

Data Brief: Response to Community Concerns about the Incidence of Brain Cancer near the Former National Fireworks site in Hanover

Massachusetts Department of Public Health

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he Massachusetts Department of Public Health, Bureau of Environmental Health (DPH) conducted a screening-level review of the incidence of brain and other nervous system (ONS) cancers in response to community concerns about a possible elevation among residents living within 2 miles of the former National Fireworks site in Hanover, MA.

This data brief summarizes the incidence of brain and ONS cancers in 8 census tracts (CTs) in Hanover, Hanson, Pembroke, Rockland, and Whitman using data collected by the Massachusetts Cancer Registry (MCR). Data for invasive brain and ONS cancers were evaluated over a 30-year period from 1986-2015 and over three shorter 10-year periods (1986-1995, 1996-2005, and 2006-2015). Data for benign brain and ONS tumors were evaluated for the 10-year period of 2006-2015. These years constitute the most recent and complete data available at the initiation of this evaluation.

Summary of Findings

- During the first 20 years of the review, 1986-2005, the number of diagnoses of invasive brain and ONS cancers in each of the 8 CTs was not statistically significantly different from the number that would be expected based on the statewide experience.
- During the most recent 10-year period of 2006-2015, statistical elevations occurred in the incidence of invasive or benign brain and ONS cancers in 3 census tracts in Hanover and Pembroke.
 - \circ $\;$ The ages at diagnosis and histologies (cell types) followed national trends.
 - \circ $\;$ The spatial and temporal distributions did not reveal any unusual patterns.
- The geographic distribution of diagnoses generally followed the pattern of population density with no unusual spatial clusters observed immediately near the former National Fireworks site, within 2 miles of the site, or beyond 2 miles of the site.
- Evaluation of two environmental concerns associated with the site found that public exposure to ionizing radiation or vinyl chloride was unlikely to have occurred.

Conclusions

Based on this screening-level review of the incidence of brain and ONS cancers (invasive and benign), there is no evidence of an association of these cancers with the former National Fireworks site.

While isolated elevations indicative of natural variation over time often occur throughout the Commonwealth and are not generally cause for concern, DPH will continue to monitor the incidence of brain and ONS cancers in Hanover CT 5031.01, Hanover CT 5031.02, and Pembroke CT 5081.01 to ensure that the observed elevations do not persist.

Background

The former National Fireworks site encompasses about 240 acres in the Towns of Hanover and Hanson. It was first used to manufacture fireworks and pyrotechnics starting in 1907. It was then used for research and development and for the manufacturing, storage, and testing of munitions for the U.S. Department of Defense during World War II until it closed around 1970. The site is currently owned by more than 40 different public and private entities. Much of the southern portion is managed by the Hanover Conservation Commission for conservation and recreation.

Past activities at the site resulted in the release of military munitions and various contaminants, primarily mercury and lead. Remediation is ongoing through the Massachusetts Contingency Plan (MCP) process with oversight by the Massachusetts Department of Environmental Protection (MassDEP). See the <u>MassDEP's Massachusetts Contingency Plan Fact Sheet and Summary of</u> September 24 and October 16, 2019 Public Meetings for more information on the site cleanup.^[1]

At the request of MassDEP, DPH spoke with officials from the Town of Hanover in June 2019 to learn about residents' concerns of a possible elevation in brain cancer incidence near the former National Fireworks site. In response, DPH participated in a public meeting in Hanover on September 24, 2019 to hear community concerns and present the scope of a screening-level review of cancer incidence data. DPH reviewed the incidence of brain and ONS cancers in 8 census tracts that encompass the area within 2 miles of the former National Fireworks site. The 8 CTs are located in Hanover, Hanson, Pembroke, Rockland, and Whitman (Figure 1).



Figure 1: Census tracts (CTs) that encompass area within 2 miles of the former National Fireworks site

What are Brain and ONS Cancers?

Invasive (malignant) brain and ONS cancers can spread throughout brain tissue. Benign (noncancerous) brain tumors grow locally but can press on or damage normal brain tissue. Both cancerous and non-cancerous brain tumors can be life threatening.

