.1	NC	NC -- NC	1	0.8	NC	NC -- NC	0	0.3	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	4	4.2	NC	NC -- NC	4	3.1	NC	NC -- NC	0	1.0	NC	NC -- NC

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 6a
Lung and Bronchus Cancer Incidence
Grafton, MA
1982-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	35	35.6	98	68 -- 137	19	20.6	92	55 -- 144	16	15.0	106	61 -- 173
7382	77	77.8	99	78 -- 124	46	46.9	98	72 -- 131	31	31.0	100	68 -- 142
7383	43	44.3	97	70 -- 131	25	27.2	92	59 -- 136	18	17.1	105	62 -- 167
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total†	156	157.5	99	84 -- 116	91	94.5	96	78 -- 118	65	63.0	103	80 -- 131

† Cases for which census tract designation was not possible are included in the town total.

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 6b
Lung and Bronchus Cancer Incidence
Grafton, MA
1982-1990

Census Tract	Total					Males					Females				
	Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI	
7381	10	15.7	64	31	-- 117	6	9.9	61	22	-- 132	4	5.8	NC	NC	-- NC
7382	37	30.8	120	84	-- 165	24	19.8	121	77	-- 180	13	11.0	118	63	-- 202
7383	18	18.8	96	57	-- 152	12	12.2	98	51	-- 172	6	6.6	91	33	-- 199
7384	0	0.0	NC	NC	-- NC	0	0.0	NC	NC	-- NC	0	0.0	NC	NC	-- NC
Town Total	65	65.3	100	77	-- 127	42	41.9	100	72	-- 135	23	23.3	99	62	-- 148

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 6c
Lung and Bronchus Cancer Incidence
Grafton, MA
1991-2000

Census Tract	Total					Males					Females				
	Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI		Obs	Exp	SIR	95% CI	
7381	25	18.9	132	86	-- 195	13	10.1	129	69	-- 221	12	8.8	136	70	-- 237
7382	40	48.6	82	59	-- 112	22	27.6	80	50	-- 121	18	21.0	86	51	-- 136
7383	25	23.8	105	68	-- 155	13	13.7	95	50	-- 162	12	10.1	119	61	-- 208
7384	0	0.0	NC	NC	-- NC	0	0.0	NC	NC	-- NC	0	0.0	NC	NC	-- NC
Town Total†	91	91.3	100	80	-- 122	49	51.4	95	71	-- 126	42	39.9	105	76	-- 142

† Cases for which census tract designation was not possible are included in the town total.

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 7a
Multiple Myeloma Cancer Incidence
Grafton, MA
1982-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	5	2.1	234	75 -- 545	3	1.1	NC	NC -- NC	2	1.1	NC	NC -- NC
7382	6	4.6	132	48 -- 287	4	2.4	NC	NC -- NC	2	2.2	NC	NC -- NC
7383	0	2.5	NC	NC -- NC	0	1.4	NC	NC -- NC	0	1.2	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total†	12	9.2	130	67 -- 228	7	4.8	145	58 -- 299	5	4.4	114	37 -- 266

† Cases for which census tract designation was not possible are included in the town total.

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 7b
Multiple Myeloma Cancer Incidence
Grafton, MA
1982-1990

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	2	1.0	NC	NC -- NC	2	0.5	NC	NC -- NC	0	0.5	NC	NC -- NC
7382	2	1.8	NC	NC -- NC	2	0.9	NC	NC -- NC	0	0.9	NC	NC -- NC
7383	0	1.1	NC	NC -- NC	0	0.6	NC	NC -- NC	0	0.5	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	4	3.9	NC	NC -- NC	4	2.0	NC	NC -- NC	0	1.9	NC	NC -- NC

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 7c
Multiple Myeloma Cancer Incidence
Grafton, MA
1991-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	3	1.1	NC	NC -- NC	1	0.5	NC	NC -- NC	2	0.6	NC	NC -- NC
7382	4	2.8	NC	NC -- NC	2	1.5	NC	NC -- NC	2	1.3	NC	NC -- NC
7383	0	1.4	NC	NC -- NC	0	0.7	NC	NC -- NC	0	0.6	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total†	8	5.3	152	65 -- 299	3	2.8	NC	NC -- NC	5	2.5	200	64 -- 466

† Cases for which census tract designation was not possible are included in the town total.

