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Frederick County Health Department

**Maryland Department of Health and Mental Hygiene
Frederick County Health Department**

INVESTIGATION OF CANCER CONCERNS IN FREDERICK, MARYLAND

SUMMARY REPORT

OCTOBER 3, 2011

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EXECUTIVE SUMMARY

This report summarizes the investigation of cancer in Frederick County using data from the Maryland Cancer Registry for cancer diagnosed from 1992 – 2008. The investigation was prompted by community concerns about cancer incidence in Frederick County, particularly in the area around Fort Detrick. The analysis consisted of:

- An evaluation of cancer incidence for cancers diagnosed from 2000 – 2007 in the three census tracts that comprise approximately a one-mile buffer around the perimeter of the Fort Detrick installation;
- An expanded evaluation in the same three census tracts for cancers diagnosed from 1992 – 2008;
- An evaluation of cancer incidence for cancers diagnosed from 1992 – 2008 in the 10 census tracts that comprise approximately a two-mile buffer around the perimeter of the Fort Detrick installation;
- A statistical analysis of how and whether cancers were clustered by geography, time, and type of cancer for all of Frederick County for the period 1992 – 2008; and,
- An analysis of the age of diagnosis for different cancers in the areas closest to Fort Detrick, compared with the age of diagnosis for the same cancers in Frederick County and Maryland.

Overall, this investigation did not find a consistent pattern of cancer diagnoses that would suggest clustering. Specifically, the investigation showed the following:

- Compared with Frederick County, there were no statistically significant increases in all cancers or in specific types of cancer in the three census tracts that constitute an area of 1-mile radius around Fort Detrick for the period 1992 – 2008.
- Compared with Maryland as a whole, lymphoma was slightly increased for the same time period (1992-2008). There were no other increases in any other cancers or in all cancers compared with the State as a whole.
- When an additional seven census tracts were added to the original three, expanding the buffered area around Fort Detrick to approximately a 2-mile radius, there were no significant increases in either all cancers or in specific types of cancer around Ft. Detrick for the period 1992—2008, compared with Frederick County or the State as a whole.
- According to an earlier analysis, the age-adjusted rate of all cancers in Frederick County had increased between 2001 and 2006, compared with both Maryland and the United States. This increase is unlikely to be related to environmental exposures in the Fort Detrick area. If cancer occurrences were affected by environmental exposures from decades ago, the effect would be less likely to show up in a narrow range of time than to be spread out over many years. Analysis of the cancer rates for the three census tracts closest to Fort Detrick for the period 2000-2007 did not show significant increases in the cancers of greatest concern, compared with either Frederick County or the State.
- Analysis of potential space-time “clustering” using the SaTScan program showed no significant clusters, when comparing specific cancer diagnosis groups with all cancer in the ten census tracts and Frederick County for the period 1992 – 2008.

- There was no significant difference in the ages at diagnosis for cancers in specific diagnostic groups in people living close to Fort Detrick (within the 10 census tracts immediately surrounding the installation) compared with people in Frederick as a whole.
- Examination of the reports by the citizens in the community showed that while there was some correspondence between those on the citizen list and those registered with the Maryland Cancer Registry, the disparity between the two data sources was sufficiently high that the cases reported by citizens could not be used directly as a case finding source.

Based on these findings, the report offers several next steps:

1. The Frederick County Health Department and the Maryland Cancer Registry will continue to review cancer incidence in Frederick County as a whole as new data become available. In light of questions related to the observed increase in cancer rates between Frederick County and Maryland between 2001 and 2006, it will be helpful to look in more detail at which cancers contributed to the observed increase and potential explanations.
2. The Department of Health and Mental Hygiene and the Frederick County Health Department will specifically look in more detail at lymphoma rates for the areas in question and for Frederick County as a whole, including different types of lymphoma, and ages of onset of different types of lymphoma.
3. If new information about environmental exposures, environmental risks, or other factors becomes available, the Department of Health and Mental Hygiene and Frederick County Health Department will review that new information in light of this and future evaluations of cancer in Frederick County.
4. Frederick County Health Department and the Department of Health and Mental Hygiene will report back to the community on the above efforts, and use those opportunities for public education and information around issues of cancer, cancer prevention, and cancer detection.

BACKGROUND

In 2010, the Maryland Department of Health and Mental Hygiene (DHMH) and Frederick County Health Department (FCHD) began a formal investigation into community concerns over cancer in Frederick City and Frederick County, Maryland. The investigation was prompted in response to:

- Concerns raised by individuals in the community about the number of persons with cancer in the community;
- Similar concerns raised by a private foundation (the Kristen Renee Foundation, KRF) that was created in memory of a family member who had died of cancer;
- Concerns raised in the community regarding the potential for chemical exposures associated with activities at Fort Detrick; and
- A recent trend upward in the annual incidence rate relative to the Maryland and U.S. rates (the rate has now returned to below the Maryland and U.S. incidence rates).^{1, 2}
- A history of general community concerns regarding cancer incidence in Frederick County

The Secretary of Health and Mental Hygiene has broad authority to investigate the causes of disease in Maryland. The Secretary shall investigate causes of diseases and mortality (Md. Code Ann., Health-General § 18-101); may adopt procedures to obtain information about diseases that are caused by toxic substances and about the incidence of these diseases (Md. Code Ann., Health-General § 18-101, § 18-105); shall investigate, if feasible, means to prevent, treat, and cure cancer; and may adopt procedures to obtain information about cancers that are caused by carcinogens and about the incidence of these cancers (Md. Code Ann., Health-General § 18-104).

The Department of Health and Mental Hygiene (DHMH) has established a formal process to respond to questions and concerns regarding cancer, which involves collaboration between the Center for Environmental Health Coordination, the Maryland Cancer Registry, and the local health department. There is also collaboration with the Maryland Department of the Environment when there are questions about potential environmental contributions to cancer or potential exposures.

Early in the investigation, meetings were held with various stakeholders, including the Kristen Renee Foundation, Fort Detrick, and the community, to learn about the concerns and questions and gather background information. These meetings generally involved both the local health department (Dr. Barbara Brookmyer, Health Officer, FCHD) and the DHMH Center for Environmental Health Coordination (Dr. Clifford Mitchell, Assistant Director for Environmental Health and Food Protection).

¹ http://fhadevlmt/pdf/cancer/CRF_Cancer_Report_2010.pdf

² <http://fhadevlmt/pdf/cancer/Incidence&MortalitySelectedTables2002-2007.pdf>

COMMUNITY DESCRIPTION

Definition of Frederick and Population of Interest

Frederick County is Maryland's largest county geographically, with an area of 664 square miles (Figure 1). The county was primarily agricultural through the mid-twentieth century, but during and after World War II, there was a rapid expansion of the industrial and manufacturing base of the county. According to the recently released 2010 decennial census, Frederick County has an official population of 233,385, an increase of 19.5% from the 2000 population of 195,277. Frederick City's population in 2010 had grown to 65,239 (28.0% of the county population). Table 1 shows the approximate breakdown of the populations by various demographic characteristics.

Frederick County still has both agriculture and light manufacturing, and more recently biotechnology, but is now also a residential exurb for Washington, DC. One of the largest employers in the county is now the Fort Detrick complex (including all of the facilities located within the boundaries of Fort Detrick), which was established and expanded rapidly in the years following the Second World War.

Community Health Concerns

Concerns in Frederick County regarding health and the environment are not new. There have been concerns raised in public forums for many years regarding the Fort Detrick facility. The Agency for Toxic Substances and Disease Registry (ATSDR) report used a 40 year exposure assumption (approximately 1955 -1992) for its assessment (ATSDR, p. 1).³ At public meetings in 2009—2011, the community has raised concerns about health impacts ranging from cancer to auto-immune conditions. The main focus of concern, however, has been on cancer.

The 2007 Frederick County community health assessment described some of the major health concerns for the county. The major causes of death in the county are heart disease, followed by cancer, each of which accounts for a bit more than a quarter of all deaths in the population, similar to Maryland and the U.S. (Table 2).

³ Agency for Toxic Substances and Disease Registry. "Public Health Assessment: Evaluation of Drinking Water Well Exposure via Confirmed Off-Site Contamination, Fort Detrick Area B Groundwater, Frederick, Maryland, EPA Facility ID: MDD985397249." Atlanta (GA): U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry: December 9, 2009.