There are two main types of primary brain and ONS tumors:

- Gliomas are a general group of tumors that start in glial cells. About 81% of invasive brain and ONS cancers are gliomas. There are several types of gliomas, including astrocytomas, oligodendrogliomas, and ependymomas. Glioblastoma is an aggressive, fast growing astrocytoma that accounts for more than half of all gliomas, making it the most common invasive brain cancer in adults. ^{[2] [3]}
- Meningiomas start in the meninges, which are layers of tissue that surround the outer part of the spinal cord and brain. Most meningiomas are benign, accounting for about 53% of all non-malignant brain tumors. ^{[3] [4]}

Metastatic or secondary brain tumors start elsewhere in the body and spread (metastasize) through the lymph system or bloodstream to the brain. In adults, metastatic tumors to the brain are more common than tumors that start in the brain (primary brain tumors). Lung, breast, kidney, colon, and melanoma are the most common primary cancers that metastasize to the brain. ^{[5][6]} Data are not collected on metastatic brain tumors in Massachusetts.

Risk Factors for Brain and ONS Cancers

Most brain and ONS cancers develop for no apparent reason and are not associated with specific risk factors. However, the following summarizes characteristics and factors that can contribute to risk in some cases. For more information, see the expanded summary of risk factors for brain and ONS cancers available on <u>Massachusetts Environmental Public Health Tracking</u>.

Age

Brain and ONS cancers are the second most common cancer type in children (after leukemia), making up about 25% of all childhood cancers. About half of all childhood brain and ONS cancers are gliomas. In children, the risk of brain and ONS cancers is greatest under age 10. Risk then increases with age between 25 and 75 years. About 80% of brain and ONS tumors are diagnosed in adults aged 40 years or older. ^{[6] [7] [8] [9]}

Sex

Men are generally more likely to develop gliomas than women, while women are more than twice as likely to develop meningiomas.^{[3][6]}

Race

The incidence of gliomas is higher in white individuals compared to black individuals, while the incidence of meningiomas is higher in black individuals compared to white individuals.^[3]

Ionizing Radiation

The most established risk factor for brain and ONS tumors (either benign or invasive) is high-dose exposure to ionizing radiation (i.e., x-rays and gamma rays). Most radiation-induced brain and ONS tumors are caused by radiation to the head from the treatment of other cancers. These brain tumors usually develop around 10-15 years after the radiation.^[2]

Hereditary Conditions

In rare cases, brain and ONS cancer run in some families. These tumors may be associated with hereditary syndromes such as neurofibromatosis types I and II, Li-Fraumeni syndrome, tuberous sclerosis, and Von Hippel-Lindau disease. Neurofibromatosis type I is the most common inherited cause of brain and ONS tumors.^{[2][7]}

Medical Conditions

People with allergies and atopic conditions (e.g., asthma, eczema) have a lower risk for gliomas. The reason is not known, but it may be that people with these conditions have more active immune systems which discourage abnormal cell growth. ^{[3] [9]}

Other Risk Factors Being Studied

Some studies have investigated workplace exposures to chemicals (vinyl chloride, nitroso compounds, pesticides, heavy metals), physical factors (head injuries, electromagnetic fields including those produced by cell phones), and infectious agents (viruses) as possible risk factors. None have shown sufficient evidence of a causal association.^[9]

Incidence of Invasive Brain and ONS Cancers During 2006-2015

Table 1 provides the number of observed and expected diagnoses of invasive brain and ONS cancers as well as standardized incidence ratios (SIRs) and confidence intervals for the 8 CTs near the former National Fireworks site during the most recent 10-year period of 2006-2015. Note that SIRs are not calculated when the number of observed diagnoses is less than five.

The incidence of invasive brain and ONS cancers was statistically significantly elevated in Hanover CT 5031.01 during this 10-year period (11 observed versus 5.4 expected). Of the 7 males and 4 females, the ages at the time of diagnosis followed what would be expected based on national trends with about 80% of individuals age 40 or older. Similarly, more than 80% of the individuals were diagnosed with a type of glioma, which also follows national trends. At the time of diagnosis, no individuals reported an occupation likely to be associated with exposure to high-dose ionizing radiation. The spatial distribution of residential addresses at the time of diagnosis generally followed the pattern of population density with no unusual spatial clustering. Approximately 25% lived within 2 miles of the site at the time of diagnosis.

