SUMMARY OF METHODS AND FINDINGS

INVESTIGATION OF ACUTE MYELOID LEUKEMIA
IN THE AREA OF MAHOPAC, ZIP CODES 10541, 10542, 10579, AND 10512
PUTNAM COUNTY, NEW YORK

A resident of the hamlet of Mahopac in Putnam County contacted the Cancer Surveillance Program to report what he believed to be an unusual occurrence of acute myeloid leukemia (AML) among residents in his neighborhood. The residents all lived in the same small neighborhood in the northwest part of ZIP Code 10541, and were diagnosed with AML in 2009 and 2010. His concern included a former farm where fuel dumping was suspected to have occurred. An initial review of these cases showed that all of the people reported by the resident were confirmed to have been diagnosed with AML or a subtype. (The exact number is not provided in order to protect patient confidentiality.) Based on this confirmation, the occurrence did appear unusual. It was determined that an investigation was needed to learn more about the occurrence of AML, and other blood cancers, in the Mahopac area.

METHODS

- To determine whether the occurrence of AML in the requestor's neighborhood was part of a larger pattern, we searched the files of the New York State Cancer Registry for additional cases of AML or other blood cancers among residents in the Mahopac area. The New York State Cancer Registry contains information on all cases of cancer diagnosed or treated in New York State, as required by law. The study area included ZIP Codes 10541 (Mahopac), 10579 (Putnam Valley), 10512 (Carmel) and point ZIP Code 10542 (Mahopac Falls), all located in Putnam County. The population of the study area was, on average, about 59,500 people for each year of the study period. We analyzed the characteristics of blood cancers among residents of the study area as a whole and by type, for those diagnosed between 2000 and 2009. We also examined the characteristics of blood cancers diagnosed in 2010, for which data were not yet official.

- We looked at the medical records of the residents living in the neighborhood of concern who were diagnosed with AML as well as those diagnosed with AML in 2010 to learn more about their individual risk factors or any exposures they may have had in common.

- We interviewed the residents living in the neighborhood of concern who were diagnosed with AML to determine whether there were any similarities among them, and to learn more about their individual risk factors or any exposures that may be related to their diagnosis.

- To identify potential sources of unusual exposures, the New York State Department of Health's Bureau of Environmental Exposure Investigation reviewed available information on environmental facilities and remediation sites in the area. The neighborhood of concern was

also discussed with staff from the Putnam County Health Department who conducted a field visit. Private drinking water wells in the neighborhood of concern were also tested.

FINDINGS

Search for other unusual patterns

- Between 2000 and 2009, a total of 291 **blood cancers**, including leukemias, lymphomas, and multiple myeloma, was identified in residents in the study area. Based on the population size and age and sex distribution of the study area, a total of 272 blood cancers was expected, a difference that is not statistically significant. The numbers of blood cancers diagnosed showed no apparent trend over the course of the time period. Blood cancers accounted for about the same percentage of all diagnosed cancers in the study area as in New York State, exclusive of New York City.

- There were 25 people diagnosed with **AML** in the study area between 2000 and 2009 which was no different from the 25 cases that were expected. A majority of the people were diagnosed after the age of 60, and more than 70% of them were male. Except for the neighborhood of concern, the addresses of the people diagnosed with AML generally followed the distribution of the population.

- There were 94 cases of **leukemia**, including AML, identified in the study area between 2000 and 2009, with 87 cases expected, a difference that is not statistically significant. A majority of the leukemias were chronic lymphocytic leukemia, followed by AML, chronic myeloid leukemia, other specified or unspecified types, and acute lymphocytic leukemia. The characteristics by type, for leukemias other than AML, were similar to what is usually observed. There were no obvious trends with time for any of the specific types of leukemia. There were six cases of hairy cell leukemia ("other specified or unspecified" type). This is a cancer of lymphocytes that accounts for about 2% of leukemia diagnoses. In the study area this cancer accounted for 6% of all leukemia diagnoses. These cases were diagnosed throughout the entire time period. There was no clustering in any area of the study and none of them lived in the requestor's neighborhood of concern.

- There were 156 cases of **lymphoma** identified in the study area between 2000 and 2009, with 148 cases expected, a difference that is not statistically significant. Lymphomas were the most frequently identified class of blood cancers in people of all ages in the study area, as is usually observed. The characteristics of these cancers were similar to what is usually observed. The number of cases diagnosed varied from year to year during the time period of the study.

- There were 41 cases of **multiple myeloma** identified in the study area between 2000 and 2009, with 37 cases expected, a difference that is not statistically significant. The characteristics of these cancers were similar to what is usually observed. The number of cases diagnosed was fairly stable over the entire time period of the study.

- **Blood cancers diagnosed in the study area in 2010** were not included in the analysis because data for that year were not yet official. However, data for this year were examined and the numbers and characteristics of cases, as a whole, were found to be consistent with data from 2000 to 2009. When the individual blood cancers were examined separately, most of the people diagnosed with AML in 2010 were under the age of 45. This is younger than what is typically seen. There were no additional cases of AML in the neighborhood of concern in 2010, other than those reported by the resident.

