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Assessment of Brain and Central Nervous System Cancer Incidence in Needham, MA 1987-1998

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I. INTRODUCTION

At the request of the Needham Health Department, the Community Assessment Program (CAP) of the Massachusetts Department of Public Health, Bureau of Environmental Health Assessment (MDPH, BEHA) conducted an evaluation of the incidence of brain and other central nervous system (CNS) cancers in the town of Needham, Massachusetts. Recent data from the Massachusetts Cancer Registry's (MCR's) regularly published report *Cancer Incidence in Massachusetts: City and Town Supplement*, which provides incidence data for each city and town in Massachusetts for 23 different types of cancer, indicated that the incidence of brain and CNS cancers was statistically significantly elevated in the town of Needham for the time period 1994-1998 compared to what would have been expected based on statewide rates of this disease (MDPH, 2001). In response to these findings and general environmental concerns voiced by the Needham Health Department, the CAP initiated a further examination of the pattern of brain and CNS cancer incidence in Needham. This report reviews the pattern of brain and CNS cancer incidence in the town of Needham and by smaller geographic area for each of its five census tracts during the time period 1987-1998 and two smaller time periods: 1987-1993 and 1994-1998. This report also examines available data on risk factors that may play a role in the development of these cancers.

II. OBJECTIVES

This analysis provides a descriptive evaluation of the occurrence of brain and CNS cancers in the town of Needham with respect to time of diagnosis, age at diagnosis, gender, and geographic distribution of the places of residence for individuals diagnosed with these cancer types. It provides a comparison of the incidence of brain and CNS cancers in Needham with respect to the incidence of these cancers in the Commonwealth of Massachusetts as a whole. Additionally, available information about factors that may be related to the development of brain and/or CNS cancers was evaluated.

The results of a descriptive analysis, such as the evaluation presented here, cannot be used to establish a causal link between a particular risk factor and a disease outcome, like brain and/or CNS cancer. However, the results of this analysis may be useful in determining if a

common etiology (i.e., cause) of brain or CNS cancer in individuals residing in Needham is possible. The results may also be helpful in identifying areas in Needham where further public health investigations or actions may be warranted. Such actions may include follow-up environmental investigations or public health interventions. The purpose of this evaluation is to report our findings on the pattern of brain and CNS cancers in Needham and discuss them in the context of the available scientific and medical information about these diseases to determine whether further public health action is warranted.

The specific objectives of this investigation were as follows:

- To examine the incidence of brain and CNS cancers in Needham by smaller geographic areas and to determine if certain areas in the town may have higher or lower rates of brain and CNS cancers;

- To evaluate the geographic distribution and spatial patterns of individuals diagnosed with brain or CNS cancers in order to determine whether an atypical geographic pattern of individuals diagnosed with these exists in certain areas of Needham;

- To review available information for characteristics of the Needham population that could suggest risk factors for the development of brain and/or CNS cancer;

- To evaluate the temporal (i.e., time) distribution of brain and CNS cancer diagnoses in Needham to determine if the incidence of these cancers has changed over time;

- To review existing environmental information for hazardous waste sites located in Needham and other sites of environmental concern to determine the likelihood that potential environmental exposures could play a role in the pattern of brain and CNS cancer incidence in Needham;

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

III. METHODS FOR ANALYZING CANCER INCIDENCE

A. Case Identification

The observed number of individuals diagnosed with brain and/or CNS cancers in this evaluation was obtained from the MCR, a division of the MDPH Bureau of Health Statistics Research and Evaluation. In 1982, the MCR began collecting information on individuals diagnosed with cancer in Massachusetts. All newly diagnosed cancer cases are required by law to be reported to the MCR within six months of the date of diagnosis (M.G.L. c.111s.111B). The seventeen-year period 1982-1998 constitutes the period for which the most recent and complete cancer incidence data were available at the time of this analysis.

The term "cancer" is used to describe a variety of diseases associated with abnormal cell and tissue growth. Primary site (location in the body where the disease originated) and histology (tissue or cell type) classify the different cancer types. Epidemiological studies have revealed that different types of cancer are individual diseases with separate causes, risk factors, characteristics, and patterns of survival (Preston-Martin & Mack, 1996). Only primary site brain or CNS cancers were included in this evaluation. The brain is a common site for the spread or metastasis of cancer from another area within the body. Brain or CNS cancers that occur as the result of metastasis, or the spread of a primary site cancer to another location in the body, are considered as separate cancers and were, therefore, not included in this evaluation.