			Total			Ι	Males		Females				
Census Tract	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	
5031.01 (Hanover)	11	5.4	203 *	101 - 363	7	3.1	229	92 - 472	4	2.4	NC	NC - NC	
5031.02 (Hanover)	2	5.4	NC	NC - NC	2	2.8	NC	NC - NC	0	2.6	NC	NC - NC	
5221.01 (Hanson)	3	3.3	NC	NC - NC	2	1.9	NC	NC - NC	1	1.5	NC	NC - NC	
5221.02 (Hanson)	1	4.3	NC	NC - NC	1	2.4	NC	NC - NC	0	1.9	NC	NC - NC	
5081.01 (Pembroke)	4	5.0	NC	NC - NC	2	2.7	NC	NC - NC	2	2.4	NC	NC - NC	
5021.01 (Rockland)	6	4.2	144	53 - 314	4	2.3	NC	NC - NC	2	1.9	NC	NC - NC	
5021.02 (Rockland)	4	4.1	NC	NC - NC	3	2.2	NC	NC - NC	1	1.9	NC	NC - NC	
5212.02 (Whitman)	4	2.8	NC	NC - NC	3	1.6	NC	NC - NC	1	1.3	NC	NC - NC	
Obs = O	95% CI = 95% Confidence Interval												
Exp = Exp	NC = Not calculated												
SIR = St	* = Statistically significant												

Table 1: Incidence Data for Invasive Brain and ONS Cancers during 2006-2015

Source: Massachusetts Cancer Registry (MCR), Office of Data Management and Outcomes Assessment, DPH.

The supplemental tables at the end of this data brief provide the number of observed and expected diagnoses, SIRs, and confidence intervals for each of the 8 CTs during the entire 30-year period of 1986-2015 and the additional two shorter 10-year periods of 1986-1995 and 1996-2005. During these time periods, no statistically significant elevations occurred. The number of diagnoses in most CTs was either less than or about as expected (within 1 or 2 diagnoses) in each time period. A few non-significant elevations were observed, but all were small and limited to one earlier time period (i.e., these elevations did not persist into the most recent time period).

Incidence of Benign Brain and ONS Tumors During 2006-2015

As a result of the Benign Brain Tumor Cancer Registries Amendment of 2002, state cancer registries were required by the National Program of Cancer Registries (NPCR) to begin collecting data on all brain tumors (malignant and non-malignant). Accordingly, Massachusetts General Law was amended in 2004 to include benign brain tumors for cancer reporting.

Table 2 provides the number of observed and expected diagnoses, SIRs, and confidence intervals for each of the 8 CTs during the 10-year period of 2006-2015. Note that SIRs are not calculated when the number of observed diagnoses is less than five.

The incidence of benign brain and ONS tumors was statistically significantly elevated in Pembroke CT 5081.01 (13 observed versus 6.8 expected). In Hanover CT 5031.02, the incidence of benign brain and ONS tumors was statistically significantly elevated among females (11 observed versus 5.3 expected) and statistically elevated overall (14 observed versus 7.6 expected). The number of diagnoses observed in the remaining 6 census tracts was not statistically significantly different from the number that would be expected based on the statewide experience.

	Total					I	Males		Females				
Census Tract	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	
5031.01 (Hanover)	9	7.4	122	56 - 232	2	2.6	NC	NC - NC	7	4.8	146	59 - 301	
5031.02 (Hanover)	14	7.6	183 *	100 - 307	3	2.4	NC	NC - NC	11	5.3	209 *	104 - 373	
5221.01 (Hanson)	5	4.5	111	36 - 260	2	1.6	NC	NC - NC	3	2.9	NC	NC - NC	
5221.02 (Hanson)	6	5.9	101	37 - 221	3	2.0	NC	NC - NC	3	3.9	NC	NC - NC	
5081.01 (Pembroke)	13	6.8	190 *	101 - 325	4	2.3	NC	NC - NC	9	4.5	199	91 - 378	
5021.01 (Rockland)	5	5.7	88	29 - 206	3	1.9	NC	NC - NC	2	3.7	NC	NC - NC	
5021.02 (Rockland)	4	5.6	NC	NC - NC	3	1.8	NC	NC - NC	1	3.7	NC	NC - NC	
5212.02 (Whitman)	3	3.9	NC	NC - NC	2	1.3	NC	NC - NC	1	2.5	NC	NC - NC	
Obs = Obser	95% CI = 95% Confidence Interval												
Exp = Expec	NC = Not calculated												
SIR = Stand	* = Statistically significant												

Table 2: Incidence Data for Benign Brain and ONS Tumors during 2006-2015

Source: Massachusetts Cancer Registry (MCR), Office of Data Management and Outcomes Assessment, MPDH.