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 8a
Non-Hodgkin's Lymphoma Incidence
Grafton, MA
1982-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	11	8.6	128	64 -- 228	6	4.4	136	50 -- 296	5	4.2	119	38 -- 277
7382	21	19.6	107	66 -- 164	15	10.7	140	78 -- 231	6	8.9	67	25 -- 146
7383	13	10.3	126	67 -- 216	10	5.7	176	84 -- 324	3	4.6	NC	NC -- NC
7384	0	0.1	NC	NC -- NC	0	0.1	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	45	38.6	117	85 -- 156	31	20.8	149	* 101 -- 211	14	17.8	79	43 -- 132

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 8b
Non-Hodgkin's Lymphoma Incidence
Grafton, MA
1982-1990

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	4	3.4	NC	NC -- NC	1	1.8	NC	NC -- NC	3	1.7	NC	NC -- NC
7382	6	7.1	85	31 -- 185	4	3.8	NC	NC -- NC	2	3.3	NC	NC -- NC
7383	3	4.0	NC	NC -- NC	2	2.2	NC	NC -- NC	1	1.8	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	13	14.5	90	48 -- 154	7	7.7	90	36 -- 186	6	6.7	89	33 -- 194

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 8c
Non-Hodgkin's Lymphoma Incidence
Grafton, MA
1991-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	7	5.0	139	56 -- 287	5	2.5	198	64 -- 463	2	2.5	NC	NC -- NC
7382	15	13.1	115	64 -- 189	11	7.1	154	77 -- 276	4	5.9	NC	NC -- NC
7383	10	6.0	166	79 -- 305	8	3.3	243 *	105 -- 479	2	2.7	NC	NC -- NC
7384	0	0.1	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	32	24.2	132	90 -- 187	24	13.0	185 *	118 -- 275	8	11.2	71	31 -- 141

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 9a
Stomach Cancer Incidence
Grafton, MA
1982-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	3	4.9	NC	NC -- NC	2	3.0	NC	NC -- NC	1	1.9	NC	NC -- NC
7382	9	10.4	86	39 -- 164	7	6.6	106	42 -- 218	2	3.8	NC	NC -- NC
7383	6	5.7	105	38 -- 229	5	3.7	134	43 -- 313	1	2.0	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	18	21.0	86	51 -- 135	14	13.3	105	57 -- 177	4	7.7	NC	NC -- NC

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 9b
Stomach Cancer Incidence
Grafton, MA
1982-1990

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	0	2.5	NC	NC -- NC	0	1.5	NC	NC -- NC	0	0.9	NC	NC -- NC
7382	5	4.8	105	34 -- 245	4	3.0	NC	NC -- NC	1	1.8	NC	NC -- NC
7383	2	2.7	NC	NC -- NC	1	1.8	NC	NC -- NC	1	0.9	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	7	9.9	70	28 -- 145	5	6.3	80	26 -- 187	2	3.7	NC	NC -- NC

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 9c
Stomach Cancer Incidence
Grafton, MA
1991-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	3	2.3	NC	NC -- NC	2	1.4	NC	NC -- NC	1	1.0	NC	NC -- NC
7382	4	5.7	NC	NC -- NC	3	3.7	NC	NC -- NC	1	2.1	NC	NC -- NC
7383	4	2.8	NC	NC -- NC	4	1.8	NC	NC -- NC	0	1.0	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	11	10.9	101	50 -- 181	9	6.9	131	60 -- 249	2	4.0	NC	NC -- NC

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 10a
Thyroid Cancer Incidence
Grafton, MA
1982-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	3	2.5	NC	NC -- NC	2	0.7	NC	NC -- NC	1	1.8	NC	NC -- NC
7382	6	6.6	91	33 -- 198	2	1.8	NC	NC -- NC	4	4.8	NC	NC -- NC
7383	3	3.1	NC	NC -- NC	0	0.9	NC	NC -- NC	3	2.2	NC	NC -- NC
7384	0	0.1	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	12	12.3	98	50 -- 171	4	3.4	NC	NC -- NC	8	8.9	90	39 -- 178