B. Calculation of Standardized Incidence Ratios (SIRs)

In order to determine whether an unusual occurrence of brain and/or CNS cancer exists in Needham as a whole or census tracts within Needham, cancer incidence data were analyzed by age-group and gender. These two criteria were used to compare the observed number of cancer cases in each Needham census tract to the number that would be expected based on the incidence of brain and CNS cancers in Massachusetts as a whole. Standardized incidence ratios (SIRs) were calculated for brain and CNS cancers for the town of Needham and each of the five census tracts that geographically subdivide the town for the 12-year time period 1987-1998 and two smaller time periods (1987-1993, 1994-1998). This year range was

selected based on the elevation in brain and CNS cancer in Needham noted by the MCR and the Needham Health Department.

Because age-group and gender specific population data are needed to calculate incidence rates, the census tract (CT) is the smallest geographic area for which cancer rates can be accurately calculated. Specifically, a CT is a smaller statistical subdivision of a city or town. Census tracts usually contain between 2,500 and 8,000 persons and are designed to be homogenous (i.e., the same throughout) with respect to population characteristics (U.S. Department of Commerce 1990). Needham is comprised of five CTs: 4031, 4032, 4033, 4034, and 4035. The geographic location and boundaries of Needham as well as the CTs located in Needham are presented in Figure 1.

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

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

Caution should be exercised, however, when interpreting an SIR because the interpretation depends on both the size and stability of the SIR. Two SIRs can have the same size but not the same stability. For example, an SIR of 150 based on four expected cases and six observed cases indicates a 50% excess in cancer, but the excess is actually due to only two cases and may be the result of chance or random variation in cancer incidence. Conversely, an SIR of 150 based on 400 expected cases and 600 observed cases represents the same 50%

excess in cancer, but because the SIR is based upon a greater number of cases, the estimate is more stable. It is very unlikely that 200 excess cases of cancer would occur by chance alone. As a result of the instability of incidence rates based on a small number of cases, SIRs are not calculated when fewer than five cases are observed.

It is necessary to obtain accurate population information in order to calculate incidence rates. The population figures used in the analysis for the twelve-year period of 1987-1998 and for the two smaller time periods (1987-1993 and 1994-1998) were mid-year population estimates based on the 1990 and 2000 U.S. Census data for each census tract in Needham (U.S. Department of Commerce 1990, U.S. Department of Commerce 2000).

C. Calculation of 95% Confidence Interval

In addition to calculating SIRs, the statistical significance of each SIR was assessed. A 95% Confidence Interval (95% CI) was calculated for each SIR to determine if the observed number of brain and CNS cancer cases is significantly different from the expected number or if the difference may be due solely to chance (Rothman and Boice 1982). A 95% CI is a method of assessing the magnitude and stability of an SIR. Specifically, a 95% CI is the range of estimated SIR values that 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 a less than 5% chance that the difference between the number of observed and expected cancer cases is the result of random fluctuation in the number of observed cancer cases.

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

In addition to indicating the significance of the SIR estimate, the width (or range) of the confidence interval also reflects the stability of the SIR estimate. For example, a narrow confidence interval (e.g., 103-115) allows a fair level of certainty that the calculated SIR is close to the true SIR of the population. A wide interval (e.g., 85-450) leaves considerable doubt about the true SIR, which could be lower than or higher than the calculated SIR. A wide interval indicates an unstable statistic.

D. Evaluation of Risk Factor Information

Through the evaluation of characteristics of the population, profiles can be constructed that may offer explanations for the observed patterns in the occurrence of brain and CNS cancers in Needham and its CTs. Risk factors such as age at diagnosis, gender, occupation, and histology (cancer cell type) are data regularly collected by the MCR for individuals diagnosed with cancer. However, information about personal risk factors that may also influence the development of brain and/or CNS cancers (e.g., family history and heredity, exposure to ionizing radiation, exposure to n-nitroso compounds, and history of head trauma) are not collected by the MCR or any other readily accessible source, and therefore, could not be evaluated in this investigation.