Of the 9 females and 4 males diagnosed in Pembroke CT 5081.01, the ages at diagnosis and the histologies (cell types) followed what would be expected based on national trends. About 90% of the individuals were age 40 or older and all diagnoses were meningiomas. Of the 8 individuals for whom an occupation was reported at the time of diagnosis, none had an occupation possibly associated with exposure to high-dose ionizing radiation. The spatial distribution of residential addresses at the time of diagnosis generally followed the pattern of population density and all but one individual lived further than 2 miles from the site.

Of the 11 females and 3 males diagnosed in Hanover CT 5031.02, the ages at diagnosis and the histologies (cell types) followed what would be expected based on national trends. Nearly 80% of the individuals were age 40 or older and about 70% were diagnosed with meningioma. Of the 9 individuals for whom occupation was reported at the time of diagnosis, none had an occupation possibly associated with exposure to high-dose ionizing radiation. The spatial distribution of residential addresses at the time of diagnosis generally followed the pattern of population density with no unusual spatial clustering. About half of the diagnoses occurred among residents living within 2 miles of the site.

Evaluation of Environmental Concerns

Concern of Exposure to Possible Buried Radioactive Waste

MassDEP is currently overseeing the removal of unexploded ordnance (UXO) at the former National Fireworks site. During research into past site operations and practices to assist in the removal of UXO, a historic map was found identifying the location of radioactive waste buried 4 feet underground in June 1961.^[10] This small area is located on the east side of Lily Pond in a portion of the site that is currently wooded and undeveloped but historically was used for storing raw materials and finished products.^[11]

An initial assessment in June 2018 surveyed radiation levels at the surface above the radioactive waste burial site and the surrounding area encompassing approximately 3,600 square feet. No levels of radiation were detected above background. ^[11] Therefore, no potential exposure pathway exists for nearby residents or trespassers.

The assessment identified two areas where metallic objects, which could be UXO, may be present at depth. Based on this finding, MassDEP required that subsurface screening be conducted to account for the possibility that radioactive waste may be encountered during the UXO removal process. The DPH Radiation Control Program provided technical assistance throughout this process, and a survey was completed in December 2020 to determine if any radioactive materials are present below the surface. In the first area, no levels of radiation were detected above background and no UXO were found. In the second area (a 25-by-25-foot square section), a 55-gallon drum of material was discovered and found to have low levels of radioactivity, slightly above background. The soil around the drum was sampled and sent to a laboratory to further identify the material. The excavation was then backfilled, covered, and fenced off to prevent inadvertent entry. The surface area continues to have no detectable radiation above background levels, meaning there continues to be no risk of exposure to the public. ^[12] Historically, radioactive waste was typically placed in a drum and mixed with a grout/concrete mix to stabilize it before being buried. It is not expected that radioactive waste is buried at any additional locations on-site beyond this specific area identified on the historic map.

A plan for excavation, removal, and off-site disposal of the material is being developed with oversight by MassDEP and technical assistance by the DPH Radiation Control Program. Part of this plan will include ensuring that there is no migration of the radioactive material into a larger area.

Concern of Possible Exposure to Vinyl Chloride

At least one resident raised a concern about possible exposure to vinyl chloride from the former National Fireworks site and its possible role as a contributing factor to the development of brain and ONS cancers among residents living near the site.

Vinyl chloride is a colorless gas used in the manufacturing of polyvinyl chloride (PVC), which is used in a variety of plastics products, including pipes, wire and cable coatings, and packaging materials. Vinyl chloride is also a breakdown product of other chlorinated volatile organic compounds (CVOCs) such as trichloroethylene (TCE) and tetrachloroethylene (PCE). In general, exposure to vinyl chloride occurs mainly in the workplace. Other pathways of exposure can include drinking water from contaminated wells or breathing vinyl chloride released from plastics industries, hazardous waste sites, and landfills. Tobacco smoke also contains low levels of vinyl chloride. While a few early studies indicated some evidence of an association between occupational exposures to high levels of vinyl chloride on a regular basis and an increased risk of brain and ONS cancers, more recent studies have not supported those findings. Overall, there is insufficient evidence in the epidemiological literature to confirm a causal association between exposure to vinyl chloride and the risk of developing brain and ONS cancers.^{[9][13][14][15]} CVOCs have been released to the groundwater at the former National Fireworks site, particularly in the Upper North Area of the site where the manufacturing occurred and where now the commercial/industrial park is located. CVOCs above certain concentrations in groundwater have the potential to impact the indoor air of those buildings with CVOC vapors emanating from the groundwater (this is referred to as vapor intrusion). The Risk Characterization that was completed as part of the 2005 Phase II Comprehensive Site Assessment Report, approved by MassDEP, concluded that there were no significant concentrations of vinyl chloride in the groundwater, likely due to the compound's volatility and the fact that it readily breaks down in aerobic environments. ^[16]