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 10b
Thyroid Cancer Incidence
Grafton, MA
1982-1990

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	0	0.8	NC	NC -- NC	0	0.3	NC	NC -- NC	0	0.6	NC	NC -- NC
7382	1	2.0	NC	NC -- NC	0	0.6	NC	NC -- NC	1	1.4	NC	NC -- NC
7383	1	1.0	NC	NC -- NC	0	0.4	NC	NC -- NC	1	0.7	NC	NC -- NC
7384	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	2	3.9	NC	NC -- NC	0	1.3	NC	NC -- NC	2	2.6	NC	NC -- NC

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

TABLE 10c
Thyroid Cancer Incidence
Grafton, MA
1991-2000

Census Tract	Total				Males				Females			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
7381	3	1.7	NC	NC -- NC	2	0.4	NC	NC -- NC	1	1.3	NC	NC -- NC
7382	5	4.9	103	33 -- 240	2	1.2	NC	NC -- NC	3	3.6	NC	NC -- NC
7383	2	2.0	NC	NC -- NC	0	0.5	NC	NC -- NC	2	1.5	NC	NC -- NC
7384	0	0.1	NC	NC -- NC	0	0.0	NC	NC -- NC	0	0.0	NC	NC -- NC
Town Total	10	8.6	117	56 -- 215	4	2.2	NC	NC -- NC	6	6.4	94	34 -- 204

Note: SIRs are calculated based on the exact number of expected cases.
Expected number of cases presented are rounded to the nearest tenth.
SIRs and 95% CI are not calculated when observed number of cases < 5.

Obs = Observed number of cases
Exp = Expected number of cases
SIR = Standardized Incidence Ratio
95% CI = 95% Confidence Interval
NC = Not calculated
* = Statistical significance

Data Source: Massachusetts Cancer Registry, Center for Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health.

Table 11
Distribution of Non-Hodgkin's Lymphoma by Histologic Subtype
1982 - 2000

NHL subtype	Grafton	Massachusetts
Diffuse	60%	44.10%
Follicular	16%	17.70%
High-Grade	0%	6.40%
Not otherwise specified (NOS)	7%	18.80%
Peripheral T-cell	4%	4.10%
Small Lymphocytic	13%	9.00%

APPENDIX A

Cancer Incidence Coding Definitions

Appendix A:
Coding Definitions of Cancer Site/Type*

	ICD-O-1 and Other Pre-ICD-O-2 Codes		*ICD-O-2 Codes*		*ICD-O-3 Codes*	
Cancer Site / Type	***Site code***	***Histology code***	***Site code***	***Histology code***	***Site code***	***Histology code***
Bladder	188.0-188.9	except 9590-9980	C67.0-C67.9	except 9590-9989	C67.0-C67.9	except 9590-9989
Bone	170.0-170.9	except O8010-O8140, O8723, O9391-O9580, O9590-O9980, B9593-B9733	C40.0-C41.9	except 8010-8140, 8723, 9391-9580, 9590-9980	C40.0-C41.9	except 9590-9989
Kidney & Renal Pelvis	189.0, 189.1	except 9590-9980	C64.9, C65.9	except 9590-9989	C64.9, C65.9	except 9590-9989
Leukemia	140.0-199.9	includes O9800-O9943, O9951, P9803-P9943, B9803-B9943	1. C00.0-C80.9 AND 2. C42.0, C42.1, C42.4	1. includes 9800-9822, 9824-9826, 9828-9941 2. includes 9823, 9827	1. C00.0-C80.9 AND 2. C42.0, C42.1, C42.4	1. includes 9733, 9742, 9800-9820, 9826, 9831-9948, 9963-9964 2. includes 9823, 9827
Liver	155.0	except 9590-9980	C22.0	except 9590-9989	C22.0	except 9590-9989
Lung & Bronchus	162.2-162.9	except 9050-9053, 9590-9980	C34.0-C34.9	except 9590-9989	C34.0-C34.9	except 9590-9989
Multiple Myeloma	140.0-199.9	includes O9730-O9732, P9733, B9733	C00.0-C80.9	includes 9731, 9732	C00.0-C80.9	includes 9731, 9732, 9734
Non-Hodgkin's Lymphoma (NHL)	140.0-199.9	includes O9590-O9642, O9670-O9710, O9750, P9593-P9643, P9693-P9713, P9753, B9593-B9643, B9703	1. C00.0-C80.9 AND 2. All sites except C42.0, C42.1, C42.4	1. includes 9590-9595, 9670-9717 2. includes 9823, 9827	1. C00.0-C80.9 AND 2. All sites except C42.0, C42.1, C42.4	1. includes 9590-9596, 9670-9729 2. includes 9823, 9827
Stomach	151.0-151.9	except 9590-9980	C16.0-C16.9	except 9590-9989	C16.0-C16.9	except 9590-9989
Thyroid	193.9	except 9590-9980	C73.9	except 9590-9989	C73.9	except 9590-9989