E. Determination of Geographic Distribution

In Needham, the geographic distribution of brain and CNS cancer cases was determined using available address information from the MCR indicating residence at the time of diagnosis. This information was mapped for each individual with a diagnosis of brain or CNS cancer during 1987-1998 using a computerized geographic information system (GIS) (ESRI, 2000). This allowed the assignment of a CT location for each case as well as a qualitative evaluation of the spatial distribution of cases at a smaller geographic level within census tracts. The geographic distribution was assessed using a qualitative evaluation of the point pattern of cases within the town and within each CT. In instances where the address information was incomplete (i.e., did not include accurate street information for Needham), efforts were made to research cases using telephone books, town residential lists, and, when applicable, death certificates issued within two years of an individual's diagnosis year.

IV. METHODS FOR ASSESSING ENVIRONMENTAL INFORMATION

Because some studies have suggested a possible association between certain environmental exposures and the development of brain and CNS cancer, information regarding hazardous waste sites located in Needham and listed with the Massachusetts Department of Environmental Protection (MDEP) was reviewed (MDEP, 2002). The MDEP investigates potentially hazardous sites in the state and conducts and oversees cleanup of these sites. These sites are regulated according to Massachusetts General Laws (MGL), Chapter 21E and the Massachusetts Contingency Plan (MCP) (contained in the Code of Massachusetts Regulations (CMR) at 310 CMR 40.0000).

Needham waste sites and spills reported to the MDEP from 1982-1993 were mapped and evaluated in terms of the locations of the places of residence of individuals diagnosed with brain and/or CNS cancers. Brain cancer is often described as having a lengthy latency or development period, sometimes in excess of 20 years. The latency period is the time between exposure to a potentially harmful substance and the development of the cancer (Preston-Martin & Mack 1996). Generally, environmental spills began to be reported to MDEP consistently in the early 1980s. Therefore, in order to focus on past exposures consistent with a latency period for brain cancer, sites or spills reported to the MDEP from 1982 to 1993 were reviewed. Environmental spills that occurred after this time period are unlikely to result in exposures relating to brain and/or CNS cancer incidence during the 1987-1998 period. These sites (1982-1993) were mapped using an electronic GIS and the proximity of these sites to the place of residence of individuals diagnosed with brain or CNS cancers was assessed.

V. RESULTS OF CANCER INCIDENCE ANALYSIS

Brain and CNS cancer incidence data from the MCR was analyzed for Needham for the 1987-1998 time period. To evaluate trends over time, brain and CNS cancer incidence for two smaller time periods (1987-1993 and 1994-1998) was also analyzed. The following sections present the results of this evaluation for Needham as a whole and for each census tract in the town. Analysis by smaller geographic areas (i.e., census tracts) helps in

understanding whether the incidence of brain and CNS cancer observed town-wide may be due to increases in particular areas of the town. Tables 1 through 3 summarize brain and CNS cancer incidence data for the town as a whole and for each census tract during each of the three periods.

A. 1987-1998 (Table 1)

During the 1987-1998 period, brain and CNS cancers occurred about as often as expected in the town of Needham as a whole for both males (21 observed versus about 20 expected, SIR=106) and females (20 observed versus about 19 expected, SIR=104). As described below, the overall rate observed during the 12-year time period 1987-1998 reflected a statistically significantly lower-than-expected rate during 1987-1993 and a statistically significant elevation in the incidence of brain and CNS cancer during 1994-1998.

Brain/CNS cancers occurred at or below expected rates in CT 4031 (6 observed versus about 9 expected, SIR=66), CT 4032 (5 observed versus 5.6 expected, SIR=89), and CT 4034 (7 observed versus 11.7 expected, SIR=60). In CT 4035, brain cancer occurred slightly more often than expected during 1987-1998 (9 observed versus about 7 expected, SIR=127). This elevation, however, was based on two additional cases above the expected number and was not statistically significant.

Individuals residing in CT 4033, located in the southern part of Needham, experienced a statistically significant elevation of brain and CNS cancers during the 1987-1998 period (14 observed versus 5.5 expected, SIR=257, 95% CI=140-431). When evaluated by gender, both males (6 observed versus about 3 expected, SIR=213) and females (8 observed versus about 3 expected, SIR=304) experienced an elevation in brain and CNS cancer incidence. The elevation observed in males in CT 4033 was not statistically significant. However, the elevation observed in females was statistically significantly higher than expected.

B. 1987-1993 (Table 2)

During the time period 1987-1993, the incidence of brain and CNS cancer in Needham as a whole was statistically significantly lower than what would be expected for men and women combined (16 observed versus about 28 expected, SIR=59, 95% CI=33-94). When evaluated by census tract, both males and females in each individual census tract in Needham experienced fewer brain/CNS cancers than expected during this time period.