A 2011 revision to the US EPA toxicity information on TCE resulted in MassDEP lowering the MassDEP standards relative to potential vapor intrusion and re-evaluating sites where releases of CVOCs have occurred. ^[17] In 2018, MassDEP sampled the indoor air of several buildings in the Upper North Area of the site. Vinyl chloride was not detected in any of the samples. ^{[18] [19]}

Soil sampling conducted in association with UXO removal efforts at the former National Fireworks site have resulted in some detections of vinyl chloride in surface and subsurface soil and sediment. Vinyl chloride will either evaporate rapidly if it is near the surface in soil or leach through the soil, ultimately entering groundwater. In the area of the former National Fireworks site, groundwater flows towards the site and the Indian Head River Corridor rather than away. Because the public supply wells are located upgradient of the site, the municipal drinking water for the Towns of Hanover and Hanson is not impacted by groundwater from the former National Fireworks site. As a result, no exposure of nearby residents to vinyl chloride from the site is expected. ^{[1][20]}

Furthermore, vinyl chloride is tested annually in public water supplies. Vinyl chloride was not detected in public drinking water supplies in any available testing data, which includes: Hanover during 2013-2020, Hanson during 2013-2020, Pembroke during 2012-2019, Rockland during 2005-2020, and Whitman (which receives its drinking water from the City of Brockton's Silver Lake Water Treatment Plant) during 2014-2020. ^[21] Based on this information, no exposure of residents to vinyl chloride from municipal drinking water in these five communities is expected. Note that although homeowners are responsible for the testing of private wells in Massachusetts, MassDEP has tested five irrigation wells of residents of Hanson living near the site upon request as a courtesy to address concerns. None of the irrigation wells had detections of volatile organic compounds (VOCs), including vinyl chloride. ^{[22][23]}

Discussion

This screening-level review of cancer incidence data was used to evaluate the pattern of cancer in a geographic context and determine whether further public health investigations or actions may be warranted. This review found small, isolated elevations in brain and ONS cancers, but no evidence of a connection between these cancers and the former National Fireworks site. There was no spatial clustering of diagnoses near the site and no unusual patterns in the ages at diagnosis or histologies (cell types) were observed. When evaluating cancer incidence data over many years, isolated elevations do occur throughout the Commonwealth reflecting natural variation and random fluctuation and are not generally cause for concern. However, DPH will continue monitoring the incidence of brain and ONS

cancers in these areas (Hanover CTs 5031.01 and 5031.02, and Pembroke CT 5081.01) to ensure that the observed elevations do not persist.

Limitations

The results presented here represent a screening-level review of cancer incidence data at the censustract level and not an investigation to determine the cause of cancer at the individual-level. Available information reported to the MCR related to risk factors for cancer development (e.g., age at diagnosis, sex, and occupation) was reviewed for residents who were diagnosed with brain and ONS cancers in CTs where elevations occurred. However, information about personal risk factors such as hereditary and medical conditions that may also influence the development of cancer is not collected by the MCR. Residential history prior to the time of diagnosis is also unknown.

When interpreting cancer incidence data, it is important to consider potentially misleading trends as apparent increases or decreases over time may reflect changes in diagnostic methods or case reporting rather than true changes in cancer occurrence. For example, the incidence rate for meningiomas in Massachusetts increased significantly after 2004 for both male and females. This may be due in part to increased detection of asymptomatic meningiomas through CAT scans and improved reporting as 2004 was the first year that non-malignant meningioma reporting was mandated. ^[27]

Conclusions

During the first 20 years of the review, 1986-2005, the number of diagnoses of invasive brain and ONS cancers in each of the 8 CTs was not statistically significantly different from the number that would be expected based on the statewide experience.