Medical records

Medical records were obtained for all of the people in the neighborhood who were reported by the resident and confirmed to have been diagnosed with AML. In addition, because the individuals diagnosed with AML in 2010 in the study area were younger than what is typically seen, medical records were obtained for these individuals. Most of the people were current or former smokers. A family history of cancer was mentioned for most of them but none of the cancers was AML. Otherwise, there was very little information available regarding history of the residents such as occupation or exposures. Given the limited information available, it is not possible to determine whether any individual characteristics may have played a role in their diagnoses.

Interviews

An interview study was conducted for all of the people who were reported by the resident and confirmed to have been diagnosed with AML. For those who were interviewed there were no strong individual risk factors. There were also no unusual exposures to chemicals such as benzene that they had in common, or occupational exposures to chemicals such as pesticides. The information obtained from the interviews does not suggest any individual characteristics that may have played a role in the diagnoses.

Environmental review

- The only listed environmental facility identified in the area of the neighborhood of concern was Mercury Sanitation, an electronics recycler. The facility is a broker only and does not actually handle any materials at that address. The US Environmental Protection Agency's public records indicate no violations or compliance issues with this facility. There was no evidence that the facility would result in any human exposures in any part of the study area.

- Staff from the Putnam County Health Department conducted a field visit to the area, including the farm property identified by the requestor of the study, and did not identify anything unusual that could be a source of potential environmental exposure.

- Putnam County Health Department staff also sampled six private drinking water wells in the area, including wells used by the people reported by the requestor of the study. The samples

were analyzed for metals, volatile and semi-volatile organic compounds, PCBs, and pesticides. No metals were detected at unusual levels or levels of health concern. None of the other tested-for chemicals were detected.

GENERAL INFORMATION: ACUTE MYELOID LEUKEMIA

Acute myeloid leukemia is a cancer of the blood cells. Some risk factors that may increase one's chance of developing AML include age and gender. AML is most often seen in adults age 65 years and older. Men are more likely than women to be diagnosed with the disease. Other risk factors include smoking, exposure to certain chemicals, exposure to a high dose of radiation, certain blood problems, and Down syndrome and certain other congenital syndromes.

CONCLUSIONS

The number of people living in one small neighborhood who were reported by the requestor to have been diagnosed with AML was confirmed as unusual. However, during the 10-year period for which Cancer Registry data were official, the present study did not find any unusual patterns of AML in the study area as a whole.

When blood cancers in the study area were examined as a whole or by type no unusual patterns were found except for an apparently unusual number of cases of hairy cell leukemia. When the cases of hairy cell leukemia were examined in greater detail, however, the characteristics did not appear unusual. The finding of an unusual occurrence of AML appeared to be limited to the neighborhood of concern. When 2010 data were examined, the characteristics of the blood cancer cases as a whole were found to be consistent with data from previous years. However, when the individual blood cancers were examined separately, the people diagnosed with AML tended to be younger than what is typically seen. Given the limited information available from the medical records reviewed, it is not possible to determine whether any individual characteristics may have played a role in the AML diagnoses. The area does not stand out as unusual in its known chemical exposures, and no widespread exposures to hazardous materials were identified. The information available does not suggest any single cause or combination of causes that might account for the AML diagnoses. Although this unusual occurrence may be related to factors we have been unable to identify, it is also possible that it occurred by chance.

Due to the finding that the people diagnosed with AML in 2010 tended to be younger than what is typically seen (most of them were younger than 45 years of age, whereas the average age of diagnosis in New York State exclusive of New York City is about 64 years), this study will be updated when cancer data for 2010 and 2011 become official, in the spring of 2014.

For more information on this investigation or on cancer in general, please contact Ms. Aura Weinstein, Director, Cancer Surveillance Program, New York State Department of Health, at (518) 473-7817.   *9/2013*

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Background

The Cancer Surveillance Program of the New York State Department of Health, Bureau of Cancer Epidemiology, responds to concerns about cancer in communities throughout New York State. In November 2010, a resident of the hamlet of Mahopac in Putnam County contacted the Cancer Surveillance Program and reported what he believed to be an unusual number of cases of acute myeloid leukemia (AML) in his neighborhood. These people all lived in the same small neighborhood in the northwest part of ZIP Code 10541, and were diagnosed in 2009 and 2010. His concern included a former farm where fuel dumping was suspected to have occurred.

The Cancer Surveillance Program reviewed the information provided by the resident and attempted to confirm the reported diagnoses through available information sources. One of these sources was the New York State Cancer Registry, which contains information on all cases of cancer diagnosed or treated in New York State, as required by law. Medical records were also obtained to further confirm the precise diagnoses for the people reported by the resident.