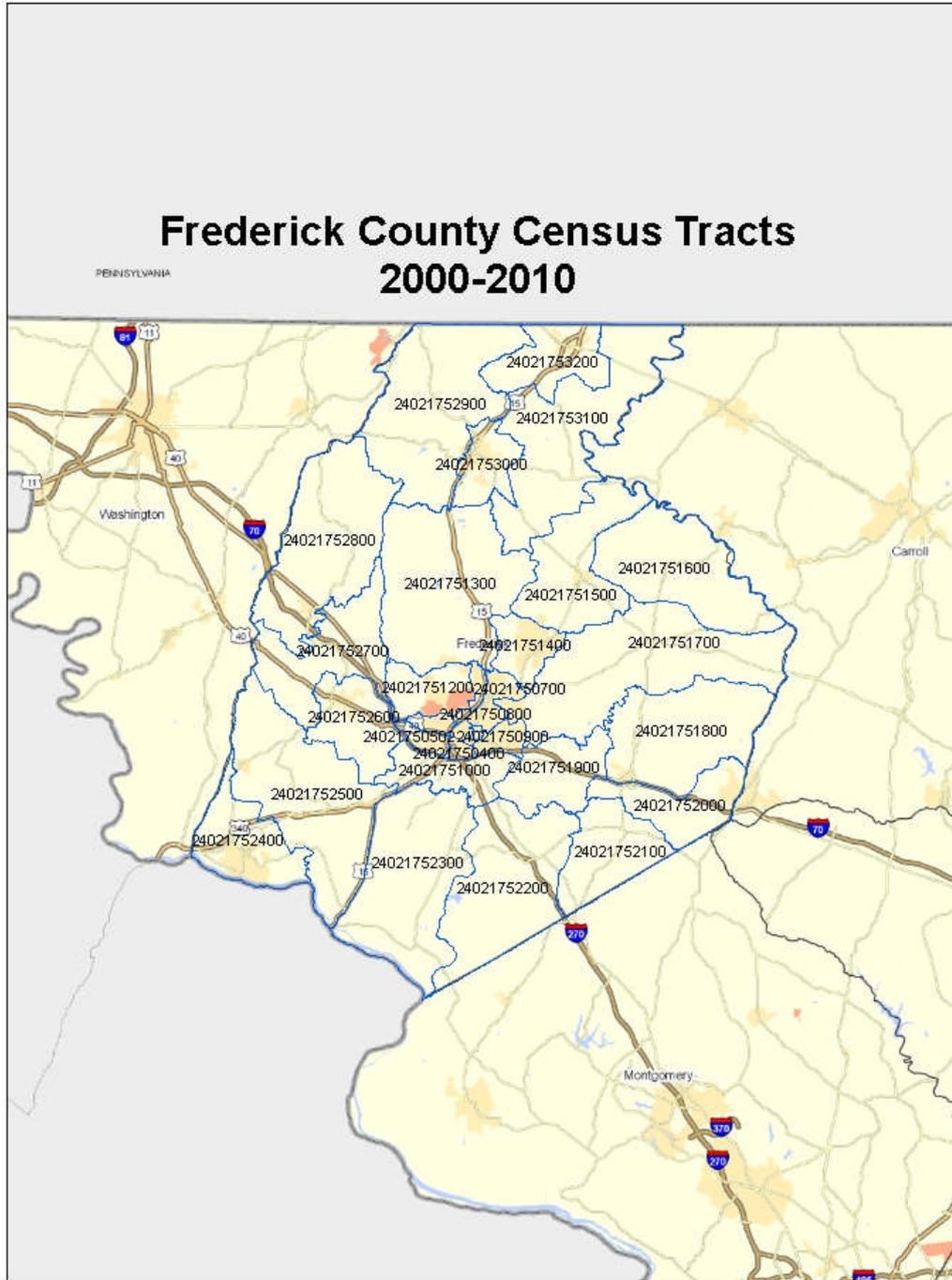


Figure 1. Map of Frederick County (outlined in blue) with census tracts.

Table 1. Demographic characteristics of Frederick City, Frederick County, and Maryland State, based on the 2009 American Community Survey.

Characteristic		Frederick City	Frederick County*	Maryland
Population		58,939	224,185	2,313,193
Sex	Male	49.2%	49.4%	48.4%
	Female	50.8%	50.6%	51.6%
Age distribution	Under 5 years	8.0%	7.0%	6.7%
	5 to 9 years	7.0%	7.0%	6.4%
	10 to 14 years	5.6%	7.6%	6.8%
	15 to 19 years	6.9%	7.4%	7.2%
	20 to 24 years	7.4%	5.9%	6.6%
	25 to 34 years	17.1%	11.5%	13.1%
	35 to 44 years	15.5%	16.7%	15.0%
	45 to 54 years	12.9%	16.1%	15.4%
	55 to 59 years	4.8%	6.0%	6.2%
	60 to 64 years	4.3%	4.7%	4.9%
	65 to 74 years	5.1%	5.4%	6.2%
	75 to 84 years	3.6%	3.2%	3.9%
	85 years and over	1.8%	1.5%	1.5%
Racial Characteristics	People declaring one race	97.7%	97.9%	98.0%
	White	69.4%	83.4%	74.5%
	Black or African-American	17.8%	8.1%	12.4%
	Asian	6.3%	3.5%	4.9%
	All other	6.5%	5%	8.2%
	Hispanic or Latino (any race)	8.8%	5.6%	6.6%
Median Household Income		\$64,833	\$80,970	\$69,475
Families below poverty level		5.3%	3.3%	5.5%

* Including Frederick City

Source: U.S. Census, American Community Survey 2005-2009, accessed 4/11/2011 at: <http://factfinder.census.gov/home/saff/>.

Table 2. Age-Adjusted Death Rates for Selected Causes (2002-2004 Annual Average Deaths per 100,000 Population)

	Frederick County	Maryland	United States	Healthy People 2010
Diseases of the Heart	235.2	227.7	233.1	213.7*
Malignant Neoplasms (Cancers)	191.9	194.6	191.1	159.9
Cerebrovascular Disease (Stroke)	59.6	53.5	53.2	48.0
Chronic Lower Respiratory Diseases	43.3	38.1	42.6	
Alzheimer's Disease	27.4	17.4	21.1	
Unintentional Injuries (Accidents)	25.7	25.8	37.2	17.5
Diabetes Mellitus	19.7	28.0	25.1	15.1
Influenza/Pneumonia	17.2	22.1	21.5	
Motor Vehicle Accidents	12.0	12.8	15.4	9.2
Intentional Self-Harm (Suicide)	10.8*	8.8	10.9	5.0
Liver Disease/Cirrhosis	6.2*	7.8	9.3	3.0
Homicide/Legal Intervention	2.3*	10.2	6.1	3.0
HIV	1.7*	10.5	4.7	0.7

Source: (Source: Frederick County Health Assessment, 2007). Accessed 9/18/2011 at:

<https://www.co.frederick.md.us/documents/Health%20Department/Health%20Care%20Coalition/Needs%20Assessment/Community%20Health%20Assessment%20Report%20-%20Frederick%20County%202007.pdf>, page 40.

Notes: Rates are per 100,000 population, age-adjusted to the 2000 U.S. Standard Population and coded using ICD-10 codes.

The Healthy People 2010 Heart Disease target is adjusted to account for all diseases of the heart;

the Healthy People 2010 target for Diabetes is adjusted to account for only diabetes mellitus coded deaths.

Rates with a * denote statistically unreliable numbers.

As a result of meetings held with the community that led to this investigation, residents raised a number of issues concerning health and the environment. Most of these concerns related to cancer in the area surrounding Fort Detrick that houses several institutions, primarily the Fort Detrick Garrison, the U.S. Army Medical Research Institute for Infectious Disease (USAMRIID), the United States Department of Agriculture, and the National Cancer Institute-Frederick (NCI-Frederick) research facility.

The specific concerns raised by community members and interest groups pertained to the possible association between cancers observed in the community and exposures to some agent or agents that were part of historic operations at Fort Detrick. Some of the principal concerns included:

- Organic compounds potentially released to groundwater from wastes disposed in Area B, an area adjacent to the main Fort Detrick facilities; and
- Herbicides, including Agent Orange, tested at Fort Detrick (including in Area B) in the 1950-1970 period.

Concerns about cancer in Frederick County have been raised for several years. These concerns have increased in part because in some recent reports the annual incidence rates for cancer in Frederick County have been higher than the overall State rate (Figure 3), particularly for the period 2001 – 2006. However, that trend line was returning to the baseline rate similar to the Maryland and the U.S rates by 2007 (Figure 4). The MCR has been looking at cancers that accounted for the increase during this period, and at possible explanations for the increase. While some community concerns about cancer were related to environmental factors, some were more generally related to issues of cancer rates without attribution to specific exposures.

Most of the health concerns related to cancers of different types occurring in the area surrounding Fort Detrick. No one cancer type predominated in discussions with the community, although some cancers (e.g., leukemia, prostate, and breast cancer) were repeatedly mentioned during public discussions.

There was also an effort by one organization, the Kristen Renee Foundation (named after a former Frederick County resident who died of cancer), to survey the community about cancer concerns. The survey results were described and/or presented during several community meetings (but are not used directly in this current report). The results did help DHMH and FCHD to identify community questions regarding possible relationships between environmental exposures and cancer in Frederick. For example, a number of individuals reported concerns about thyroid cancer and potential environmental exposures. Although thyroid cancer was not originally one of the cancers investigated by DHMH, it was added after the Kristen Renee Foundation's presentation of those survey results.

Maryland All Cancer Sites Incidence Rates by Geographical Area: Comparison to U.S. Rate, 2003-2007