*Note: Includes invasive tumors only, selected by excluding in situ stages J0, S0, TTISNXM0, TTANXMX, TTANXM0, TTAN0MX, TTISN0M0, TTISNXMX, TTISN0MX, TTISN0M0, TTIN0M0, TTIN0MX, TTINXM0, and TTINXMX (1982-1994 data) or by specifying behavior code (1995-2000 data).

APPENDIX B

Risk Factor Information for Selected Cancer Types

Bladder Cancer

The American Cancer Society estimates that bladder cancer will affect 60,240 people in the U.S. in 2004, accounting for 6% of all cancers diagnosed in the United States among men and 2% among women. In Massachusetts, bladder cancer accounts for approximately 5% of all cancers diagnosed among males and females combined (ACS, 2004). Males are three times more likely to develop bladder cancer than females and whites are two times more likely to develop this disease than blacks. The risk of bladder cancer increases with age and the mean age at diagnosis is 68-69 years (ACS, 2000).

The greatest risk factor for bladder cancer is cigarette smoking. Smokers are more than twice as likely to develop bladder cancer compared to nonsmokers (ACS, 2000). The risk of developing bladder cancer increases with the number of packs smoked per day and with duration of smoking. Further, the risk of bladder cancer may be higher in women than in men who smoke comparable numbers of cigarettes (Castelao et al., 2001). Approximately 25-60% of all bladder cancers can be attributed to tobacco use (Johansson and Cohen, 1997). Smoking cessation has been found to reduce the risk of developing bladder cancer by 30% to 60% (Silverman et al., 1996).

Studies have also revealed a number of occupations that are associated with bladder cancer. In fact, exposures to chemicals in the workplace account for an estimated 20-25% of all bladder cancers diagnosed among men in the U.S. (Johansson and Cohen, 1997). Occupational exposure to aromatic amines, such as benzidine and 2-naphthylamine, increases the risk of bladder cancer (ACS, 2000). These chemicals were common in the dye industry in the past. A higher risk of bladder cancer has also been observed among aromatic amine manufacturing workers as well as among workers in the rubber, leather, textiles, printing, and paint products industries (ACS, 2000; Silverman et al., 1996). The development of new chemicals, changed worker exposures, and the elimination of many known bladder carcinogens in the workplace have caused shifts in those occupations considered to be high risk. For example, risks among dye, rubber, and leather workers have declined over time, while other occupations such as motor vehicle operation (e.g., drivers of trucks, buses, and taxis) and the aluminum industry have emerged as potential high-risk occupations (Silverman et al., 1996). However, specific occupational exposures in these occupations have not been confirmed and study findings are not consistent. Further, the risk of bladder cancer from occupational exposures may be increased among smokers (ACS, 2000).

Dietary factors such as consumption of fried foods as well as foods high in fat and cholesterol have been found to be associated with increased bladder cancer risk (Silverman et al., 1996). Use of the Chinese herb, Aristocholia fangchi, found in some dietary supplements, has also been linked with bladder cancer (ACS, 2000). Use of some anti-cancer drugs (e.g., cyclophosphamide and chlornaphazine), use of phenacetin, and infection with Shistosoma haematobium (a parasite found in Africa) are thought to be associated with the development of bladder cancer, however, not all epidemiological studies have produced convincing findings (Silverman et al., 1996).

Other risk factors for bladder cancer include a personal history of bladder cancer, certain rare birth defects involving the bladder, and exposure to ionizing radiation (ACS, 2000; Silverman et al., 1996). Exposure to chlorinated by-products in drinking water has also been suggested to increase bladder cancer risk, however, a recent population-based study found that an association was present only among smokers (Cantor et al., 1998).