The review of the medical records showed that all of the people reported by the resident were diagnosed with AML, although at least one of them was diagnosed with a subtype of AML. (Exact numbers are not provided in order to protect patient confidentiality.) Based on this confirmation, the occurrence did appear unusual. It was decided to conduct a study to learn more about the occurrence of AML in the Mahopac area. Follow-up activities included 1) a search of Cancer Registry files to identify any additional cases of AML or other blood cancers among residents of the Mahopac area to see if the confirmed cases of AML were a part of any larger pattern; 2) a review of the medical records for all of the people who were reported by the resident; 3) interviewing all of the people who were reported by the resident; and 4) a review of available environmental information to identify any potential for unusual environmental exposures in the area. This report presents the results of these follow-up activities.

Search for other unusual patterns

Methods The source of information on blood cancer diagnoses among residents of the Mahopac area was the New York State Cancer Registry. As noted in the background section, the Cancer Registry contains information on all cases of cancer diagnosed or treated in New York State, as mandated by law. One person can be hospitalized many times, at different hospitals, over a period of years for the same cancer. Each separate hospital admission is

reportable to the Cancer Registry. As multiple reports on the same cancer are received, they are combined with existing information to continuously update Cancer Registry files to reflect the fullest and most accurate information available. At the time this follow-up began, cancer incidence data were considered official through 2009, meaning that reports for this year and previous years were essentially complete and the data had passed all quality assurance checks. Information on cancer cases was updated through November 2011.

Variation in cancer incidence among different geographic areas reflects not only true differences in cancer occurrence, but also differences in how cancer is diagnosed, treated, and recorded in different areas of the state. The completeness and accuracy of the Cancer Registry depend upon reporting from hospitals, laboratories, managed care organizations and other sources. The Cancer Registry has been certified as more than 95% complete by the North American Association of Central Cancer Registries. In addition, the Cancer Registry has received gold certification from the Association since 2000 (data year 1996), the highest certification given to central cancer registries (1).

Leukemia, lymphoma, and multiple myeloma are all cancers of the blood or blood-forming system. Since it is plausible that these diseases may have similar causes, all three classes of blood cancers were examined as a first step to ensure that the confirmed cases of AML were not part of a larger pattern.

To identify additional blood cancers diagnosed among residents of the Mahopac area, we looked at ZIP Codes 10541 (Mahopac) including point ZIP Code 10542 (Mahopac Falls), 10579 (Putnam Valley) and 10512 (Carmel), all located in Putnam County (see map). Point ZIP Codes have residential post office boxes but no associated delivery area and are included because a person with a point ZIP Code likely lives somewhere in the area. This study area was chosen because it is a larger area that contains the neighborhood of concern. Cancer Registry records were searched for people living in these four ZIP Codes who were diagnosed with leukemia, lymphoma, or multiple myeloma since 2000.

As stated above, Cancer Registry data were official through 2009. For that reason, comparisons for cancer patterns in the study area with those in other areas were only done for 2000-2009. Since at least one of the people diagnosed with AML in the requestor's neighborhood was diagnosed in 2010, data were also examined for this year, although no comparisons were made.

Findings A search of Cancer Registry records identified a total of 291 blood cancers among residents of the study area during the 10-year study period for which data were official, 2000-2009. The 291 blood cancers diagnosed in the 10 years of the study translates to an average of 29.1 diagnoses per year. Table 1 shows that numbers of blood cancers diagnosed in any one year during the time period of the study ranged from 16 to 36. The total numbers of blood

cancers diagnosed showed no apparent trends. In the first half of the time period numbers of cases diagnosed were fairly stable, but in the second half of the time period they varied from year to year. There was also an average of about three cases fewer per year in the second half of the time period (30.8 vs. 27.4).

In the study area during 2000 to 2009, blood cancers accounted for approximately 9.1% of all diagnosed cancers (a total of 3,194 cancer diagnoses). In New York State, exclusive of New York City, blood cancers accounted for approximately 8.8% of all diagnosed cancers during the same time period (a total of 762,787 cancer diagnoses). This indicates that there does not appear to be an unusual number of blood cancers in the study area.

The number of blood cancers that would be expected in the study area was calculated by applying cancer incidence rates by age and sex for a reference area to the estimated population of the study area by age and sex. The reference area selected for this investigation was New York State, exclusive of New York City. The population of the study area for 2000-2009 was estimated using data from the United States Census for 2000 and 2010. The Poisson model was used to determine the probability that chance alone could explain an increase or decrease in the observed number of cancer cases compared to the expected number (2). If the probability of observing an excess or deficit was 0.025 or less for any of the blood cancer sites examined, the result was considered to be statistically significant. Non-significant excesses or deficits were considered to represent random variations in observed patterns of disease.

For this investigation, a total of 291 blood cancers was observed and a total of 272 blood cancers was expected based on the population size and age and sex distribution of the study area, a difference that is not statistically significant (see Table 2). This indicates that there does not appear to be an unusual number of blood cancers in the study area. Expected numbers for specific types of blood cancers were also examined and discussed below.

Specific types of blood cancers diagnosed in the study area between 2000 and 2009 included 94 leukemias, 156 lymphomas, and 41 multiple myelomas (see Table 2).