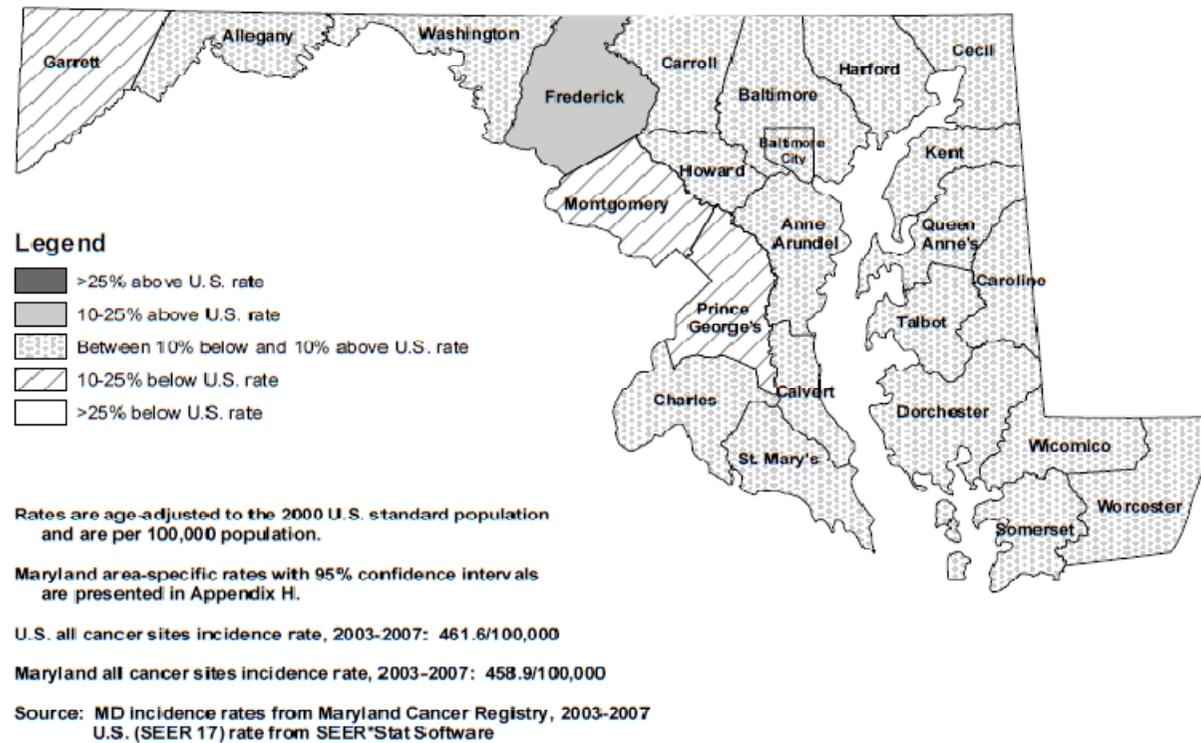
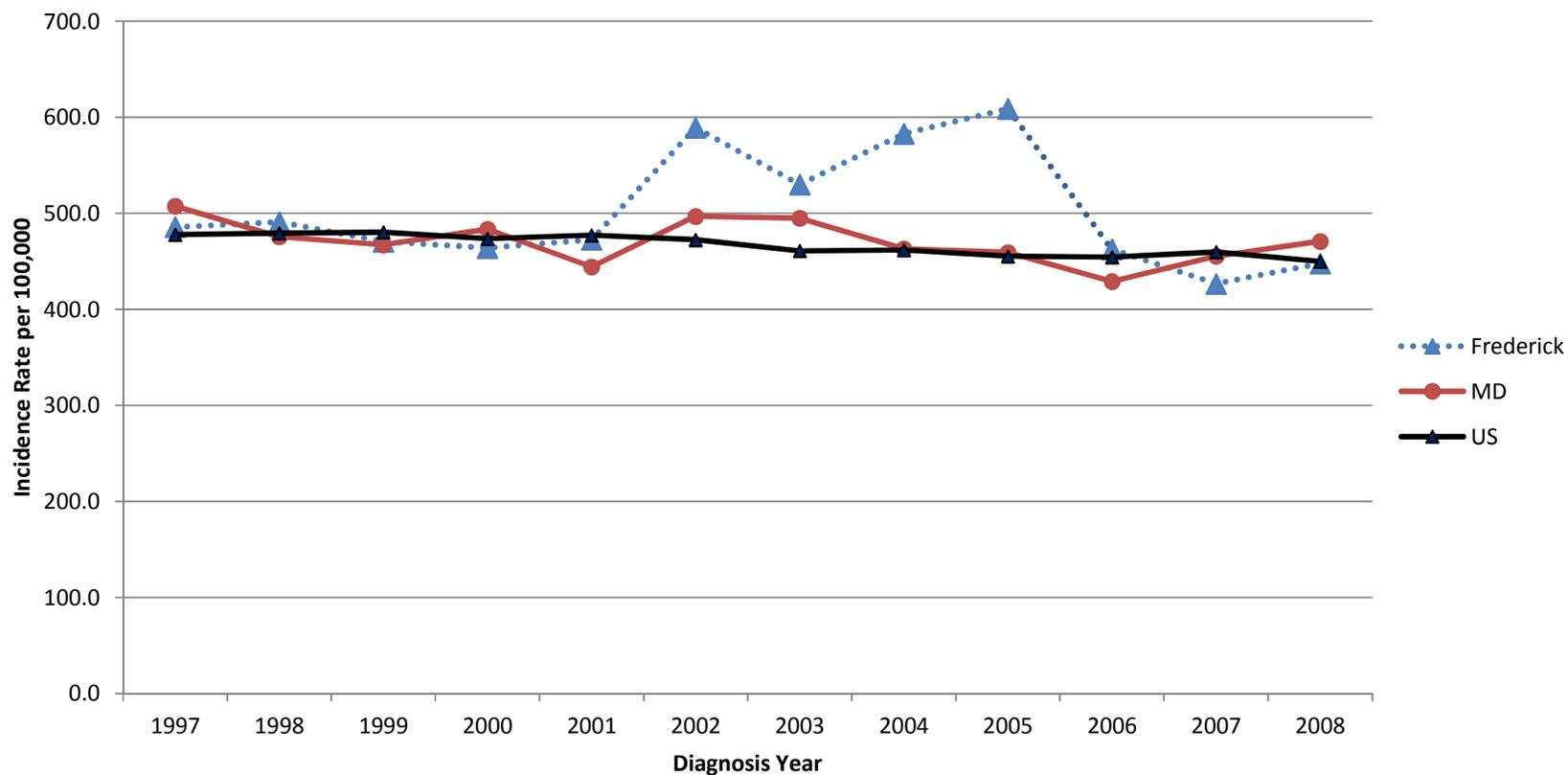


Figure 2. Age-adjusted rates for all cancer incidence, by county, 2003-2007. Source: Maryland Cigarette Restitution Fund Program. Cancer Report 2009, p. 19. http://fhadevlt/pdf/cancer/CRF_Cancer_Report_2010.pdf

Incidence Rates for All Cancers 1997--2008: Frederick County, Maryland, and U.S.*



*Incidence rates age adjusted and standardized to the 2000 U.S. Standard Population
Source: Maryland Cancer Registry, September, 2011

Figure 3. Incidence rates of all cancer in Frederick County, in Maryland and in the United states, 1997 --2008

ENVIRONMENTAL DATA

The assessment of potentially hazardous environmental factors in Frederick County was conducted with input from the Maryland Department of the Environment (MDE) and the FCHD, as well as the environmental health unit of Fort Detrick. The goal was to conduct an inventory of potential environmental hazards, based on available data sources. These included:

- Air quality data
- Water quality data
- Hazardous waste sites
- Point sources
- History of land use

As part of the assessment of environmental issues, DHMH reviewed data supplied by the Fort Detrick environmental health unit. This included a large number of reports prepared by contractors for the U.S. Army Environmental Command that looked at groundwater issues on, or potentially originating from, the base.

Air Quality

Air quality in Frederick County is monitored by MDE at one fixed monitoring station, located at the Frederick Municipal Airport that began monitoring in 1998. This station only monitors for ozone and contributes to the regional picture of air pollution used by EPA and MDE. The station is not particularly helpful in pinpointing any local sources of air pollution, since ozone is not emitted directly into the atmosphere from any source, but is secondarily produced through the chemical reaction of nitrogen oxides, volatile organic compounds and sunlight.

Based on data from this monitoring station, air quality with respect to ozone in the region has improved considerably over the past decade, with the design value declining from 92 parts per billion (ppb) in 2000 to 75 ppb in 2010. The design value is a measure of air quality used to determine compliance with the National Ambient Air Quality Standards (NAAQS). The current NAAQS for ozone is 85 ppb. It should be noted that this measure of air quality does not include any other pollutants for which NAAQS have been established (carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter less than 2.5 microns in diameter (PM-2.5) and lead) or any hazardous air pollutants (HAPs), which consist of many volatile and semi-volatile organic chemicals and other organic chemicals, some of which have been implicated as potential or likely carcinogens. Some emissions data for HAPs are available from the toxic release inventory (TRI)⁴, discussed below.

It is also important to recognize that while the objective of Frederick area air monitoring station is population exposure, the data are not as useful in distinguishing possible differences in

⁴ <http://www.epa.gov/tri/>

exposure within the region. In order to look at differences in air pollution levels in different geographic areas within Frederick County, one would generally need to estimate differences by developing computer models of air quality.

Drinking Water Supply

Most residences surrounding Fort Detrick are now served by the public water supply. Most of the water (88%) for Frederick City and County comes from surface water sources, primarily the Potomac River. According to the most recent consumer confidence report for the public water supply, the system meets all federal and state standards for drinking water quality.⁵

Potentially Significant Industrial and Waste Sites

Historically, Frederick County included both agriculture and industrial activity. A map of current and recent industries supplying data to the U.S. EPA's TRI shows that, in addition to Fort Detrick, there are a number of industries producing hazardous chemicals, including metals (primarily aluminum and steel), cement and building materials, and paints (Figure 4). TRI data are available for these facilities, but because TRI data are not exposure measurements and have little relationship to individual risk, the TRI data were not used in the assessment of personal exposures in this investigation.

Groundwater Monitoring Data from Fort Detrick

Area B of the Fort Detrick site was used for disposal of chemical, biological, and radiological material from the 1940s through approximately 1970. Area B had been used in the past to store explosives and to test materials and currently includes a landfill for municipal waste. The U.S. EPA placed Fort Detrick Area B Ground Water on the National Priorities List (NPL) in April, 2009 because of groundwater contaminated with the organic solvents trichloroethene (TCE) and tetrachloroethene (PCE). Extensive groundwater monitoring has been performed to evaluate the fate and transport of contaminants in groundwater at Area B (Figure 5). There is currently additional site evaluation underway, but the results were not available at the time this report was prepared.

⁵ Source: Frederick County Division of Utilities & Solid Waste Management, Annual Water Quality Report, 2010