During the most recent 10-year period of 2006-2015, the incidence of brain and ONS cancer (invasive and benign) was generally either less than or as expected based on the statewide experience except for the following statistically significant elevations:

- In Hanover CT 5031.01, invasive brain and ONS cancer was statistically elevated during 2006-2015 with 11 observed diagnoses compared to 5 that would be expected.
- In Hanover CT 5031.02, benign brain and ONS tumors were statistically elevated among females during 2006-2015 with 11 observed diagnoses compared to 5 that would be expected and among the total population with 14 observed diagnoses compared to 8 that would be expected.
- In Pembroke CT 5081.01, benign brain and ONS tumors were statistically elevated with 13 diagnoses observed compared to 7 that would be expected.

Statistical significance does not necessarily imply public health significance. Determination of statistical significance is just one tool used to interpret SIRs.

Closer examination of risk factor information for these elevations as well as the spatial and temporal distributions did not reveal any unusual patterns or suggest that a common environmental factor played a primary role in these cancer diagnoses.

- The geographic distribution of residential addresses at the time of diagnosis generally followed the pattern of population density with no unusual spatial clusters observed immediately near the former National Fireworks site, within 2 miles of the site, or beyond 2 miles of the site.
- No elevations in the incidence of invasive brain and ONS cancers or benign brain and ONS tumors were consistent over time.
- The ages at the time of diagnosis and histologies (cell types) followed what would be expected based on national trends.

Based on the screening-level review of the incidence of brain and ONS cancers (invasive and benign), there is no evidence of an unusual pattern associated with the former National Fireworks site. In response to isolated elevations, DPH will continue to monitor the incidence of brain and ONS cancers in CTs 5031.01 and 5031.02 in Hanover, and CT 5081.01 in Pembroke.

Data Sources and Method Notes

Data Sources:

Massachusetts Cancer Registry, Office of Data Management and Outcomes Assessment, MDPH.

Method Notes:

- All new diagnoses of invasive cancer, as well as certain in situ (localized) cancers, 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).
- Individuals diagnosed with cancer were selected for inclusion based on the residential address provided to the hospital or reporting medical facility at the time of diagnosis.
- The year 2015 was the most recent year for which complete cancer incidence data were available at the initiation of this analysis.
- For this evaluation, brain and ONS cancer diagnoses were identified using SEER cancer definitions in the ranges: C70.0-C72.9 excluding 9050-9055, 9140, and 9590-9992. Invasive brain and ONS cancers were defined by behavior code 3. Non-malignant cases include both benign tumors (behavior code 0) and tumors of uncertain behavior (behavior code 1).
- The North American Association of Central Cancer Registries (NAACR) has estimated that the MCR case ascertainment is more than 95% complete.
- An SIR is the ratio of the observed number of cancer diagnoses in an area to the expected number of diagnoses, multiplied by 100. Age-specific statewide incidence rates were applied to the population distribution of each CT to calculate the number of expected cancer diagnoses.

It is standard MCR policy not to calculate rates with fewer than five observed diagnoses due to instability.

- The statistical significance of an SIR is assessed by calculating a 95% confidence interval (CI) to determine if the observed number of diagnoses is "statistically significantly different" from the expected number or if the difference may be due solely to chance. 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% percent chance that the observed difference (either increase or decrease) is the result of random fluctuation in the number of observed cancer diagnoses.
- The MDPH is bound by state and federal patient privacy and research laws not to make public the names or any information (e.g., place of residence) that could personally identify individuals with cancer whose diagnoses have been reported to the MCR (M.G.L. c.111. s. 24A).

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Resources

For information on this bulletin or other environmental health concerns:

MDPH Bureau of Environmental Health Environmental Epidemiology Program 250 Washington Street Boston, MA 02108 Tel. (617) 624-5757 www.mass.gov/dph/environmental_health

For additional cancer incidence data: Massachusetts Environmental Public Health Tracking 250 Washington Street Boston, MA 02108 Tel. (800) 319-3042 www.mass.gov/dph/matracking For information on the ongoing remediation at the former National Fireworks site:

MassDEP Southeast Regional Office Deborah Marshall-Hewlitt 20 Riverside Drive Lakeville, MA 02347 Tel. (508) 946-2888 https://www.mass.gov/locations/massdepnortheast-regional-office