Leukemias There were 94 cases of leukemia identified in the study area and 87 cases were expected, a difference that is not statistically significant. The number of cases of leukemia diagnosed ranged from four to 16 per year with an average of 9.4 cases per year. The number of cases diagnosed was stable from 2000 to 2003 and then decreased in 2004. After 2004, the number of cases diagnosed remained below what was seen from 2000 to 2003 and was stable through 2009.

The diagnoses of leukemia were separated into the following most common types and then examined: acute myeloid leukemia (AML), acute lymphocytic leukemia (ALL), chronic lymphocytic leukemia (CLL), and chronic myeloid leukemia (CML).

In the study area AML was diagnosed in 25 people, and 25 cases were expected. The age at diagnosis ranged from late childhood to the elderly. The average age at diagnosis was 62 years. In New York State exclusive of New York City, for the same time period, the average age at diagnosis was 64 years. In the study area, more males than females were diagnosed with this particular type of leukemia, which is what is typically seen. The number of cases diagnosed annually ranged from one to five with an average of 2.5 per year.

The street address at the time of diagnosis for each individual diagnosed with AML from 2000 to 2009 was plotted on a map of the study area. The addresses generally followed the distribution of the population, with several cases in the more densely populated areas within the Towns of Carmel and Kent and other addresses widely scattered in the more rural areas.

For the other major types of leukemia, there were fewer than six diagnoses of ALL in the study area during 2000 to 2009 (exact numbers are not provided in order to protect patient confidentiality). Individuals diagnosed with ALL ranged in age from early childhood to the elderly with the diagnoses distributed similarly between males and females. The number of cases diagnosed in any given year ranged from zero to two. There were 38 diagnoses of CLL occurring in people who were in their late thirties and older, with a majority in their early sixties and older. The average age at diagnosis was 63 years. A majority of the cases were male as is typically seen. The number of cases diagnosed annually ranged from one to six with an average of 3.8 per year. CML was identified in 15 people, ranging in age from young adults to the elderly. The average age at diagnosis was 63 years. A majority of the people were male as is typically seen. The number of cases diagnosed ranged from zero to five with an average of 1.5 per year.

The remainder of the leukemias diagnosed in the study area were in the category other specified or unspecified types of leukemia. Five different types were represented, including acute biphenotypic leukemia; lymphoid leukemia, not otherwise specified; prolymphocytic leukemia, T-cell type; hairy cell leukemia; and aggressive NK-cell leukemia. The ages ranged from early adulthood to the elderly.

A majority of the other specified or unspecified types of leukemia were hairy cell leukemia, of which there were six. This is a cancer of lymphocytes that accounts for about 2% of all leukemia diagnoses. In the study area, hairy cell leukemia accounted for about 6% of leukemia diagnoses. Because of this, these cases were examined more closely. The cases were diagnosed throughout the entire time period. The ages at diagnoses were not different from what one would expect to see. The street addresses at the time of their diagnosis were plotted on a map of the study area. There was no clustering of cases in one area; they were rather spread out over two of the ZIP Codes in the study area. None of these cases were diagnosed in the requestor's neighborhood of concern.

Lymphomas There were 156 cases of lymphoma identified in the study area with 148 cases expected, a difference that is not statistically significant. The number of lymphomas diagnosed annually in the study area ranged from seven to 23 with an average of 15.6 cases per year. The number of cases diagnosed varied from year to year, increasing some years and decreasing others, during the entire time period of the study.

Lymphomas include Hodgkin disease, and various other types known collectively as the non-Hodgkin lymphomas. As is usually observed, lymphomas were the most frequently identified class of blood cancer in people of all ages in the study area. Of these, 26 were cases of Hodgkin disease and 130 were non-Hodgkin lymphoma.

Residents of the study area diagnosed with Hodgkin disease ranged in age from the teens to the elderly, although, as is typically seen, the majority were young adults. The average age at diagnosis was 36 years. Slightly more males than females were diagnosed with this cancer. The number of cases diagnosed in any one year during the time period ranged from one to five with an average of 2.6 per year. There were 130 cases of non-Hodgkin lymphoma diagnosed. These occurred among people ranging from young children to the elderly, with a majority over the age of 60. Typically 50% of people diagnosed with non-Hodgkin lymphoma are age 65 and older. The average age at diagnosis in the study area was 60 years. More males than females were diagnosed with this cancer. The number of cases diagnosed in any one year ranged from six to 21 with an average of 13.0 per year.

Multiple Myeloma There were 41 cases of multiple myeloma identified in the study area with 37 cases expected, a difference that is not statistically significant. The age at diagnosis ranged from late forties to the elderly with an average age of 67 years. A majority of the people were males. The number of cases of multiple myeloma diagnosed during the time period of the study for any one year ranged from one to eight with an average of 4.1 per year. The number of cases diagnosed was fairly stable over the time period.