References

American Cancer Society. 2004. Cancer Facts & Figures 2004. Atlanta: American Cancer Society, Inc.

American Cancer Society. 2000. Bladder Cancer. Available at: http://www3.cancer.org/cancerinfo/.

Cantor KP, Lynch CF, Hildesheim ME, et al. 1998. Drinking water source and chlorination by-products I. Risk of bladder cancer. Epidemiology 9(1):21-28.

Castelao JE, Yuan JM, Skipper PL, et al. 2001. Gender- and smoking-related bladder cancer risk. J Natl Cancer Inst 93(7):538-45.

Johansson SL, Cohen SM. 1997. Epidemiology and etiology of bladder cancer. Semin Surg Oncol 13:291-298.

Silverman D, Morrison A, Devesa S. Bladder Cancer. In: Cancer Epidemiology and Prevention. 2nd Ed, edited by Schottenfeld D, Fraumeni. JF. New York: Oxford University Press: 1996.

Non-Hodgkin's Lymphoma

Lymphomas are cancers involving the cells of the lymphatic system. The majority of lymphomas involve the lymph nodes and spleen but the disease may also affect other areas within the body. Non-Hodgkin's lymphoma (NHL) is a classification of all lymphomas except Hodgkin's disease. Thus NHL is a mixed group of diseases that is characterized by the malignant increase in specific cells of the immune system (B or T lymphocytes). B-cell lymphomas are more common than T-cell lymphomas, accounting for about 85% of all cases of NHL (ACS, 2003). The various types of NHL are thought to represent different diseases with different causes (Scherr and Mueller, 1996). NHL can occur at all ages, however, the average age at diagnosis is in the early 60s and the incidence of this disease generally increases with age. This disease is more common in men than in women and affects whites more often than African Americans or Asian Americans (ACS, 2003). The American Cancer Society estimates that approximately 54,370 Americans will be diagnosed with NHL in 2004, making it the sixth most common cancer in the U.S. among both men and women, excluding non-melanoma skin cancers (ACS, 2004).

Overall, between 1973 and 1997, the incidence of NHL in the U.S. grew 81% (Garber, 2001), although during the 1990s, the rate of increase appears to have stabilized (ACS, 2004). In Massachusetts, the incidence of NHL increased 50% during 1982-1997 from 10.5 cases per 100,000 to 15.7 cases per 100,000 (MCR, 1997 and 2000). The increase in NHL incidence has been attributed to better diagnosis, greater exposure to causative agents, and, to a lesser extent, the increasing incidence of AIDS-related lymphomas (Devesa and Fears, 1992; Scherr and Mueller, 1996). Although the primary factors related to the development of NHL include conditions that suppress the immune system, viral infections, and certain occupational exposures, these factors are thought to account for only a portion of the increase observed in this cancer type (Scherr and Mueller, 1996). The observation that the rate of increase is declining for NHL may be attributed in part to increased use of antiretroviral therapy to slow HIV progression (Wingo et al., 1998).

NHL is more common among people who have abnormal or compromised immune systems, such as those with inherited diseases that suppress the immune system, individuals with autoimmune disorders, and people taking immunosuppressant drugs following organ transplants. Genetic predisposition (e.g., inherited immune deficiencies) only accounts for a small proportion of NHL cases (Scherr and Mueller, 1996). AIDS patients have a 100- to 300-fold higher risk for NHL than the general population (again, these cases account for only a minor part of overall NHL incidence) (Garber, 2001). NHL has also been reported to occur more frequently among individuals with conditions that require medical treatment resulting in suppression of the immune system, such as cancer chemotherapy. However, current evidence suggests that the development of NHL is related to suppression of the individual's immune system as a result of treatment, rather than the treatment itself (Scherr and Mueller, 1996).