SUPPLEMENTAL DATA

	Total						Males		Females			
Census Tract	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
5031.01 (Hanover)	18	14.1	128	76 - 202	11	7.8	141	70 - 252	7	6.3	112	45 - 230
5031.02 (Hanover)	14	15.4	91	50 - 153	6	7.8	77	28 - 167	8	7.6	106	46 - 209
5221.01 (Hanson)	7	8.8	80	32 - 164	4	4.8	NC	NC - NC	3	4.0	NC	NC - NC
5221.02 (Hanson)	10	11.5	87	41 - 159	4	6.3	NC	NC - NC	6	5.2	115	42 - 251
5081.01 (Pembroke)	15	15.8	95	53 - 156	7	8.9	78	31 - 161	8	6.9	116	50 - 229
5021.01 (Rockland)	14	12.4	113	62 - 190	8	6.7	120	52 - 236	6	5.7	105	38 - 229
5021.02 (Rockland)	9	11.9	75	34 - 143	6	6.1	98	36 - 212	3	5.8	NC	NC - NC
5212.02 (Whitman)	9	8.0	112	51 - 213	6	4.3	138	50 - 301	3	3.7	NC	NC - NC

Supplemental Table 1: Incidence of Invasive Brain and ONS Cancers in the Eight CTs Near the Former National Fireworks Site Over the 30-Year Period 1986-2015

Supplemental Table 2: Incidence of Invasive Brain and ONS Cancers in the Eight CTs Near the Former National Fireworks Site Over the 10-Year Period 1986-1995

	Total					Males		Females				
Census Tract	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
5031.01 (Hanover)	3	4.1	NC	NC - NC	2	2.2	NC	NC - NC	1	1.9	NC	NC - NC
5031.02 (Hanover)	6	5.0	119	43 - 259	3	2.5	NC	NC - NC	3	2.5	NC	NC - NC
5221.01 (Hanson)	0	3.0	NC	NC - NC	0	1.6	NC	NC - NC	0	1.4	NC	NC - NC
5221.02 (Hanson)	5	3.5	141	45 - 329	1	1.9	NC	NC - NC	4	1.7	NC	NC - NC
5081.01 (Pembroke)	5	3.7	134	43 - 313	2	1.9	NC	NC - NC	3	1.8	NC	NC - NC
5021.01 (Rockland)	4	4.5	NC	NC - NC	2	2.3	NC	NC - NC	2	2.1	NC	NC - NC
5021.02 (Rockland)	3	3.2	NC	NC - NC	2	1.6	NC	NC - NC	1	1.6	NC	NC - NC
5212.02 (Whitman)	0	2.6	NC	NC - NC	0	1.3	NC	NC - NC	0	1.3	NC	NC - NC

	Total						Males		Females				
Census Tract	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	
5031.01 (Hanover)	4	4.6	NC	NC - NC	2	2.0	NC	NC - NC	2	2.6	NC	NC - NC	
5031.02 (Hanover)	6	5.0	121	44 - 263	1	2.6	NC	NC - NC	5	2.4	211	44 - 263	
5221.01 (Hanson)	4	2.9	NC	NC - NC	2	1.6	NC	NC - NC	2	1.3	NC	NC - NC	
5221.02 (Hanson)	4	3.7	NC	NC - NC	2	2.1	NC	NC - NC	2	1.6	NC	NC - NC	
5081.01 (Pembroke)	6	5.0	119	43 - 259	3	2.9	NC	NC - NC	3	2.1	NC	NC - NC	
5021.01 (Rockland)	4	4.0	NC	NC - NC	2	2.2	NC	NC - NC	2	1.8	NC	NC - NC	
5021.02 (Rockland)	2	3.8	NC	NC - NC	1	2.0	NC	NC - NC	1	1.8	NC	NC - NC	
5212.02 (Whitman)	5	2.6	193	62 - 450	3	1.4	NC	NC - NC	2	1.2	NC	NC - NC	

Supplemental Table 3: Incidence of Invasive Brain and ONS Cancers in the Eight CTs Near the Former National Fireworks Site Over the 10-Year Period 1996-2005

Obs = Observed number of diagnosis	95% CI = 95% Confidence Interval
Exp = Expected number of diagnosis	NC = Not calculated
SIR = Standardized Incidence Ratio	* = Statistically significant