Additional Blood Cancers - Other and Unspecified There were additional blood cancers diagnosed in the study area that did not fall under any of the specific blood cancer types discussed above (exact numbers are not provided in order to protect patient confidentiality). They were of two types, follicular dendritic cell sarcoma (a cancer of immune system cells found in lymph nodes) and Waldenstrom macroglobulinemia (a cancer producing large numbers of one type of antibody). When the characteristics of these cancers were examined more closely, they were not found to be unusual. These cancers were excluded from the results of the study.

Blood cancers diagnosed in 2010 Blood cancers diagnosed in 2010 were also examined and, as a whole, were found to be consistent with data from previous years. However, when the individual blood cancers were examined separately, the people diagnosed with AML were all younger than what is typically seen, with most of them being less than 45 years of age. Even

after removing those diagnosed with AML in the neighborhood of concern, the average age was still unusual, although numbers were small. As of June 2013, there were no additional cases of AML, other than the ones reported by the requestor, in the neighborhood of concern that were diagnosed in 2010.

Medical Records

Methods Medical records were reviewed for all of the people in the neighborhood who were reported by the resident to have been diagnosed with AML, and also for those people in the study area who were diagnosed with AML in 2010, who tended to be younger than what is typically seen, to gain some additional information about their diagnosis. Information sought from the medical records included exposure to radiation, long-term exposure to certain chemicals such as benzene, certain blood disorders such as chronic myeloproliferative disorders (polycythemia vera, essential thrombocytopenia, and idiopathic myelofibrosis), congenital syndromes, and smoking status. These are all risk factors that may increase one's chance of being diagnosed with AML.

Findings Very little information was available regarding the reported cases' medical histories. None of the medical records reviewed mentioned whether any of the people diagnosed with AML in the neighborhood of concern had any exposure to radiation. An occupation or place of employment was listed for most people, with one individual stating an exposure to a toxic substance that is not known to be a risk factor for AML, and another being employed in the manufacturing industry. It was not possible to determine what any of the individuals specifically did for employment, therefore it is difficult to determine what, if anything, any of them could have been exposed to or for how long. The majority of the people were current or former smokers. Some of the people had a family history of other cancers. These included a variety of cancers (e.g. colon, breast, leukemia, Hodgkin disease, lung) but no mention of AML specifically. One of the people had a previous cancer, but the type of treatment was not specified. Given the limited information available from the medical records on these individuals, it is not possible to determine whether any individual characteristics may have played a role in the diagnoses.

Interviews

Methods To obtain more information about individual risk factors that may be related to their diagnoses, an interview study was conducted that included all of the people in the neighborhood who were reported by the resident to have been diagnosed with AML. The aim of this study was to determine whether there were any similarities among the individuals diagnosed with AML, and to learn more about their medical and family histories, occupations, places of residence, and any exposures they may have had.

Before attempting to contact any of the people identified, medical records were obtained from all hospitals that reported them to the Cancer Registry. Information from the medical records and the continually updated Cancer Registry listings was then consulted to determine whether any of the patients were deceased. For those not found to be deceased, physicians listed in the medical record were contacted to determine if they had any concerns with our contacting these patients. If the physicians did not express any objections to the interview, patients were contacted directly by letter and asked to participate. For patients known to be deceased, a letter was sent to the next-of-kin, asking them to participate on behalf of the patient. Letters were followed up by a telephone call during which an attempt was made to schedule an interview.

Interviews were conducted by telephone by a trained interviewer using a questionnaire developed for the study. Questions were asked regarding the patient's family medical history, personal medical history, their occupational history, and their residential history from birth to the time of their AML diagnosis. Questions were also included on specific exposures that may be associated with AML.

Findings Interviews were obtained for most, but not for all of the patients. Interviews that could be obtained were completed by the patients themselves, or by the next-of-kin.

For those who were interviewed, none were born in Mahopac. They lived in the neighborhood of concern for five to nine years prior to their AML diagnosis. None of the patients had a previous cancer. Some reported a family history of various cancers among first and second degree relatives, but none of the cancers was AML. None of the individuals had any of the blood disorders that have been associated with AML, which include disorders such as polycythemia vera, essential thrombocytopenia, and idiopathic myelofibrosis. None of the individuals had any congenital syndromes such as Down syndrome. Some of the individuals were previous smokers. Occupations noted for these individuals from age 16 to the time of diagnosis included blue-collar and white-collar occupations with no two individuals having the same occupation. One occupation involved ionizing radiation, but workers in this occupation are generally well shielded. Various occupational and residential exposures were noted including exposures to pesticides, herbicides, fertilizers, and other chemicals. There were no reported exposures to chemicals such as benzene, which are established risk factors for AML, and no occupational exposures to chemicals such as pesticides, which are suspected risk factors.

Environmental review

Methods To identify potential sources of unusual exposures, staff from the Bureau of Environmental Exposure Investigation (BEEI) of the New York State Department of Health (NYSDOH), Center for Environmental Health, reviewed available information on environmental

facilities and remediation sites in the study area. Sources included NYSDOH's Environmental Facilities and Cancer Mapping website (3), the US Environmental Protection Agency's (EPA) EnviroMapper (4), and BEEI's files and databases. The neighborhood of concern was also discussed with staff from the Putnam County Health Department. Several of the private drinking water wells in the neighborhood of concern were also tested.