C. 1994-1998 (Table 3)

During the most recent time period, 1994-1998, brain and CNS cancer occurred statistically significantly more than expected in Needham as a whole for both males (13 observed versus about 6 expected, SIR=210, 95% CI=112-360) and females (12 observed versus about 5 expected, SIR=229, 95% CI=118-400).

When evaluated by census tract, individuals residing in CT 4034 experienced brain and CNS cancer slightly lower than the expected rate (2 observed versus about 3 expected). Additionally, in CTs 4031 and 4032 brain and CNS cancers occurred at approximately the rate that would be expected (3 observed versus about 3 expected in CT 4031 and 3 observed versus about 2 expected in CT 4032). However, a statistically significant elevation was observed in CT 4033 for brain and CNS cancer (10 observed versus about 2 expected, SIR=643, 95% CI=308-1183). When evaluated by gender, both males (4 observed versus about 1 expected) and females (6 observed versus about 1 expected, SIR=867, 95% CI=317-1888) in CT 4033 experienced elevations in brain and CNS cancer incidence. The elevation observed among females in this census tract was statistically significant. Brain and CNS cancers in CT 4035, located northern part of Needham, also occurred statistically significantly more often than expected among males and females combined for this time period (7 observed versus about 2 expected, SIR=330, 95% CI=132-680).

VI. RESULTS OF ANALYSIS OF RISK FACTOR INFORMATION

In order to better understand the patterns of brain and CNS cancer incidence in Needham, factors that are thought to contribute to an individual's risk for developing these types of cancer were evaluated. As brain and CNS cancer are comprised of a number of different cell types, review of the histology (cell type) of brain and CNS cancers diagnosed among residents of Needham is important to help to determine whether an atypical pattern of disease is occurring. Other risk factors reviewed include gender, age, race, and occupation. Specifically, brain and CNS cancers are slightly more common among males and, after a peak in childhood (e.g., under age 10), risk declines slightly until around age 25, and increases consistently as age increases thereafter (Preston-Martin & Mack 1996). In general, the highest rates of brain and central nervous system cancers tend to occur in whites. In addition, research has shown that some occupational exposures may increase the risk of developing brain and CNS cancer among individuals employed in such industries as plastics manufacturing, aspartame (or artificial sweetener) manufacturing, electrical work, veterinary or agricultural work, as well as among some workers in the nuclear and rubber industries and in certain health professions. These data are collected by the MCR and are reviewed below for individuals diagnosed with brain and CNS cancer in Needham. However, risk factors such as heredity, consumption of nitrites and other N-nitroso compounds found in some foods (e.g., cured meats), exposure to ionizing radiation, and history of head trauma, which have been associated with an increased risk of developing brain or CNS cancer in some studies, could not be evaluated because information related to these factors for individuals with brain or CNS cancer in Needham was not available. Therefore, the extent of the role these factors may have played in the incidence of brain and CNS cancer in Needham in unclear. For more information regarding potential risk factors for brain and CNS cancer, see Appendix A.

A. Histology

Histologic (cell type) distribution was reviewed for diagnoses of brain and CNS cancers in Needham. Patterns of disease were compared to known or established incidence trends to

assess whether any unexpected patterns exist. Primary brain and CNS tumors (i.e., brain cancer) comprise two main types: gliomas and malignant meningiomas. Gliomas are a general classification of malignant tumors that also include a variety of subtypes. Meningiomas are not technically brain tumors as they arise from the meninges, which are tissues that surround the outer part of the spinal cord and brain. These tumors account for approximately 50% of reported brain and CNS cancers but the majority (85%) are benign (non-cancerous) (ACS 2002a). In both children and adults, gliomas are the most common major histologic type and over 80% of gliomas are astrocytic gliomas (i.e., astrocytomas and gliobastoma multiforme) (Preston-Martin and Mack 1996). In children, about half of all brain and CNS cancers are astrocytomas and about 25% are medulloblastomas (ACS 2002a).