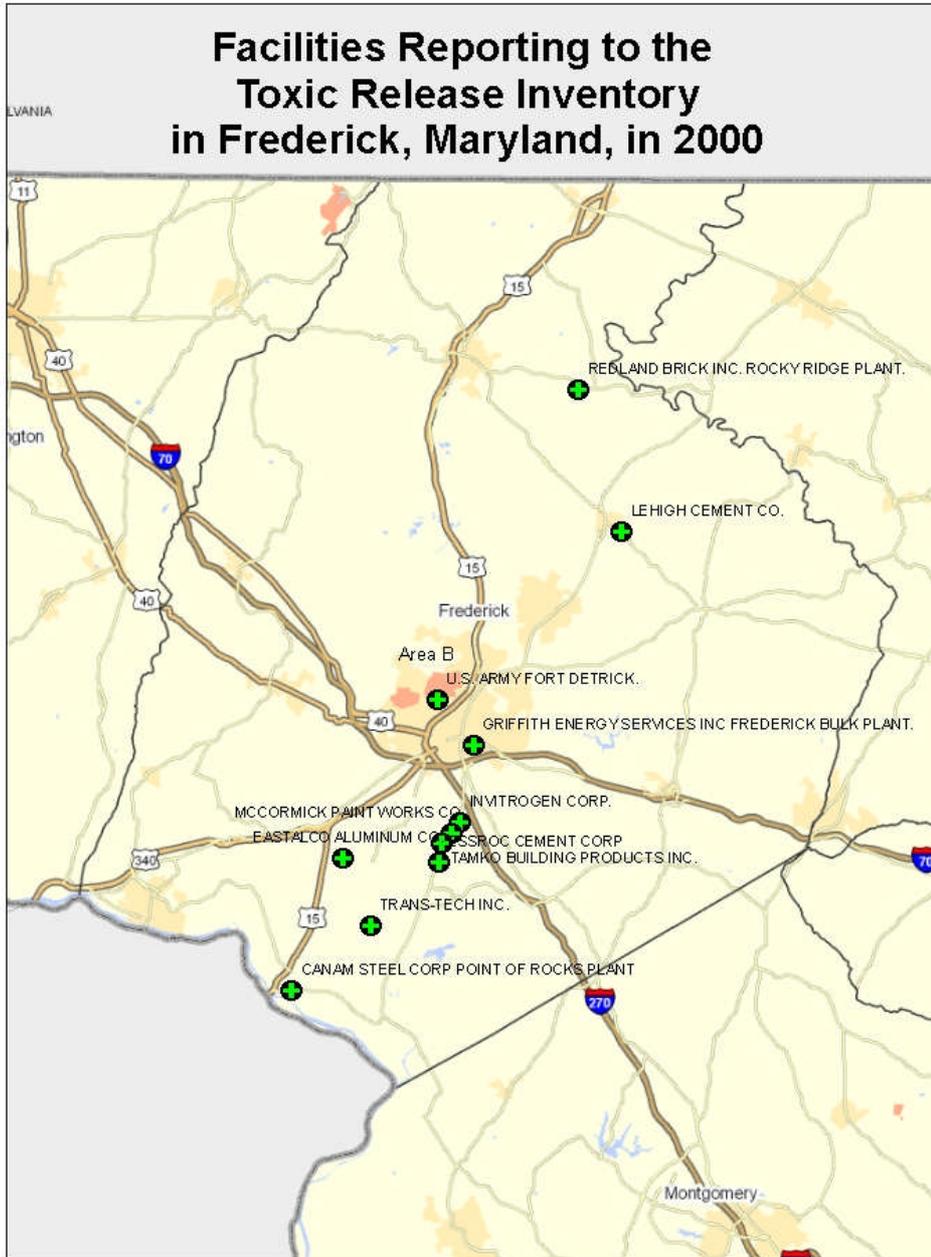


Figure 4. Frederick County entities reporting to the Toxic Release Inventory as of 2000 (accessed on TRIExplorer, http://iaspub.epa.gov/triexplorer/tri_release.chemical, 6/26/2011).

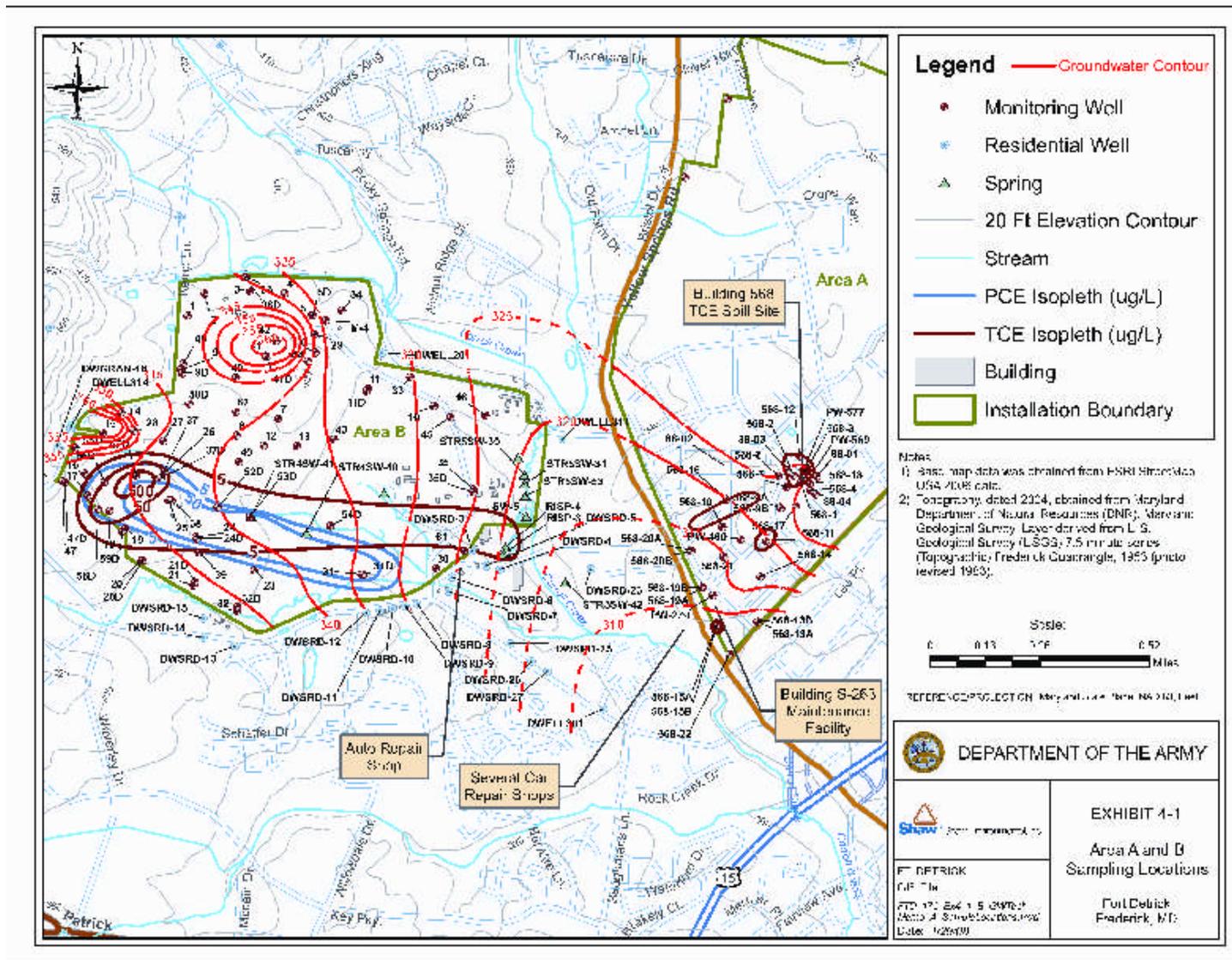


Figure 5. Groundwater sampling locations in Areas A and B, Fort Detrick (Source: Fort Detrick).

HEALTH DATA

Background to the Investigation of Cancer

The initial phase of the investigation was to review any relevant historical studies and basic data from the Maryland Cancer Registry (MCR). MCR receives reports of tumors from hospitals, laboratories, radiation facilities, ambulatory surgical centers, and physicians licensed in Maryland. For Maryland residents diagnosed outside of Maryland, the MCR has 13 interstate notification agreements, including one with the District of Columbia, and receives data from these jurisdictions twice yearly.

Data Sources and Selection of Cases and Comparison Data

Sources of data used in the investigation included: (1) cancers diagnosed in Maryland residents between 1992 and 2008 that were reported to the MCR (described in more detail below); (2) U.S. Census data; and (3) reports from the community from people who were concerned about cancer, reported either to the Kristen Renee Foundation or to the FCHD.

- The MCR data:
 - Cancer cases are reportable to DHMH by Maryland statute (Health-General §§ 18-203 and 18-204) and Code of Maryland Regulations 10.14.01.
 - Annually, Maryland geocodes the Address at Diagnosis (geocoding is the assignment of a latitude and longitude for mapping, in this case based on the Address at Diagnosis) of the cases reported to the MCR with Diagnosis Date of January 1, 2000 or later and revises ZIP codes and determines Census Tract on each case. See Appendix A for additional information.
 - The MCR provided the Center for Environmental Health Coordination with a preliminary line list of all the reported cancer cases diagnosed between 2000 through 2007 who had Address at Diagnosis in three Census Tracts of interest and who were in the MCR database as of 12/1/2009.
 - The MCR geocoded the Frederick County cancer cases with date of diagnosis in 1992 through 1999 and 2008 (i.e., new cases not yet geocoded for 2008). Additionally, cases in the data set with diagnosis years 2000—2007 that were originally not geocoded in the first analysis were reviewed, and those with Addresses at Diagnosis that had addresses sufficiently complete to be geocoded were then geocoded. All cases with diagnosis years 1992—1999 and 2008, were added to the initial 2000—2007 Frederick County data set along with their latitude, longitude, updated ZIP codes, and Census Tracts.
 - Overall, for Frederick County cancer cases from 1992—2008, 94% had an Address at Diagnosis that could be geocoded.

- Data were reviewed and cases with addresses that were not in Frederick County were removed (n=278).
- The MCR staff provided the Center for Environmental Health Coordination with a final geocoded line list (a line list is literally a listing of each individual case) of all reported Frederick County cancer cases diagnosed between 1992 through 2008, where the Address at Diagnosis was Frederick County, from the MCR database as of 02/08/2011.
- The MCR staff calculated final standardized incidence ratios (SIRs) that compared the data from the MCR consolidated database as of 02/08/2011 for **observed** invasive cancer cases (invasive cancers are generally more aggressive cancers that have spread either locally or by metastasis from where they originally developed) in the 10 Census Tracts compared to the **expected** invasive cases for the 10 Census Tracts using Frederick County and Maryland State age-specific rates. The SIRs were derived using SEER Stat to determine Frederick County and Maryland State age-specific rates for cases diagnosed between 1992 through 2008 that were registered in the MCR consolidated database of 02/08/2011. (See Attachment B.)
- All data for calculation of SIRs were derived from the MCR data to standardize methods of data collection from 1992 to 2008. No data reported from the citizen list (see below) was used in calculation of SIRs

Cases for Maryland were selected by:

- Diagnosis State = Maryland

Cases for Frederick County were selected by:

- Diagnosis County = Frederick County;
- Diagnosis State = Maryland; and
- Removing cases that were incorrectly attributed to Frederick County (e.g., documented Hagerstown address in Washington County) (n=278 cases).

Cases in the three Census Tract areas that were included in the initial SIRs included invasive cancer cases from Frederick County that had:

- Census Tract of Address at Diagnosis = 750501, 750700, 751200

Cases in the ten Census Tract area that were included in the later SIRs included invasive cancer cases from Frederick County that had:

- Census Tract of Address at Diagnosis = 750100, 750200, 750300, 750400, 750501, 750502, 750600, 750700, 750800, 751200

- Census data used to calculate the SIRs for the three original and 10 final Census Tracts were obtained for 1990 and 2000 from <http://factfinder.census.gov>

- The citizens who were concerned about cancer began developing a list of people with health concerns. This list (“citizen list”) was submitted to the Frederick County Health Department and transmitted to DHMH, MCR in late September, 2010.