Findings Staff did not identify any unusual potential environmental exposures of concern in the area. The EPA website identified two facilities that staff evaluated more closely. One, Mercury Sanitation, Inc., an electronics recycler, is located on Barrett Hill Road. The facility is a broker only and does not actually handle any materials at that address. The EPA's public records indicate no violations or compliance issues with this facility. The other facility identified, the former Cross-Country Sanitation landfill, was improperly mapped into this neighborhood and is actually in the Town of Patterson (also in Putnam County).

BEEI staff also discussed the area with staff from the Putnam County Health Department. They were not aware of any unusual sources of potential environmental exposures. Staff from the Putnam County Health Department conducted a field visit to the area, including the farm property identified by the requestor, and did not identify anything unusual that could be a source of potential environmental exposure.

Putnam County Health Department staff also sampled six private drinking water wells in the area, including the ones used by all of the people diagnosed with AML that were reported by the requestor. The Department of Health's Wadsworth Center laboratories analyzed the samples that the county staff collected. The samples were analyzed for metals, volatile organic compounds, organochlorine pesticides, PCBs, nitrogen/phosphorus pesticides and semi-volatile organic compounds. No metals were detected at unusual levels or levels of health concern. None of the other tested-for chemicals were detected.

Discussion

Leukemia Leukemias are cancers of the cells in the bone marrow that give rise to the various types of blood cells. The leukemias can be classified according to the course of the disease (acute or chronic), and the type of blood cell affected (lymphocytic or non-lymphocytic). Acute myeloid leukemia (AML), is generally a disease of older people and is uncommon in persons less than 40 years of age. Acute lymphocytic leukemia (ALL) is the most common type of leukemia in children, but also affects adults, particularly the elderly. Chronic lymphocytic leukemia (CLL) most commonly affects adults over age 55 and rarely occurs in children. Chronic myeloid leukemia (CML) occurs mainly in adults, but has been known to affect children. Although it is often thought of as a disease of children, most cases of leukemia occur in older adults.

There were six cases of hairy cell leukemia diagnosed in the study area. These fall under the category of other specified or unspecified types of leukemia. Risk factors for this cancer may include exposure to pesticides, herbicides, and diesel fuel or gasoline.

At this time, scientists do not know what causes most cases of leukemia. Different types of leukemia have been found to have different, but overlapping, sets of risk factors. Since it has not always been possible to look at different types of leukemia separately, much of what is known about leukemia risk factors comes from studies where all the leukemias are looked at as a group. In addition, not all risk factors identified for adults are applicable to children, and certain risk factors identified for children do not hold for adults. Most types of leukemia have been associated with exposure to high doses of ionizing radiation, such as atomic bombs or radiation treatments for other forms of cancer. People with Down syndrome and certain other genetic abnormalities are known to develop leukemia more frequently. Certain unusual forms of leukemia are caused by a rare virus. Long-term exposures to certain chemicals found in the workplace, such as benzene, have also been linked to leukemia, and people treated with certain anti-cancer drugs are known to be at higher risk. Recent research suggests that leukemia, especially the myeloid types, is associated with cigarette smoking (5, 6).

Lymphomas Lymphoma is the name for cancers that develop in the lymphatic system, a part of the body's immune system. The lymphatic system helps the body fight infection and diseases. It is made up of thin tubes, similar to blood vessels, that branch into tissue throughout the body. These tubes carry a watery, colorless fluid, called lymph, which contains infection–fighting cells. These cells are called lymphocytes. Along the network of tubes are small, oval-shaped organs called lymph nodes. Groups of lymph nodes are found in the armpits, neck, chest, abdomen and groin. Other parts of the lymphatic system are the thymus, spleen, tonsils and bone marrow. Lymphatic tissue is also found in the stomach, skin and intestines and other body parts. Lymphomas are often divided into two groups: Hodgkin lymphoma and non-Hodgkin lymphoma.

Non-Hodgkin lymphoma occurs more frequently in men than in women. It also occurs more frequently in whites than in African-Americans. Although children can get non-Hodgkin lymphoma, the risk of getting lymphoma increases with age. Approximately 70% of people diagnosed with lymphoma are age 50 and older. Hodgkin lymphoma occurs slightly more often in males than in females. It can occur in both children and adults and is most common in early adulthood (ages 15 to 40) and in late adulthood (after age 55). It is rare before the age of five. Approximately 10%-15% of cases are diagnosed in children and teens.

At this time, scientists do not know exactly what causes non-Hodgkin or Hodgkin lymphoma. People with depressed immune systems, such as those who have had organ transplants and individuals with HIV/AIDS, have an increased risk of getting non-Hodgkin lymphoma. Research studies among farmers and other occupations also suggest that exposure

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to herbicides, pesticides and certain other chemicals may be associated with the development of non-Hodgkin lymphoma. Risk factors associated with Hodgkin disease include having had infectious mononucleosis, family history of Hodgkin disease and having a higher socioeconomic background (7, 8).