Of the 41 individuals diagnosed with brain and CNS cancer in Needham between 1987 and 1998, 38 (93%) were diagnosed with brain cancer and five were diagnosed with other CNS cancers (e.g., cancer of the spinal cord). Consistent with expected trends in histology distribution, the majority of brain and CNS cancers diagnosed among residents of Needham were gliomas (88%). Of these 38 gliomas, 28 (74%) were astrocytomas or glioblastomas and 10 were other glioma subtypes or were not classified as to specific subtype. Meningiomas accounted for 7% (n=3) of all brain and CNS cancers in this area between 1987-1998. All four of the brain and CNS cancer diagnoses among children in Needham were of the astrocytoma subtype.

B. Gender and Age

Of the 41 individuals diagnosed with brain or CNS cancer in Needham during the years 1987-1998, 20 were female (49%) and 21 were male (51%). The gender distribution for the town as a whole closely follows the expected distribution when compared to that of Massachusetts (Figure 2). In Massachusetts, 48% of brain and CNS cancer cases were diagnosed in females and 52% were diagnosed in males. In the United States, the American Cancer Society (ACS) estimates that 17,000 individuals will be diagnosed with brain and/or CNS cancers in 2002 with 44% of the diagnoses among females and 56% among males (ACS, 2002a).

When evaluated by smaller time periods, the gender distribution of individuals diagnosed with brain and/or CNS cancers in Needham closely follows that in Massachusetts. For the time period 1987-1993, 47% of the brain and CNS cancer cases in Needham occurred among females and 53% occurred among males whereas 45% brain and CNS cancer cases in Massachusetts occurred among females and 55% occurred among males (Figure 3). For the time period 1994-1998, female and male brain and CNS cancer cases in Needham were 48% and 52% while in Massachusetts they were 44% and 56%, respectively (Figure 4).

However, as noted previously, females in CT 4033 experienced a statistically significant elevation in the incidence of brain and CNS cancer during the overall time period 1987-1998 due to a statistically significant elevation during the most recent time period (i.e., 1994-1998). In this census tract during 1987-1998, 57% of the diagnoses were among females while 43% were among males. During 1994-1998, 60% of the diagnoses in CT 4033 were among females while 40% were among males.

The incidence rates for brain and CNS cancer were calculated and adjusted by age according to six age categories: 0-19, 20-44, 45-64, 65-74, 75-84, 85+. A review of age-group specific SIRs for each census tract was not possible because of the small number of diagnoses in each group. However, the age distribution of brain and CNS cancers in Needham was reviewed. In Needham as a whole during 1987-1998, the average age of diagnosis was 45 years. Four individuals were diagnosed between the ages of 0 and 19 (average age = 12.8). In general, the observed distribution of cases by age showed that the highest percentage of cases occurred in individuals who were between 45 and 64 years of age for both Needham (39%) and Massachusetts (30%) (Figure 5).

C. Race

In general, brain and CNS cancers occur more frequently in whites than in other races (Preston-Martin & Mack 1996). According to the 2000 U.S. Census, approximately 95% of Needham residents are white (U.S. Department of Commerce, 2000). Additionally, 88% of individuals diagnosed with brain and/or CNS cancers from 1994 to 1998 in Needham were white. The remaining 12% of individuals were either black or of an unknown race.

D. Occupation

Available occupational data for the 41 individuals diagnosed with brain or CNS cancer during 1987-1998 was evaluated with respect to suspected risk factors for these cancer types. Although studies are not conclusive, occupations such as plastics manufacturing, aspartame (sugar substitute) manufacturing, electrical and electric utility work, verterinarians, agricultural work, certain health professions (e.g., pathologists, physicians, dentists, and nurses), nuclear industry work, and rubber industry work may be associated with an increased risk of developing brain or CNS cancer (ACS 2002b, Kheifets 2001, Yeni-Komshian & Holly 2000, Preston-Martin & Mack 1996).

Townwide, four individuals reported working in the health care industry in occupations possibly associated with a higher incidence of brain or CNS cancer (e.g., nursing and dentistry), however, specific exposures associated with these occupations have not been established. These individuals resided in different areas of town and were not geographically concentrated in any one neighborhood or census tract. Eleven individuals in Needham were reported as retired or with unknown occupations. The remaining 26 individuals reported occupations that are not thought to be associated with an increased risk of brain or CNS cancer. However, from the available information, it was not possible to assess individual occupational exposure to established or suspected risk factors for brain or CNS cancer. Therefore, although the information reviewed suggests the possibility that occupational exposures may have contributed to the development of brain or CNS cancer among some individuals, it is difficult to determine what role, if any, occupational exposures played in the incidence of brain and CNS cancer in Needham overall.