Several viruses have been shown to play a role in the development of NHL. Among organ transplant recipients, suppression of the immune system required for acceptance of

the transplant leads to a loss of control or the reactivation of viruses that have been dormant in the body (e.g., Epstein-Barr Virus [EBV] and herpesvirus infections). In addition, because cancer-causing viruses are known to cause lymphomas in various animals, it has been proposed that these types of viruses may also be associated with the development of NHL among humans without compromised immune systems. Infection with the human T-cell leukemia/lymphoma virus (HTLV-I) is known to cause T-cell lymphoma among adults. However, this is a relatively rare infection and most likely contributes only a small amount to the total incidence of NHL (Scherr and Mueller, 1996). EBV infection is common among the general population and has been shown to play a role in the development of most cases of transplant and AIDS related NHL. The combination of immune system deficiencies and EBV infection may cause some people to develop NHL (ACS, 2003). Although viruses are causal factors for some subtypes of NHL, to date, studies have shown that the role of EBV in the development of NHL in the general population may not be large (Scherr and Mueller, 1996). Moreover, the high prevalence of EBV in the general population suggests that EBV may be only one of several factors in the development of this cancer.

Recent studies have found that a type of bacteria, Helicobacter pylori, a common cause of stomach ulcers, can also cause some lymphomas of the stomach (ACS, 2003). An important implication of this finding is that treatment with antibiotics could prevent some NHL of the stomach.

Some occupations have been associated with an increased risk of developing NHL, such as occupations related to chemicals or agriculture. Farmers, herbicide and pesticide applicators, and grain workers appear to have the most increased risk (Zahm, 1990 and 1993; Tatham et al., 1997). Studies conducted among agricultural workers have demonstrated increases in NHL among those using herbicides for more than 20 days per year and individuals who mix or apply herbicides. A greater incidence of NHL appears to be related specifically to exposure to the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) and organophosphate insecticides (Wigle et al., 1990; Zahm et al., 1990; Zahm et al., 1993). Further studies of exposure to these chemicals and NHL incidence have shown that the increased risk is attributed to a specific impurity, 2,3,7,8-tetrachlorodibenzo-p-dioxin or 2,3,7,8-TCDD, present in these herbicides. However, reports of accidental industrial exposures to TCDD alone have not demonstrated an increased risk of NHL (Scherr and Mueller, 1996). An elevated risk for NHL development has also been noted among fence workers, orchard workers, and meat workers. High-dose exposure to benzene has been associated with NHL (ACS, 2003), however, a recent international cohort study indicated that petroleum workers exposed to benzene were not at an increased risk of NHL (Wong and Raabe, 2000).

In addition, epidemiological studies of long-term users of permanent hair coloring products have suggested an increased incidence of NHL (Zahm et al., 1992; Scherr and Mueller, 1996). However, a recent population based study found no association between the use of hair color products and an increased risk of developing NHL. The researchers further stated that results from this study and previous studies, including experimental

animal studies, provide little convincing evidence linking NHL with normal use of hair dye (Holly et al., 1998).

Although radiation (e.g., nuclear explosions or radioactive fallout from reactor accidents) has been implicated in the development of some cancers, including NHL (ACS, 2003), there is little evidence for an increased risk of lymphoma due to radiation (Scherr and Mueller, 1996).

Recent studies have suggested that contamination of drinking water with nitrate may be associated with an increased risk of NHL (Ward et al., 1996). Nitrate forms N-nitroso compounds which are known carcinogens and can be found in smoked or salt-dried fish, bacon, sausages, other cured meats, beer, pickled vegetables, and mushrooms.

Smoking has also been suggested to increase the risk of NHL. A study that evaluated the history of tobacco use and deaths from NHL determined that people who had ever smoked had a two-fold increase of dying from NHL as compared to those who never smoked. Further, a four-fold increase was found among the heaviest smokers (Linet et al., 1992). In addition, a more recent study that primarily examined occupation and NHL risk found a significant association with high levels of cigarette smoking and all NHL types (Tatham et al., 1997). However, a recent review of 5 cohort studies and 14 case-control studies concludes that results of epidemiological studies have been inconsistent and that smoking has not been determined to be a definitive risk factor in the development of NHL (Peach and Barnett, 2000).

A recent Danish study has linked the use of tricyclic and tetracyclic antidepressants to NHL, however, more research is needed on this possible association (Dalton et al., 2000).

Although NHL is associated with a number of risk factors, the causes of this disease remain unknown. Most patients with NHL do not have any known risk factors (ACS, 2003).