Multiple Myeloma Multiple myeloma is a cancer of the plasma cells. Plasma cells are a type of white blood cell and are part of the immune system. They are found in the bone marrow, the soft tissue found inside some hollow bones. The plasma cells can become cancerous and produce a tumor called a plasmacytoma which usually develops in a bone but can also be found in other tissue. Multiple myeloma is diagnosed when many plasma cell tumors are found throughout the bones.

Multiple myeloma is a relatively uncommon cancer. It is most often seen in adults age 65 and older. Less than 1% of cases are seen in people less than 35 years of age. Men are slightly more likely than women to be diagnosed with this disease. African Americans are almost twice as likely as white Americans to be diagnosed with multiple myeloma.

Risk factors that may increase one's chance of developing multiple myeloma include: exposure to radiation (accounting for a very small number of cases), family history of multiple myeloma, working in a petroleum-related industry, being overweight or obese, or having other plasma cell diseases (monoclonal gammopathy of undetermined significance [MGUS] or solitary plasmacytoma) (9).

Study findings This study identified a total of 291 blood cancers among residents of the study area during the 10-year study period. Of those blood cancers, 94 were identified as leukemias, 156 were lymphomas, and 41 were multiple myelomas. All of the blood cancers were examined further both as a whole and by specific blood cancer. When all of the blood cancers were examined, no unusual patterns were found. The total number of blood cancers that was diagnosed was not statistically different from the number of blood cancer diagnoses expected. The numbers of cases diagnosed in any one year for the first half of the study were fairly stable, but in the second half of the time period they varied from year to year. There was also an average of about three cases fewer per year in the second half of the time period.

When the blood cancers diagnosed between 2000 and 2009 were examined individually, there were no unusual characteristics found for AML. A majority of the people were diagnosed at an age when AML is most frequently found. Most of the people were also male. The numbers of cases diagnosed per year were fairly stable, with fewer cases diagnosed in the second half of the study. The only unusual geographic pattern found when the street addresses at the time of diagnosis were plotted on a map was in the neighborhood of concern where a small number of people were diagnosed with AML in a small area in a short time period. Otherwise the addresses of the people diagnosed with AML outside of the neighborhood of

concern were spread out over the entire study area and generally followed the distribution of the population. The percentage of all diagnosed cancers that were AML was about the same in the study area compared with New York State, exclusive of New York City during the time period of the study. The number of cases of AML diagnosed was the same as the number of cases expected.

For leukemias as a whole, the percentage of all cancers that were leukemia was about the same in the study area as in New York State, exclusive of New York City during the time period of the study. The number of leukemias diagnosed in the study area was about what would be expected. The ages of the cases ranged from young children to the elderly. Nothing unusual was found when the four most common types of leukemia were examined separately.

There was an excess of hairy cell leukemia, a less commonly found leukemia. When characteristics of this cancer were examined more closely, no unusual patterns were found. The cancers were diagnosed throughout the entire time period of the study. There was no clustering of cases in one area but the cases were spread out over two of the ZIP Codes in the study area. None of these cases were diagnosed in the requestor's neighborhood of concern.

For the remaining more common blood cancers, nothing unusual was found. The numbers of blood cancers observed and the numbers of blood cancers expected were not significantly different for any of the individual cancers. Ages at diagnosis of the people with the different cancers were similar to what is typically found, and there were no obvious trends with time in the number of diagnoses.

Blood cancer cases diagnosed in 2010, where data were not yet official, were also examined and were found to be consistent with data from previous years with one exception. The people diagnosed with AML in this year tended to be younger than what is typically seen. As of June 2013, there were no additional cases of AML diagnosed in the neighborhood of concern in 2010.

To obtain more information about individual risk factors that may be related to their diagnoses, medical records were reviewed, and an interview study was conducted, that included all of the people in the neighborhood who were reported by the resident to have been diagnosed with AML. The review of medical records, and interview study, found no strong individual risk factors. There were also no unusual exposures that the patients had in common, such as exposures to chemicals such as benzene, or occupational exposures to chemicals such as pesticides. The information obtained from the medical records and interviews does not suggest any individual characteristics that may have played a role in the diagnoses. The people who were interviewed lived in the neighborhood of concern for five to nine years prior to their diagnosis of AML. For many types of cancer, the disease is not diagnosed until 10 to 30 years after exposure to a cancer-causing agent; however, for leukemia the latency can be less than

ten years. Considerations of cancer latency therefore do not rule out the possibility that the cancers of the people who could be interviewed could have been caused by an exposure in the neighborhood.

Environmental considerations For any substance to have an effect on human health, people have to come into contact with it. This is what is known as exposure. People may be exposed to a chemical substance by breathing it in (inhalation), consuming it in food or water (ingestion), or getting it on their skin (dermal exposure). Even with exposure, not all hazardous substances cause cancer. The risk of developing cancer upon exposure to a cancer-causing substance depends on the amount of the substance people are exposed to, the length of time they are exposed to it, and how often they are exposed to it.