VII. GEOGRAPHIC DISTRIBUTION

Place of residence at the time of diagnosis was mapped for each individual diagnosed with brain or CNS cancer in Needham during the 1987-1998 period to assess any possible geographic pattern of diagnoses. In addition to quantitatively determining census tract-specific incidence ratios when possible, a qualitative evaluation was conducted to determine

whether brain and CNS cancer cases appeared to be concentrated in some areas within the town or within a particular CT. Because of confidentiality reasons, maps of the locations of individuals diagnosed with brain and CNS cancer in Needham cannot be provided in this report. However, the point pattern of diagnoses was reviewed and the results are summarized here.

During the 1987-1993 period, 16 individuals were diagnosed with brain or CNS cancer in Needham. No statistically significant elevations were noted in Needham or any of its CTs during this time period. Additionally, individuals diagnosed with brain or CNS cancer from 1987 to 1993 lived in locations uniformly distributed throughout the town and, thus, were not concentrated in any one area.

Twenty-five individuals were diagnosed with brain or CNS cancer in Needham during the 1994-1998 time period where approximately 11 diagnoses were expected. As described above, the statistically significant elevation observed townwide was primarily due to statistically significant elevations in brain and CNS cancer incidence among residents of CTs 4033 and 4035 during 1994-1998. In CT 4033, a geographic concentration of diagnoses was noted near the Needham Junction neighborhood. Specifically, eight of the ten individuals diagnosed with brain and CNS cancer in this CT during this time period resided to the northeast of the Needham Junction Commuter Rail Station (see Figure 6). Review of case information from the MCR for these individuals revealed that brain and CNS cancer diagnoses in this area were distributed evenly among both males and females. Among females diagnosed with brain or CNS cancer in this area, two were under the age of 19 and two were adults of older ages. Among males diagnosed with brain or CNS cancers in this area, ages ranged from the late 40s to late 70s. As described above, the incidence of brain cancer among both males and females peaks during childhood and then, after age 25, risk increases with age. All of the individuals that were under age 40 at the time of diagnosis were diagnosed with astrocytoma, a type of brain cancer most common in younger individuals (Preston-Martin & Mack 1996). Of the five older (over age 40) individuals diagnosed in this area, four were diagnosed with glioblastomas or astrocytomas. These brain cancer histologies are the most common for older adults (Preston-Martin & Mack 1996).

Needham Junction is a high-density residential area and the most densely populated area of CT 4033. The geographic distribution of brain and CNS cancer diagnoses in this census tract can likely be attributed at least in part to the increased population density in this area. The role that other factors (e.g., heredity, diet, etc.) may have played in brain and CNS cancer incidence observed in CT 4033 during 1994-1998 is unclear.

A statistically significant elevation among both males and females combined was also noted in CT 4035 during 1994-1998. Most of the seven individuals resided in the greater Needham Heights area, to the north and northeast of the Needham Heights Commuter Rail Station (see Figure 6). The distribution of cases in the Needham Heights area closely matches the pattern of housing density in CT 4035. Additionally, brain and CNS cancer diagnoses in this area were distributed evenly among males and females. Further, the demographic and histology pattern of brain/CNS cancer incidence in this area was consistent with what would be expected based on available medical literature (i.e., individuals were diagnosed with the types of brain and CNS cancers most common for their age groups). Again, Needham Heights is a densely populated area of the town and no specific pattern of diagnoses with respect to place of residence at time of diagnosis emerged when this information was reviewed.

Individuals diagnosed with brain or CNS cancer in the remaining four CTs for this time period were fairly evenly distributed across these areas and were not concentrated in any one neighborhood in Needham.

VIII. AVAILABLE ENVIRONMENTAL INFORMATION AND CANCER INCIDENCE

As noted above, several environmental exposures have been suggested to be related to the development of brain and CNS cancer among some individuals. For example, some studies have reported a link between exposure to petroleum-related compounds, vinyl chloride, aspartame, lead, and pesticides and brain and CNS cancer risk among workers in certain industries (ACS, 2002b; Sathiakumar et. al., 2001; Delzell et. al., 1999; Cocco et al., 1998). Although no specific environmental issues were cited by the Needham Board of Health as