References

American Cancer Society. 2004. Cancer Facts & Figures 2004. Atlanta: American Cancer Society, Inc.

American Cancer Society. 2003. Non-Hodgkin's Lymphoma. Available at: http://www3.cancer.org/cancerinfo/.

Dalton SO, Johansen C, Mellemkjaer L, Sorensen HT, McLaughlin JK, Olsen J, and Olsen JH. 2000. Antidepressant medications and risk for cancer. Epidemiology 11(2):171-6.

Devesa SS and Fears T. 1992. Non-Hodgkin's lymphoma time trends: United States and international data. Cancer Res 52(19 Suppl.):5492s-549s.

Garber K. 2001. Lymphoma rate rise continues to baffle researchers. J Natl Cancer Inst 93(7):494-6.

Holly EA, Lele C, Bracci PM. 1998. Hair-color products and risk for non-Hodgkin's lymphoma: a population-based study in the San Francisco Bay area. Am J Public Health 88(12):1767-73.

Linet MS, McLaughlin JK, Hsing AW, Wacholder S, Co Chien HT, Schuman LM, et al. 1992. Is cigarette smoking a risk factor for non-Hodgkin's lymphoma or multiple myeloma? Results from the Lutheran Brotherhood cohort study. Leuk Res 16(6-7):621-624.

Massachusetts Cancer Registry. 1997. Cancer Incidence and Mortality in Massachusetts 1987-1994: Statewide Report. August 1997. Massachusetts Department of Public Health, Bureau of Health Statistics, Research and Evaluation, Massachusetts Cancer Registry. Boston, MA.

Massachusetts Cancer Registry. 2000. Cancer Incidence and Mortality in Massachusetts 1993-1997: Statewide Report. March 2000. Massachusetts Department of Public Health, Bureau of Health Statistics, Research and Evaluation, Massachusetts Cancer Registry. Boston, MA.

Peach HG and Barnett NE. 2001. Critical review of epidemiological studies of the association between smoking and non-Hodgkin's lymphoma. Hematol Oncol 19(2):67-80.

Scherr PA and Mueller NE. Non-Hodgkin's Lymphomas. In: Cancer Epidemiology and Prevention. 2nd Ed, edited by Schottenfeld D, Fraumeni. JF. New York: Oxford University Press: 1996.

Tatham L, Tolbert P, Kjeldsberg C. 1997. Occupational risk factors for subgroups of non-Hodgkin's lymphoma. Epidemiology 8(5):1551-8.

Ward MH, Mark SD, Cantor KP, Weisenburger DD, Correa-Villasenor A, Zahm SH. 1996. Drinking water nitrate and the risk of non-Hodgkin's lymphoma. Epidemiology 7(6):465-71.

Wigle DT, Semenciw RM, Wilkins K, Riedel D, Ritter L, Morrison HI, et al. 1990. Mortality study of Canadian male farm operators: non-Hodgkin's lymphoma mortality and agricultural practices in Saskatchewan. J Natl Cancer Inst 82(7):575-82.

Wingo PA, Ries LAG, Rosenberg HM, Miller DS, and Edwards BK. 1998. Cancer incidence and mortality, 1973-1995: A report card for the U.S. Cancer 82(6):1197-1207.

Wong O and Raabe GK. 2000. Non-Hodgkin's lymphoma and exposure to benzene in a multinational cohort of more than 308,000 petroleum workers, 1937-1996. J Occup Environ Med 42(5):554-68.

Zahm SH, Weisenburger DD, Babbit PA, Saal RC, Vaught JB, Blair A. 1992. Use of hair coloring products and the risk of lymphoma, multiple myeloma, and chronic lymphocytic leukemia. Am J Public Health 82:990-97.

Zahm SH, Weisenburger DD, Babbit PA, Saal RC, Vaught JB, Cantor KP, et al. 1990. A case-control study of non-Hodgkin's lymphoma and the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) in Eastern Nebraska. Epidemiology 1(5):349-56.

Zahm SH, Weisenburger DD, Saal RC, Vaught JB, Babbitt PA, Blair A. 1993. The role of agricultural pesticide use in the development of non-Hodgkin's lymphoma in women. Archives of Environmental Health 48(5):353-8.