To assess the potential for exposure to known chemical contaminants, the NYSDOH BEEI examined available environmental databases. There was no evidence that the one facility in the area of the neighborhood of concern would result in any exposures to any part of the study area. Six private drinking water wells in the area, including some in the neighborhood of concern, were sampled for metals and chemicals. No metals were detected at unusual levels or levels of health concern and none of the other tested-for chemicals were detected.

Interpretation

The number of people living in one small neighborhood who were reported by the requestor to have been diagnosed with AML was confirmed as unusual. However, during the 10-year period for which Cancer Registry data were official, 2000-2009, the present study did not find any unusual patterns of AML in the study area as a whole.

No unusual patterns were found when blood cancers were examined as a whole or by type except for an apparently unusual number of cases of hairy cell leukemia. When the cases of hairy cell leukemia were examined in greater detail, however, the characteristics did not appear unusual. The finding of an unusual occurrence of AML appeared to be limited to the neighborhood of concern. When 2010 data were examined, the characteristics of the blood cancer cases as a whole were found to be consistent with data from previous years. However, when the individual blood cancers were examined separately, the people diagnosed with AML tended to be younger than what is typically seen. Given the limited information available from the medical records reviewed, it is not possible to determine whether any individual characteristics may have played a role in the AML diagnoses. The area does not stand out as unusual in its known chemical exposures, and no widespread exposures to hazardous materials were identified. The information available does not suggest any single cause or combination of causes that might account for the AML diagnoses. Although this unusual occurrence may be related to factors we have been unable to identify, it is also possible that it occurred by chance.

Due to the finding that the people with AML diagnosed in 2010 tended to be younger than what is typically seen, this study will be updated when cancer data for 2010 and 2011 become official, in the spring of 2014.

Table 1. Blood cancer[1] diagnoses by year, ZIP Codes 10541 (Mahopac), 10579 (Putnam Valley), 10512 (Carmel) and point ZIP Code 10542 (Mahopac Falls), Putnam County, New York, 2000-2009[2]

Year	Number of diagnoses
2000	28
2001	32
2002	33
2003	34
2004	27
2005	16
2006	29
2007	36
2008	27
2009	29
Total 2000-2009	291

[1]Includes leukemias, lymphomas, and multiple myeloma
[2]Source of data: New York State Cancer Registry

Table 2. Blood cancer[1] diagnoses by type and sub-type, ZIP Codes 10541 (Mahopac), 10579 (Putnam Valley), 10512 (Carmel) and point ZIP Code 10542 (Mahopac Falls), Putnam County, New York, 2000-2009[2]

	Number of diagnoses observed	Number of diagnoses expected[3]
Leukemias	94	86.8
Acute myeloid leukemia (AML)	25	25.4
Chronic lymphocytic leukemia (CLL)	38	33.7
Chronic myeloid leukemia (CML)	15	10.5
Acute lymphocytic leukemia (ALL)	–[4]	9.0
Other and unspecified leukemias	–[4]	8.3
Lymphomas	156	148.4
Hodgkin disease	26	20.0
Non-Hodgkin lymphomas	130	128.3
Multiple myeloma	41	37.1
TOTAL BLOOD CANCERS	291	272.3

[1]Includes leukemias, lymphomas, and multiple myeloma
[2]Source of data: New York State Cancer Registry
[3]Expected numbers are based on standard cancer incidence rates by age and sex for New York State, exclusive of New York City. Standard rates are applied to the total 2000-2009 study population (294,851 males and 299,958 females) to obtain expected numbers of cases.
[4]Exact numbers are not provided in order to protect patient confidentiality

Table 3. Blood cancer[1] diagnoses by type and sub-type, ZIP Codes 10541 (Mahopac), 10579 (Putnam Valley), 10512 (Carmel) and point ZIP Code 10542 (Mahopac Falls), Putnam County, New York, 2000-2009[2]

	Percent of All Cancers (Study Area)	Percent of All Cancers (NYS exc. NYC)
Leukemias	2.9%	2.8%
Lymphomas	4.9%	4.9%
Multiple myeloma	1.3%	1.2%
TOTAL BLOOD CANCERS	9.1%	8.8%

[1]Includes leukemias, lymphomas, and multiple myeloma
[2]Source of data: New York State Cancer Registry

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MAHOPAC STUDY AREA
ZIP CODES 10512, 10541 (INCLUDING POINT ZIP 10542), AND 10579
PUTNAM COUNTY, NEW YORK

Town of Patterson

Town of Kent

10512

Town of Phillipstown

PUTNAM COUNTY

Town of Putnam Valley

Town of Carmel

Town of Southeast

10579

10541

Point ZIP 10542

WESTCHESTER COUNTY

Town of Somers

	ZIP Code Boundaries
	Town Boundaries

0   2   4

Miles