potentially playing a role in the incidence of brain and CNS cancer in the town, the CAP evaluated the locations of potential environmental sources in Needham in relation to the location of individuals diagnosed with brain and CNS cancer to determine whether a pattern of diagnoses exists in relation to these sites. This included a review of petroleum-related and/or hazardous waste sites and spills reported to the MDEP from 1982 to 1993. Also, brain cancer is often described as having a lengthy latency (or development) period, sometimes in excess of 20 years, between exposure to a potentially harmful substance and the development of the cancer (Preston-Martin & Mack 1996). Thus, in order to focus on past exposures consistent with the latency period often associated with brain/CNS cancers, the sites reported to the MDEP during 1982-1993 were comprehensively reviewed. Environmental spills that occurred after this time period are unlikely to result in exposures relating to brain and/or CNS cancer incidence during the 1987-1998 period.

Although the Massachusetts General Laws require that MDEP be notified of contamination that exceeds specified levels, it is important to note that chemical concentrations detected in environmental media do not necessarily represent a health threat. In order for a compound to impact one's health, it must not only be present in a certain environmental media but one must also come into contact with the compound via the contaminated media (e.g., through ingestion, inhalation, or skin absorption). Therefore, the presence of contaminants at a site alone does not necessarily indicate a potential health impact to nearby residents. However, the pattern of individuals diagnosed with brain and CNS cancers in Needham in proximity to the site may indicate that an environmental factor could be related to the incidence of this cancer type in Needham.

A summary of the spills in Needham reported to MDEP from 1982 to 1993 is presented in Table 4. A total of 176 hazardous waste sites, confirmed spills, or potential spills were reported to MDEP from 1982 to 1993. Approximately 26% of sites reported to MDEP during this time period did not have sufficient address information to allow for mapping of the site location. The locations of the sites with sufficient address information (about 130 sites) are shown in Figure 7. Of all the reported sites, the type of material found at a particular site was unknown for 11%. Seventy-nine percent of waste sites in Needham

during this time period involved petroleum-related chemicals (e.g., oils, fuels, gasoline). The remaining 10% of sites involved other chemicals (e.g., metals, organic compounds, pesticides). The locations of these sites were evaluated in relation to the places of residence of individuals diagnosed with brain or CNS cancer in Needham from 1987-1998.

Although some scientific studies have found that long-term occupational exposure to high levels of petroleum-related chemicals may lead to the development of brain cancer (Sathiakumar et. al., 2001; Delzell et. al., 1999), no studies are currently available that evaluate any possible associations between lower-level environmental exposures (i.e., exposures that might occur in a residential setting) to petroleum-related chemicals and brain cancer. Specific details regarding the source and quantity of spills was not available for the majority of sites. However, many of these releases occurred at gas stations or involved leaks from underground storage tanks or vehicle fuel tanks. Based on a review of the available information, it is unlikely that residents of Needham would have been exposed to significant levels of petroleum-related compounds associated with reported spills. Further, no specific spatial pattern of diagnoses in CT 4033 or 4035 (where statistically significant elevations of brain and CNS cancer were noted during 1994-1998), or in any other area of the town, was observed in relation to the locations of these sites.

Some studies have indicated that occupational exposure to vinyl chloride, lead, aspartame, or pesticides may contribute to the development of brain cancer. Three waste sites reported to MDEP between 1982-1993 were described as involving one of these chemicals. Two of these sites were not located in any areas of town proximal to places of residence for individuals diagnosed with brain or CNS cancer between 1987 and 1998. One of these sites, reported to MDEP in 1983, involved polyvinyl chloride (PVC) and was located on Junction Street in the Needham Junction area of CT 4033, where several cases of brain and CNS cancer were noted in the 1994-1998 period. The amount of PVC associated with this site is unknown. Although some scientific studies to date have suggested a possible association between occupational exposure to vinyl chloride, a colorless gas used in the manufacturing of PVC and plastics, and the development of brain and other cancers (McLaughlin & Lipworth, 1999), exposure to PVC, an inert solid, has not been linked to brain and CNS cancer.

Moreover, there is no evidence that residents of the Needham Junction area were exposed to contamination associated with this site.

Thirty-three percent of the sites listed with MDEP during the 1982-1993 time period were located in CT 4035. A statistically significant elevation among both males and females combined was also noted in CT 4035 during the 1994-1998 period. Generally, many of the waste sites in this CT were located east of Interstate 95 in an industrial area. Although this region is primarily industrial, a small residential neighborhood is located within this area. However, no spills were reported from 1982-1993 in this residential community. Additionally, no cases of brain or CNS cancer were reported in this neighborhood from 1987-1998.