Calculation of Standardized Incidence Ratios

The first part of the investigation was to determine whether specific types of cancer or cancer as a whole in the area of Fort Detrick have been occurring at an increased rate compared with some reference population (in this case, Frederick County and the State of Maryland). To do this, a standardized incidence ratio (SIR) was calculated for all invasive cancer and for each selected cancer type. 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. It is obtained as following:

$SIR = \text{Observed Cases} / \text{Expected Cases}$

The “observed” cancer of interest cases in the Census Tract areas surrounding Fort Detrick were compared to the “expected” number of cases in that same area derived from the MCR data. The “expected” number of cases for the Census Tract areas surrounding Fort Detrick were estimated by multiplying the incidence rates, based respectively on Frederick County and on Maryland State over the same period of years, times the population in the Census Tract areas.

Expected cases based on Frederick County rates = the sum over all age groups of the [(age-specific cancer incidence rate for Frederick) X (population of the census tract areas surrounding Fort Detrick)]

Expected cases based on Maryland rates = the sum over all age groups of the [(age-specific cancer incidence rate for Maryland) X (population of the Census Tract areas surrounding Fort Detrick)]

The *direct method* was applied as described by Breslow and Day,⁶ to compare the number of invasive cancers with Address at Diagnosis in the Census Tract area surrounding Fort Detrick to “standard populations,” in this case the Frederick County and State of Maryland as a whole populations. The refined cancer cases list from the census tract areas surrounding Fort Detrick from the MCR were used for the observed value of cases when calculating standardized incidence ratios (SIRs) and 95% confidence intervals (CIs) for the cancer types included in the invasive cancer case definitions.

⁶ Breslow N.E., Day N.E. Statistical Methods in Cancer Research: Vol.2 Lyons France; International Agency for Research on Cancer. 1987

When the MCR data were complete through 2008, final SIRs were calculated using data for the years 1992 – 2008 for both the observed cases in the census tracts surrounding Fort Detrick and the expected cases based on Frederick County and Maryland State MCR data from February 8, 2011. To calculate SIRs, the most current Census data available at the time (1990 and 2000) were used to estimate the annual population for each year between 1990 and 2000, assuming a constant, linear growth from 1992 to 2008 for each age group.

More information on SIRs is provided in Appendix B.

Phase 1 Investigation: Initial Analysis of Cancer Incidence in 3 Census Tracts around Fort Detrick

The first analysis of MCR data was a calculation of standardized incidence ratios for cancers that are usually thought to be important and affected by environmental exposures in investigations of cancer and the environment. These include cancers that are the most common in the general population (lung and bronchus, female breast, colorectal, and prostate), and those that have been associated with environmental exposures in the past (brain and central nervous system, kidney and bladder, leukemia and lymphoma, liver, and thyroid). The first phase looked at the rates of these cancers in three census tracts approximately equivalent to a one mile buffer around Fort Detrick. The justification for this approach was to look at cancers in those individuals who live closest to Fort Detrick and would therefore be most likely to be exposed to any environmental release from the facility. It was recognized, however, that simply living close to the facility did not mean that such exposures had occurred; furthermore, if groundwater contamination had been the route of exposure, the exposure of individuals to chemicals in groundwater was probably affected by other factors as well as distance, such as the direction of water flow underground, or whether households used bottled water or tap water.

The FCHD worked with the Frederick County government to construct a map, using a geographic information system (GIS) program, that showed buffers around the perimeter of Fort Detrick (Areas A and B), at one-mile increments, out to a distance of 10 miles. Census tract maps were superimposed on the buffers (Figure 5), and three census tracts were identified that most nearly corresponded to the inner 1 mile buffer (census tracts 751200, 750501, and 750700).

The MCR staff calculated SIRs using the MCR database as of 12/1/2009 for observed invasive cancer cases in these three census tracts compared to expected incidence from Frederick County and Maryland State rates. Invasive cancer includes all invasive cancer reportable to the MCR (see http://fha.state.md.us/cancer/mcr_regs.cfm, which excludes basal and squamous cell carcinoma of the non-genital skin) and includes in situ bladder cancer. The disease-specific rates were derived using SEER Stat on cases diagnosed between 2000 through 2007 in the updated consolidated MCR database as of 12/1/2009.

The SIRs for the following individual invasive cancer types: lung and bronchus, female breast, colorectal, prostate, brain and central nervous system, kidney and bladder (including renal pelvis), leukemia and lymphoma, liver, and thyroid as well as all cancers were calculated. The

International Classification of Disease for Oncology (ICD-O-3) primary site (PSite) and histology codes for the site-specific cancers used for SIR calculation are listed below:

- Lung and bronchus: C34.0-C34.9; any histology except 9050-9055, 9140 and 9590-9989.
- Female breast: C50-50.9, female gender; any histology except codes 9050-9055, 9140 and 9590-9989.
- Colorectal: C18.0-C20.9, C26.0; any histology except codes 9050-9055, 9140 and 9590-9989.
- Prostate: C61.9; any histology except codes 9050-9055, 9140 and 9590-9989.
- Brain and Central Nervous System (CNS): C70.0-C72.9 any histology except codes 9050-9055, 9140 and 9590-9989.
- Kidney and Bladder (including in-situ bladder):
 - C64.9, C65.9; any histology except 9050-9055, 9140 and 9590-9989; and
 - C67.0-C67.9 (invasive, Behavior=3; in situ, Behavior=2); any histology except 9050-9055, 9140 and 9590-9989.
- Leukemia:
 - C42.0, 42.1, 42.4; with Histology=9823, 9827
 - Any PSite with Histology= 9733, 9742, 9800, 9801, 9805, 9820, 9826, 9831-9837, 9840, 9860, 9861, 9863, 9866, 9867, 9870-9876, 9891, 9895-9897, 9910, 9920, 9930, 9931, 9940, 9945, 9946, 9948, 9963, 9964.
- Lymphoma:
 - C 00.0-C80.9; with Histology=9650-9667
 - Any PSite with Histology=9590-9596, 9670-9671, 9673, 9675, 9678-9680, 9684, 9687, 9689-9691, 9695, 9698-9702, 9705, 9708-9709, 9714-9719, 9727-9729
 - C00.0-C80.9 excluding codes C42.0, C42.1, C42.2; with Histology=9823, 9827.
- Liver: C22.0-C22.9; any histology except codes 9050-9055, 9140 and 9590-9989.
- Thyroid: C73.9; any histology except codes 9050-9055, 9140 and 9590-9989.

The results, which were shared with the community at an October 4, 2010 public meeting, are summarized in Table 3, which shows the observed and the expected cases for the three census tracts and the preliminary SIRs with 95% confidence intervals (CIs) compared to rates in Frederick County and to Maryland as a whole. Overall, there were no individual cancers in the three census tracts of concern that were statistically significantly different than expected from Frederick County or Maryland rates. Only All Cancers for the three census tracts were significantly increased in comparison the State of Maryland but not to Frederick County as a whole.

Some of the limiting factors in this initial analysis included:

- The MCR was created in the early 1990's, and the first complete year of data was 1992. The period of concern for cancer cases in Frederick ranged from diagnoses in the 1970's and after, and the MCR did not contain cancers diagnosed before 1992, limiting the utility of the MCR data for a 40 year evaluation.

- When the investigation started, MCR data were available only through 2007, and cancer cases diagnosed prior to 2000 had not been geocoded and did not have census tract assignments. This limited the ability to perform SIRs with cancer cases diagnosed from 1990-1999; geocoding of the earlier cases rectified the issue by the time of this final report.
- The initial analysis looked at a very broad range of cancer diagnoses because exposures of concern could be varied (based on historical reports and recent restoration activities).

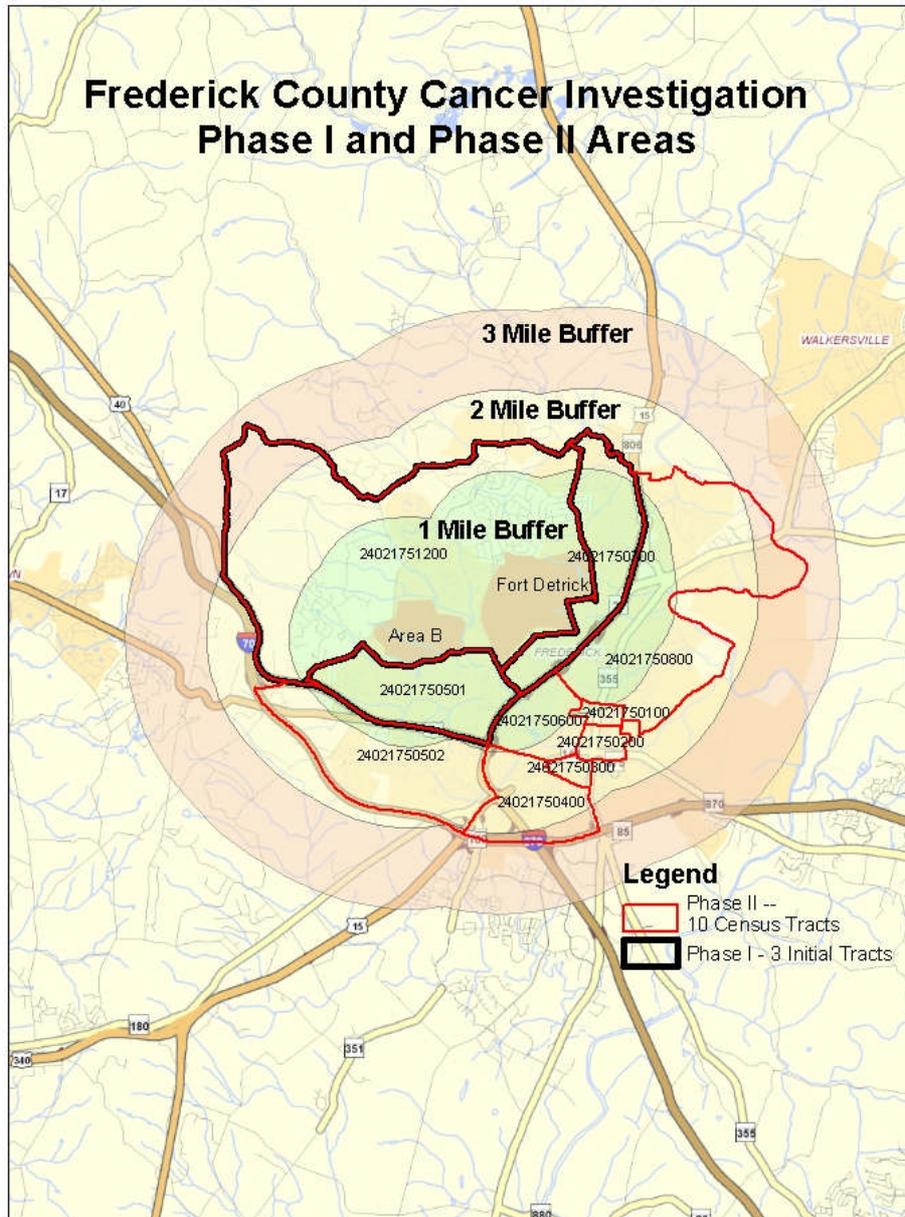


Figure 6. Maps of census tracts and 1, 2, and 3-mile buffers included in Phase 1 (initial) and Phase 2 (follow up) investigation of cancer in Frederick.