Nineteen waste sites were reported to MDEP as being located in CT 4033 from 1982-1993. This comprises about 11% of all waste sites reported in Needham for this time period. In CT 4033, a statistically significant elevation of brain and CNS cancer was noted during the 1994-1998 time period. However, review of the geographic distribution of individuals diagnosed with brain or CNS cancer in this CT in relation to the locations of reported waste sites did not suggest a spatial correlation.

IX. **DISCUSSION**

Despite a statistically significantly lower-than-expected rate of brain and CNS cancer in Needham during 1987-1993, statistically significant elevations in the incidence of these cancers were noted in the town as a whole and for Needham CTs 4033 and 4035 during the 1994-1998 time period. A geographic concentration of several individuals who were diagnosed with brain and/or CNS cancers in CT 4033 during 1994-1998 was noted near the Needham Junction area. It is important to note that this area is a more densely populated area of town. Most of the individuals diagnosed with brain and/or CNS cancers during 1994-1998 who lived in this area had disease characteristics (e.g., gender, age at diagnosis, and histology type) that are consistent with what would be expected based on established patterns of brain and CNS cancer. Finally, the environmental data reviewed did not suggest that residents of

Needham diagnosed with brain and/or CNS cancer were likely to be at risk of exposure to a common environmental contaminant associated with hazardous waste sites in the town.

Although several individuals diagnosed with brain and/or CNS cancer during 1994-1998 in Needham lived in the greater Needham Heights area in CT 4035, the disease characteristics and traits (e.g., age, histology, gender, race) noted in these individuals was also consistent with what would be expected based on the current scientific/medical literature. Additionally, the distribution pattern of individuals diagnosed with brain or CNS cancer during this time period was consistent with the pattern of housing density in this area and no specific concentration of diagnoses was noted in relation to any waste sites reported to MDEP. Thus, the elevation of brain/CNS cancer incidence in CT 4035 during 1994-1998 does not appear to be due to any particular environmental exposure or factor.

Other than the elevation observed during 1994-1998, the pattern of brain and CNS cancer in Needham occurred as expected with regard to age, gender, and histology. Despite numerous scientific and medical investigations, the causes of brain and CNS cancer remain largely unknown. Among the possible risk factors investigated in relation to this type of cancer are ionizing radiation, electromagnetic fields, occupational exposures (as discussed above), exposure to nitrites and other N-nitroso compounds, head trauma, and genetic disorders. Of these, the most established risk factor is high-dose exposure to ionizing radiation (i.e., x-rays or gamma rays) (ACS, 2002b). There is no obvious source of ionizing radiation in Needham. Moreover, there is no historical evidence of high levels of nitrites/nitrates (or any other contaminant) in the Needham drinking water supply (Needham DPW, 2002). For more information on risk factors associated with brain and CNS cancer, please refer to Appendix A.

X. CONCLUSIONS

Although statistically significant elevations in the incidence of brain and CNS cancer were observed in Needham CTs 4033 and 4035 during 1994-1998, review of the available case information, environmental data, and geographic pattern of diagnoses does not suggest a common factor (environmental or non-environmental) related to these diagnoses. For some individuals, it is possible that occupational exposures could have played a role. It is

unknown whether individual risk factors (i.e., exposure to ionizing radiation, genetics, head injury, etc.) or the role of chance may also be related to some of these diagnoses.

A review of recent data from the MCR suggests that the elevation in brain and CNS cancer incidence observed in Needham during 1994-1998 may not be persisting over time. Seven diagnoses of brain and CNS cancer in Needham have been reported to the MCR since 1999. Although standardized incidence ratios cannot be calculated due to incomplete cancer incidence data for the state, this number appears to be consistent with the expected number of diagnoses based on the population of the town. Moreover, the individuals diagnosed with brain and CNS cancer are not concentrated in CT 4033, CT 4035, or any other part of Needham but are distributed fairly evenly throughout the town.

XI. RECOMMENDATIONS

The Community Assessment Program recommends no further investigation at this time based on the information reviewed. However, we will continue to monitor the incidence of brain and CNS cancers in Needham through the Massachusetts Cancer Registry to determine if the patterns of these cancers change.

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APPENDIX A:

Risk Factor Information for Brain and CNS Cancer