Table 3. Cases Observed in the 3 Census Tracts and Expected Numbers of Cases for Specific Cancer Sites, 2000-2007 (Census Tracts 750501, 750700, 751200)

Cancer Type*	Observed Number of Cases in CT 750501, 750700, 751200	^ Expected Number of Cases based on Frederick County rates 2000-2007	SIR** compared to Frederick County	95% CI	CT 750501, 750700, 751200 Statistically different from Frederick County	Expected Number of Cases based on Maryland 2000-2007	SIR** compared to Maryland	95% CI	CT 750501, 750700, 751200 Statistically different from Maryland
All sites	1059	1072	0.99	0.93-1.05	No	957	1.11	1.04-1.17	Yes
Lung & Bronchus	149	141	1.06	0.89-1.24	No	133	1.12	0.94-1.31	No
Female Breast	159	161	0.99	0.84-1.15	No	148	1.07	0.91-1.25	No
Colorectal Cancer	102	114	0.89	0.73-1.08	No	99	1.03	0.83-1.24	No
Prostate	141	146	0.96	0.81-1.14	No	136	1.04	0.87-1.22	No
Brain & CNS	11	17	0.66	0.32-1.15	No	14	0.80	0.39-1.41	No
Kidney & Bladder	79	76	1.04	0.82-1.29	No	65	1.21	0.95-1.50	No
Leukemia & Lymphoma	79	71	1.11	0.88-1.38	No	63	1.26	1.00-1.57	No
Thyroid	29	32	0.90	0.60-1.29	No	24	1.18	0.78-1.69	No

* Includes all invasive cancer excluding basal and squamous cell carcinoma of the non-genital skin, and including in situ bladder cancer

** Standard Incidence Ratio = Observed Cases/ Expected Cases

^ Observed and Expected cases derived from Maryland Cancer Registry consolidated data as of 12/1/2009

Phase II Investigation: Expansion of Area and Period of Interest

Following the presentation of the Phase I investigation results, there were discussions among Frederick County citizens, the county health officer, and state health officials about how to proceed. Based on recommendations from the public and health officials, we decided to look at MCR data for Frederick prior to the year 2000 from 1992—1999 because the dates of operation and contamination at Fort Detrick went back to the 1940s and 50s. The earliest complete population-based cancer data in the MCR is diagnosis year 1992. In addition, the area of investigation was expanded, as described below.

At the time of the Phase I investigation, the MCR had not geocoded “address at diagnosis” for cancer cases with diagnosis dates of 1992 through 1999; therefore, geocoding of these data was undertaken. The public also felt the one mile area of concern was too tight around Fort Detrick; therefore, the area of concern was expanded to approximately a two mile radius that included ten census tract areas (census tracts 750100, 750200, 750300, 750400, 750501, 750502, 750600, 750700, 750800 or 751200). Figure 5 is a map of the original three census tract area, the 1-mile and 2-mile buffers, and the additional seven census tracts. For calculation of the SIRs for the 10 Census Tracts, an **invasive cancer case** was defined as an invasive cancer case registered in the MCR as of February 8, 2011.

Table 4 shows the expanded analysis of cancer cases observed and expected in the three census tracts corresponding to the one mile buffer for the entire period available (1992-2008). The table shows that the SIR for lymphomas in the three census tracts was statistically increased in comparison to the State of Maryland, but not to Frederick County as a whole. This means that the rate of lymphomas in the area immediately around Fort Detrick was not significantly different than the rate of lymphomas in the County overall. However, it was significantly increased compared with the State rate of lymphomas.

The finding of a small but significant increase in the standardized incidence rate for lymphoma compared with Maryland but not with Frederick County bears some discussion. First, because the standardized incidence rate was not significantly increased for Frederick County, there appears to be no significant difference between the three census tracts surrounding Fort Detrick and the rest of the County as a whole. This does not suggest that there is some difference in lymphoma rates between the population closer to Fort Detrick and the County as a whole. At the same time, the increase in observed versus expected cases based on overall State rates should be investigated further, looking for example at rates of lymphoma in Frederick County for different types of lymphomas (Hodgkins versus non-Hodgkins), and different ages of onset.

Table 5 shows the final SIRs that include the ten census tracts and data from incidence years 1992-2008. Overall, there were no individual cancers in the ten census tracts of concern that were statistically significantly different than what would be expected from Frederick County or Maryland rates. The All Site SIR of 0.097 for the ten census tract area was significantly **lower** than Frederick County as a whole, but not significantly different from Maryland (in other words, based on the population at the time, if the rate had been the same as the rate of cancer for

Frederick County overall, one would have expected there to be a slightly higher total number of cancers, 4,592, rather than the 4,379 actually observed).

Table 4. Cases Observed in the 3 Census Tracts and Expected Numbers of Cases for Specific Cancer Sites, 1992-2008 (Census Tracts 750501, 750700, 751200)

Cancer Type	Observed Number in CTs 750501, 750700, 751200	Expected cases based on Frederick County 1992-2008	SIR** compared to Frederick County	95% CI	CTs 750501, 750700, 751200 Statistically different from Frederick County	Expected cases based on Maryland 1992-2008	SIR** compared to Maryland	95% CI	CTs 750501, 750700, 751200 Statistically different from Maryland
	n	n^				n^			
All sites	1906	1931	0.99	0.94-1.03	No	1896	1.00	0.96-1.05	No
Lung & Bronchus	269	257	1.05	0.92-1.18	No	271	0.99	0.88-1.12	No
Female Breast	315	299	1.05	0.94-1.18	No	296	1.06	0.95-1.19	No
Prostate	255	261	0.98	0.86-1.10	No	278	0.92	0.80-1.04	No
Brain & CNS	25	31	0.80	0.51-1.17	No	27	0.92	0.59-1.34	No
Kidney & Bladder	136	139	0.98	0.82-1.15	No	127	1.07	0.89-1.27	No
Leukemia	37	42	0.89	0.62-1.22	No	40	0.93	0.65-1.28	No
Lymphoma	102	91	1.12	0.91-1.36	No	82	1.25	1.01-1.50	Yes
Liver	17	13	1.31	0.75-2.08	No	19	0.88	0.50-1.39	No
Thyroid	44	50	0.89	0.64-1.18	No	39	1.13	0.82-1.51	No

SeerStat data as of 02/08/2011 was used to calculate expected number of cases using Frederick County and Maryland.

CT* Census Tract. SIR** Standard Incidence Ratio= Observed Cases/Expected Cases. ^ expected number of cases=(1992-2008 Frederick or Maryland State cancer rates) X (population of 3 CTs*). Observed and Expected cases derived from Maryland Cancer Registry consolidated data as of February 8, 2011 with county and Maryland age-specific rates calculated in SEER Stat and used to determine expected numbers the 3 census tracts.

Table 5. Cases Observed in the 10 Census Tracts and Expected Numbers of Cases for Specific Cancer Sites, 1992-2008 (Census Tracts 750100,750200,750300,750400,750501,750502,750600,750700,750800, 751200)

Cancer Site*	^Observed Number in 10 Census Tracts	^Expected Number of Cases Based on Age-Specific Frederick County Rates 1992-2008	SIR** compared to Frederick County	95% CI	10 Census Tracts Statistically Different from Frederick County?	^Expected Number of Cases Based on Age-Specific Maryland Rates 1992-2008	SIR** compared to Maryland	95% CI	10 Census Tracts Statistically Different from Maryland?
	n	n^				n^			
All sites	4,379	4,592	0.95	0.93-0.98	Yes--Lower	4,498	0.97	0.94-1.00	No
Lung & Bronchus	605	620	0.98	0.89-1.06	No	651	0.93	0.86-1.00	No
Female Breast	682	698	0.98	0.90-1.05	No	689	0.99	0.92-1.07	No
Colorectal Cancer	480	517	0.93	0.85-1.02	No	495	0.97	0.88-1.06	No
Prostate	599	634	0.95	0.87-1.23	No	667	0.89	0.83-0.97	No
Brain & CNS	65	72	0.90	0.69-1.15	No	62	1.04	0.80-1.32	No
Kidney & Bladder***	316	334	0.95	0.84-1.06	No	304	1.04	0.93-1.16	No
Leukemia	82	99	0.83	0.66-1.03	No	94	0.87	0.69-1.08	No
Lymphoma	207	213	0.97	0.84-1.11	No	192	1.08	0.94-1.24	No
Liver	34	31	1.10	0.76-1.54	No	46	0.74	0.50-1.03	No
Thyroid	97	111	0.88	0.70-1.07	No	87	1.12	0.90-1.36	No

* Includes all invasive cancer excluding basal and squamous cell carcinoma of the non-genital skin, and including in situ bladder cancer

** Standard Incidence Ratio= Observed Cases/Expected Cases

***Includes in situ bladder cancer

^ expected number of cases=(1992-2008 Frederick or Maryland State cancer rates) X (population of 10 CTs*). Observed and Expected cases derived from Maryland Cancer Registry consolidated data as of February 8, 2011 with county and Maryland age-specific rates calculated in SEER Stat and used to determine expected numbers the 10 census tracts.

Analysis of Geographic and Temporal Clustering

After evaluation of the SIRs, the Frederick County cancer data from the MCR for years of diagnosis 1992-2008 was analyzed for geographic and temporal clustering, using the SaTScan software.⁷ Essentially, the SaTScan software creates a number of circles at each point and looks at those circles over time, identifying those circles in which the number of cases (of a cancer of one diagnostic group) is unusually high, when compared with the overall number of cancers occurring over time for the entire area, but outside of that circle, and adjusting for age at diagnosis and gender. The software identifies the most likely cluster with a log-likelihood ratio and a probability statistic (p-value) that corresponds to the probability that the cluster did not occur by chance alone. Another unique feature of SaTScan is that since the probability of the largest log likelihood statistic is only evaluated once using the Markov Chain Monte Carlo procedure, the reported probability value is not influenced by multiple comparisons, e.g., inflated *p* value.

The MCR provided a file to the Center for Environmental Health Coordination of all cancer diagnoses with Address at Diagnosis of Frederick County, 1992-2008. This consisted of 17,315 total cases, of which 15,594 were invasive cancer cases. An additional 1,721 cases were *in situ* and “benign” brain or central nervous system cases that were excluded from the subsequent cluster analysis. Another 958 cases were excluded because they did not have latitude/longitude, and could therefore not be mapped by the program. There were 592 records with cancer types (these included eye cancers, Kaposi’s sarcoma, lip cancers, a category of other poorly-defined, and soft tissue cancers) that were not coded in a diagnostic group, but were included in the 14,636 cases used as a “denominator” population of all cancers for SaTScan. The total number of diagnoses that could be coded in the analysis by cancer diagnostic group was 14,044 (Table 6).

Each cancer diagnostic group was analyzed using a retrospective space-time analysis with the discrete Poisson probability model in SaTScan version 9.1.1.⁸ The study period included the years 1992 – 2008, and cases within diagnostic groups were compared with the underlying population of all cancers in Frederick County for the same period, adjusting for the age category at diagnosis (in 10 year intervals) and sex of each case. Alpha was set at $p < 0.05$ for all analyses.

Table 7 summarizes the results of the cluster analysis. No cluster was found to be significant (that is, the probability for all cluster outcomes were $p > 0.05$). The common cancer groups (breast, prostate, lung, and gastro-intestinal) were not significant and had very large radii (this was expected, as these cancers constituted a significant proportion of the all cancers, i.e., the denominator data). Of note, the various clusters were widely distributed geographically around the county, rather than in only a few locations. This lends support to the absence of a “true”

⁷ Kulldorff M. and Information Management Services, Inc. SaTScanTM v9.1.1: Software for the spatial and space-time scan statistics. <http://www.SaTScan.org/>, 2011.

⁸ Kulldorff M. A spatial scan statistic. *Communications in Statistics: Theory and Methods*, 26:1481-1496, 1997.

clustering of cases of cancer of a specific type, as well as the absence of a confirmed statistical event.

Table 6. Diagnostic Groups Constructed for Cluster Analysis, Based on Cancer Diagnoses in Maryland Cancer Registry, 1992-2008

Cancer Diagnostic Group	MCR "Cancertypes" Included in Group	Number of Cases	Total Cases in Cluster Analysis
Breast			2,243
	Female breast	2,223	
	Male breast or gender not identified	20	
Bone	Bone and Joint	38	38
Dermatologic			747
	Other skin	47	
	Skin melanoma	700	
Endocrine			411
	Other endocrine	26	
	Thyroid	385	
Gastrointestinal			2,875
	Anus	28	
	Colon not rectal	1,150	
	Esophagus	155	
	Floor of mouth	28	
	Gall bladder	41	
	Gum other mouth	48	
	Hypopharynx	26	
	Larynx	128	
	Majel salivary gland	31	
	Oropharynx	13	
	Other digestive	117	
	Other buccal pharyngeal	58	
	Pancreas	309	
	Rectum and sigmoid	454	
	Small intestine	48	
	Stomach	155	
	Tongue	86	
Genitourinary			1,247
	Bladder	407	
	<i>In situ</i> bladder	239	
	Kidney and renal	425	
	Other urinary or Other male genital	14	
	Penis	19	
	Testis	116	
	Ureter	27	
Gynecologic			901

	Cervix	143	
	Corpus uteri	429	
	Other female genital	75	
	Ovary	237	
	Uterus, not otherwise specified	17	
Hematologic			1,166
	Acute lymphocytic leukemia	37	
	Acute myelocytic leukemia	90	
	Chronic lymphocytic leukemia	96	
	Chronic myelocytic leukemia	35	
	Hodgkin's lymphoma	118	
	Multiple myeloma	177	
	Non-Hodgkin's lymphoma	568	
	Other leukemia	45	
Liver	Liver	80	80
Neurologic			231
	Brain	218	
	Other nerve	13	
Prostate	Prostate	2,133	2,133
Lung			1,972
	Lung and bronchus	1,897	
	Mesothelioma	20	
	Nasopharynx or Other respiratory	55	
Diagnoses Included in the Analysis by Major Diagnostic Group			14,044
Diagnoses Not Assigned to a Group but Included in Denominator			592
Total Diagnoses Used for Denominator			14,636

Table 7. Results of SaTScan Cluster Analysis of Cancers Diagnosed with an Address in Frederick County, 1992-2008 (N=14,044)*

Cancer Diagnostic Group	Cluster Size (radius in kilometers)	Probability Value (p-value)	Statistically Significant
Breast	5.5	1.0	No
Bone	1.8	0.93	No
Dermatologic	6.3	0.86	No
Endocrine	3.4	0.098	No
Gastrointestinal	6.9	1.0	No
Genitourinary	8.0	1.0	No
Gynecologic	11.7	0.91	No
Hematologic	7.2	0.57	No
Liver	3.2	0.89	No
Neurologic	0	0.129	No
Prostate	22.1	0.94	No
Pulmonary	3.6	0.93	No

*Based on a discrete Poisson probability model using SaTScan version 9.1.1.

Age at Diagnosis

To test the hypothesis that exposure might lead to earlier age at cancer diagnosis, median age at cancer diagnosis was calculated for the cases with Address at Diagnosis in the 10 census tracts of interest, to compare to the same data for cases in Frederick County, and in Maryland. We used a “proc means” procedure in PC SAS 9.2 software to compute descriptive statistical analyses such as means, medians, and standard deviations. Table 8 shows the median age at diagnosis for invasive and in situ cancer cases in the 10 census tract area around Ft. Detrick, Frederick County, and Maryland by the diagnostic groupings described above (Table 6, column 1). The cases in the 10 census tract area are not different from the median age at diagnosis of cases in Frederick as a whole.

In order to test statistically the difference in ages of diagnosis, mean age of diagnosis was calculated for all diagnostic groups. The diagnostic groups were used because the relatively small number of cases for individual cancer types made the comparison of mean age at diagnosis less likely to show a statistically significant difference. Differences in means were then compared using a t-test. This showed no significant difference in age at diagnosis between the diagnosed cases with addresses in the 10 census tracts and all of Frederick County (Table 9).

**Table 8. Age at Diagnosis for all In Situ and Invasive Cancer*
 for All Cancer Diagnoses, 1992 - 2008***

Median Age at Diagnosis in Years			
Cancer Group	Frederick, 10 Census Tracts	Frederick County	Maryland
Bone	38	38	44
Breast	61	59	60
Endocrine	42	45	49
Gastrointestinal	70	68	69
Genito urinary (incl. bladder)	70	66	68
Gynecologic	58	58	59
Hematologic	65	64	65
Liver	61	62	65
Lung	71	70	69
Neurologic	59	56	57
Prostate	69	68	68
Skin--Melanoma	59	57	59

*Includes all invasive and in situ cancer excluding basal and squamous cell carcinoma.

Source: Maryland Cancer Registry, Consolidated Data 02082011

Table 9. Age at Diagnosis for all In Situ and Invasive Cancer for All Cancer Diagnoses, 1992 - 2008*

Mean Age at Diagnosis in Years (standard deviation)			
Cancer Group	Frederick, 10 Census Tracts	Frederick County	Significant Difference?
Bone	42.6 (25.9)	40.6 (22.9)	No
Breast	61.6 (15.4)	60.6 (14.9)	No
Endocrine	44.8 (15.1)	47.2 (15.4)	No
Gastrointestinal	68.3 (13.8)	67.8 (22.2)	No
Genito urinary	65.2 (17.7)	63.4 (17.2)	No
Gynecologic	60.5 (16.2)	59.9 (15.2)	No
Hematologic	59.9 (20.0)	59.6 (20.1)	No
Liver	61.8 (17.9)	62.8 (16.0)	No
Lung	69.3 (11.6)	68.5 (11.5)	No
Neurologic	55.7 (20.7)	52.0 (22.9)	No
Prostate	68.4 (10.5)	69.0 (30.3)	No
Skin--Melanoma	57.1 (17.9)	57.1 (38.6)	No

*Includes all invasive and in situ cancer excluding basal and squamous cell carcinoma.

Source: Maryland Cancer Registry, Consolidated Data 02082011

Citizen List Evaluation

In addition to the quantitative analysis of cancer data within the MCR, DHMH attempted to evaluate the list of diagnoses provided by citizens in order to determine whether and how the list might be incorporated in the investigation.

In order to compare the citizen list to the Maryland Cancer Registry, the following fields were added to the list:

- Whether the report was for a single person (some listings referred to multiple individuals);
- Whether the report was about cancer or some other health concern;
- Whether the cancer on the citizen list was “reportable” under MCR policy and State law (some cancers do not have to be reported, so would be unlikely to be found in the MCR)

Once this was done, the list was then reviewed by MCR staff. If an individual entry had more than one apparent tumor location (for example, if a listing reported cancer of the lung, liver, and brain), then the entry was re-entered so that the same individual would be listed three times (one

for each of the different tumors). This is the same way that the MCR works, because it is a registry in which each tumor identified has its own entry (even if it is from the same individual). The Citizen List was then matched to the MCR database as of 12/01/2009.

Based on the comparison, there were three possible outcomes:

1. The cancer found in the MCR for that person was only in the MCR and not reported by the citizen;
2. Whether the citizen report of cancer matched the type of cancer in the MCR;
3. Whether the citizen report of cancer did not match the type of cancer in the MCR.

For citizen reports that did **not** match with data in the MCR, a field captured possible reasons why the case was not found in the MCR. Five match attempts between the two lists were done, matching on the following fields:

- First name, last name, city
- Last name, city
- First name, last name
- Last name, diagnosis year
- First name, diagnosis year

The results of each match were reviewed and information about probable matches was added to the citizen list. The results are shown in Table 10.

There were 435 **people** (as distinct from diagnosis, since a person may have more than one diagnosis) with one or more **conditions** reported on the citizen list including conditions *other than cancer*; 398 of those were reports of people having one or more types of cancer. For these 398 people, 452 were cancers that would have been reportable to the MCR if the person's address at diagnosis had been Maryland, and the date of diagnosis had been between 1992 and 2008. In the MCR as of 12/9/2010, there were 15,594 cancer cases with date of diagnosis between 1992 and 2008 and address at diagnosis in Frederick County.

Of the 452 cancers, 183 reports on the citizen list were matches to cancers in MCR by person name and type of cancer, 269 cancers reported on the citizen list were not found in MCR. Possible reasons for not finding the cancers are shown in Table 10. There were 68 reports for which no reason was identified as to why the cancer was not listed in the MCR. Additionally, 21 cancers were found in the MCR for the people listed on the citizen list but their cancer(s) had not been reported on the citizen list.

Based on this evaluation, health officials concluded that the reports from citizens represented only a selected sample of cancer cases diagnosed in Frederick County during 1992—2008. In addition, the reports on the list could not be incorporated into the ongoing investigation without an entirely separate process of gathering additional cases and identifying the size of the population living in the community at the time (which is necessary to calculate the rates used to

compare cancer over time), all of which was outside the scope and resources of this investigation.

Table 10. Evaluation of the Citizen List and Match to the Maryland Cancer Registry

Number of people with one or more conditions reported including conditions <i>other than cancer</i>	435
Number of people reporting one or more cancers	398
Number of tumors reported	476
Number of reportable tumors reported	452
Probable matches found in the MCR	183
Not found in the MCR	269
Reasons why potentially not found:	
No Name or insufficient identifying info	42
Diagnosed before 1992	68
Diagnosed in 2008—2010, too recent to be in MCR	46
No diagnosis date	27
Could be a metastatic site from another tumor that was found *	16
Possibly not reportable	2
No reason identified	68
Number of reportable tumors NOT reported by citizens but a probable match was found in MCR by the patient's name	21

* Bone, brain, liver, and lung are common metastatic sites; if they were reported but not found, they could have been reported in the MCR with the primary site and not as the metastatic site given in the citizen list.

CONCLUSIONS

The purpose of this investigation was to determine whether there was evidence of an increase in cancer in Frederick County, particularly in the area around Fort Detrick. The investigation showed the following:

- Compared with Frederick County, there were no statistically significant increases in all cancers or in specific types of cancer in the three census tracts that constitute an area of 1-mile radius around Fort Detrick for the period 1992 – 2008.

- Compared with Maryland as a whole, lymphoma was slightly increased for the same time period (1992-2008). There were no other increases in any other cancers or in all cancers compared with the State as a whole.
- When an additional seven census tracts were added to the original three, expanding the buffered area around Fort Detrick to approximately a 2-mile radius, there were no significant increases in either all cancers or in specific types of cancer around Ft. Detrick for the period 1992—2008, compared with Frederick County or the State as a whole.
- According to an earlier analysis, the age-adjusted rate of all cancers in Frederick County had increased between 2001 and 2006, compared with both Maryland and the United States. This increase is unlikely to be related to environmental exposures in the Fort Detrick area. If cancer occurrences were affected by environmental exposures from decades ago, the effect would be less likely to show up in a narrow range of time than to be spread out over many years. Analysis of the cancer rates for the three census tracts closest to Fort Detrick for the period 2000-2007 did not show significant increases in the cancers of greatest concern, compared with either Frederick County or the State.
- Analysis of potential space-time “clustering” using the SaTScan program showed no significant clusters, when comparing specific cancer diagnosis groups with all cancer in the ten census tracts and Frederick County for the period 1992 – 2008.
- There was no significant difference in the ages at diagnosis for cancers in specific diagnostic groups in people living close to Fort Detrick (within the 10 census tracts immediately surrounding the installation) compared with people in Frederick as a whole.
- Examination of the reports by the citizens in the community showed that while there was some correspondence between those on the citizen list and those registered with the Maryland Cancer Registry, the disparity between the two data sources was sufficiently high that the cases reported by citizens could not be used directly as a case finding source.

In 1992, the Maryland General Assembly enacted Maryland Health-General Article, §§18-203 and 18-204 which created consistent reporting of quality data to Maryland Cancer Registry. Analysis of MCR data can only be conducted on cases reported to the MCR during the official years. Cases reported prior to 1992 are suspect for quality and consistency and do not provide adequate data for analysis. The number of cancers in a given community is influenced by completeness of reporting of cancer cases to the MCR.

In addition, the MCR stresses caution in analysis by address at cancer diagnosis. This address may or may not be where the person with cancer was possibly exposed to any potential carcinogen. The complex nature of cancer, potential environmental exposures, family history, personal behavior, and movement into and out of a geographic area, can make it difficult to see a clear relationship between exposure and cancer diagnosis in the analysis of the cancer registry data.

Other potential limitations of this investigation should also be noted:

- Cancers occurring prior to 1992 were not addressed, and cannot be evaluated using data from the Maryland Cancer Registry. If there is concern about possible cancers linked to

exposures occurring in the period from the 1940s or 1950s to 1970, even with the latency period for cancer (the period between a chemical exposure that has the potential to cause cancer and the clinical appearance of the cancer) of up to several decades, it is possible that any cancer potentially related to exposures might have occurred prior to 1992. However, in order to determine whether some cancers that happened before 1992 were more frequent than they should have been, it would be necessary to have the same kind of information that the MCR provides for the earlier time period. To know the baseline rates of cancer by type in this area would require some way of counting or reconstructing the population living in the area, as well as a means of identifying many if not most of the cancers diagnosed. This effort would require considerable resources and is beyond the scope of this investigation.

- The quantitative analysis of space-time clustering is a relatively new type of analysis, and there are many assumptions built into the analysis. The assumptions about how diagnoses are grouped, what the comparison population should be, and how to structure the analysis can be debated. In this investigation, the analysis was used to help strengthen the overall conclusions, but is not seen at this point as having sufficient validity that it could be used by itself to determine in fact whether a cluster is or is not occurring.
- Maryland Cancer Registry data is based on address of residence at cancer diagnosis. MCR data on other risk factors such as smoking, family history, occupation, occupational exposures, and industry or address where a case worked, is lacking. Therefore, it is not possible to incorporate those risk factors in the analysis. It is possible that these risk factors could play a role in cancer development. However, it is not possible to address this omission without collecting additional data.

In conclusion, there is no consistent evidence from Maryland Cancer Registry data, by a variety of analyses, that there is an increase in the rate of cancers diagnosed in people whose address of residence at the time of cancer diagnosis was within the 3 or 10 census tracts immediately surrounding Fort Detrick for the period 1992 – 2008, when compared with cancer rates for Frederick County as a whole. When compared with cancer rates for Maryland as a whole, there is a small increase observed for lymphoma, but this difference may not be limited to the census tracts surrounding Fort Detrick. Similarly, there is no indication that cancers in this area were occurring at significantly younger ages than in the rest of the population. This investigation does not offer any conclusions regarding potential exposures in this population, but does indicate that, given all of the limitations described above, it does not appear that the cancers investigated here behaved any differently in this population than in Frederick County or Maryland as a whole.

NEXT STEPS

1. The Frederick County Health Department and the Maryland Cancer Registry will continue to review cancer incidence in Frederick County as a whole as new data become available. In light of questions related to the observed increase in cancer rates between Frederick County and Maryland between 2001 and 2006, it will be helpful to look in more detail at which cancers contributed to the observed increase and potential explanations.
2. The Department of Health and Mental Hygiene and the Frederick County Health Department will specifically look in more detail at lymphoma rates for the areas in question and for Frederick County as a whole, including different types of lymphoma, and ages of onset of different types of lymphoma.
3. If new information about environmental exposures, environmental risks, or other factors becomes available, the Department of Health and Mental Hygiene and Frederick County Health Department will review that new information in light of this and future evaluations of cancer in Frederick County.
4. Frederick County Health Department and the Department of Health and Mental Hygiene will report back to the community on the above efforts, and use those opportunities for public education and information around issues of cancer, cancer prevention, and cancer detection.

Appendix A: MCR GIS Methods/Processes for Geocoding

Step 1: Three passes with stepwise removal of prefix, suffix, and street type

- Pass 1. Geocode using full address (house number + street name + prefix + suffix + street type + 5-digit Zip code).
- Pass 2. With full address, remove only prefix + suffix from address
- Pass 3. With full address, remove prefix + suffix + street type. Keep house number + street name + 5-digit Zip code.

Step 2: Three passes introducing Zip code relaxation (first 3 digits of zip code only)

- Pass 1: Use full address with 3-digit zip (house number + street name + prefix + suffix + street type + 3-digit zip)
- Pass 2: Remove only prefix + suffix; keep house number + street name + street type + 3-digit zip
- Pass 3: Remove prefix + suffix + street type; keep house number + street name + 3-digit zip

Step 3: Three passes introducing County of Diagnosis (dxcounty) using FIPS code and removing Zip code from all passes in Step 3

- Pass 1: Use full address with FIPS code instead of Zip code (house number + street name + prefix + suffix + street type + FIPS code)
- Pass 2: Remove only prefix + suffix; keep house number + street name + street type + FIPS code
- Pass 3: Remove prefix + suffix + street type; keep house number + street name + FIPS code

Appendix B: Description of Standardized Incidence Ratio Calculations

A standardized incidence ratio (SIR) compares the number of new cancer cases observed in a population (in this case, the population living within the designated census tracts around Fort Detrick) each year (observed incident cases) with the number that you would expect to occur if the rates of disease were the same as in the comparison (standard) population (either Frederick County or Maryland). Age-specific rates for the standard population, which come from the Maryland Cancer Registry, are used to calculate the expected number of cases in each age group in Frederick. These are then added up to come up with a total number of expected cases. The actual (observed) number of cases is divided by the expected number, to calculate the SIR. The mathematical formula for this is:

$$\frac{\sum c_{ia}}{\sum p_{is}n_{ia}} = \frac{\text{Observed cases in area}}{\text{Expected cases if standard rates applied to population}}$$

- Where:
- a = The area of interest (e.g., Poolesville)
 - s = The standard area (Montgomery County or Maryland)
 - c_{ia} = The number of cancer cases in the i th age cohort of the population of interest
 - n_{ia} = The number of individuals in the i th age cohort of the population of interest
 - p_{is} = The incidence rate in the i th age cohort of standard population

(adapted from Harold A. Kahn and Christopher T. Sempos, "Statistical Methods in Epidemiology", Oxford University Press, 1989, pp 85-136.)