

Ewing's Family of Tumors, Childhood  
Cancer, and Radiation-Related  
Cancer Incidence Review for  
Washington County and Canon-  
McMillan School District in  
Pennsylvania

Bureau of Epidemiology,  
Division of Community  
Epidemiology

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**pennsylvania**  
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Table of Contents	1
Background	2
Methods	3
Results	5
Limitations	8
Conclusions	9
References	10
Appendix A: Tables	11
Appendix B: Map	17

## Background

Since the first story on Ewing's sarcoma aired on news channel WPXI on Feb. 13, 2019<sup>1</sup>, the state health department has received many calls from concerned parents regarding the potential cancer cluster in the area. The news reported multiple children in Canon-McMillan School District, Washington County, had been diagnosed with Ewing's sarcoma, and several parents came forward saying their children were also diagnosed with the same disease. Residents in the area were concerned and thought all the cases occurred in the same area over a very short period of time, since the news report did not state the location of the cases or when they were diagnosed.

Ewing's sarcoma is a cancerous tumor that occurs in bones or soft tissues, such as cartilage or nerves. There are several types of Ewing's sarcoma, including Ewing's sarcoma of bone, extrasosseous Ewing's sarcoma, peripheral primitive neuroectodermal tumor (pPNET) and Askin tumor. These tumors are considered to be related because they have similar genetic causes. These types of Ewing's sarcoma can be distinguished from one another by the tissue in which the tumor develops. The exact cause of Ewing's sarcoma remains largely unknown.<sup>2,3</sup> Chromosomal studies have found that Ewing's sarcoma cells are often characterized by an abnormal change in their genetic makeup known as a reciprocal translocation.<sup>2,4</sup> The most common mutation, occurring in approximately 85 percent of Ewing's sarcoma tumors, involves two genes, the EWSR1 gene on chromosome 22 and the FLI1 gene on chromosome 11.<sup>4</sup> Ewing's sarcoma is most common in people who are between 10 and 20 years old, occurs slightly more often in males than in females, and is more common among whites than in other ethnic groups. Studies of children with Ewing's tumors have not found links to radiation, chemicals or any other environmental exposures.<sup>5</sup>

The incidence rate of 3 per million children referenced in media reports and by the UPMC oncologist Dr. Julia Meade is limited to Ewing's sarcoma of the bone. This rate only accounts for about 87 percent of all Ewing's sarcomas. Extrasosseous (or extraskkeletal) Ewing's sarcoma in the soft tissues around bones, such as cartilage and pPNETs, occurs in nerve tissue which can be found in many parts of the body and is not included in this incidence estimation.<sup>6</sup> It is estimated 250 children are diagnosed with one of these types of tumors each year in the United States.<sup>7</sup>

This analysis provides a comparison of the incidence rate of Ewing's family of sarcomas in Washington County, as well as in the Canon-McMillan School District, as compared to the incidence rate found in the rest of the state. Radiation-related cancers were also included in this analysis, because concerned citizens mentioned historical radiation-related environmental issues in the area. Canonsburg historically had a uranium processing plant, and a disposal area under federal agency oversight remains in the area.<sup>8-10</sup>

## Methods

The Pennsylvania Cancer Control, Prevention and Research Act of 1980 and the Pennsylvania Department of Health's regulations concerning reporting of communicable and noncommunicable diseases require all health care providers diagnosing or treating cancer patients to report those cases to the Pennsylvania Cancer Registry (PCR). Cancer data are reported by hospitals, clinics, laboratories, radiation facilities, cancer centers, surgical centers, doctor's offices, death certificates and through data exchange when Pennsylvania residents are diagnosed or treated in other states. The Pennsylvania Cancer Registry started receiving data in 1984, and 1985 was the first year the registry received completed data from all facilities. This analysis used cancer incidence data reported to the PCR, as well as estimated population data by school district and county from the U.S. Census Bureau.

Ewing's family of tumors (EFOT) is defined as any cancer diagnosis with histologic/behavior codes of:

1. 9260/3 (Ewing sarcoma) -- not limited by primary site
2. 9364/3 (Peripheral neuroectodermal tumor/pPNET) -- all primary sites except C70.0-C72.9 (including sites in the brain, meninges, spinal cord, cranial nerves and other parts of the central nervous system)
3. 9473/3 (Primitive neuroectodermal tumor, NOS) -- all primary sites except C70.0-C72.9 (including sites in the brain, meninges, spinal cord, cranial nerves and other parts of the central nervous system)
4. 9365/3 (Askin tumor)

This definition is based on the Stanford University School of Medicine surgical pathology criteria<sup>11</sup> and is referenced on the National Cancer Institute's website in the SEER Inquiry System, question: 20160028.<sup>12</sup>

Childhood cancer is defined as cancers in children diagnosed between 0 and 19 years.

Cancer types related to ionizing radiation exposure<sup>13,14</sup> were defined using the table below:

Cancer Type	ICD-O-3 Topography Code	ICD-O-3 Morphology Code
Bone and joints	C40-C41	Excluding 9050-9055, 9140, 9590-9992
Biliary	C22.1, C2	Excluding 9050-9055, 9140, 9590-9992
Bladder	C67	Excluding 9050-9055, 9140, 9590-9992
Brain and other nervous system	C70-C72	Excluding 9050-9055, 9140, 9590-9992
Breast	C50	Excluding 9050-9055, 9140, 9590-9992
Colon	C18-C20, C26.0	Excluding 9050-9055, 9140, 9590-9992
Esophagus	C15	Excluding 9050-9055, 9140, 9590-9992
Gallbladder	C23.9	Excluding 9050-9055, 9140, 9590-9992
Kidney and renal pelvis	C64.9, C65.9	Excluding 9050-9055, 9140, 9590-9992

<b>Cancer Type</b>	<b>ICD-O-3 Topography Code</b>	<b>ICD-O-3 Morphology Code</b>
Leukemia excluding chronic		9801, 9805-9809, 9826, 9835-9836, 9840, 9861, 9865-9867, 9869, 9871-9874, 9891, 9895-9897, 9898, 9910-9911, 9920, 9931
Liver and intrahepatic bile	C22.0, C22.1	Excluding 9050-9055, 9140, 9590-9992
Lung and bronchus	C34	Excluding 9050-9055, 9140, 9590-9992
Melanoma	C44	8720-8790
Myeloma		9731, 9732, 9734
NHL		9590-9597, 9670-9671, 9673, 9675, 9678-9680, 9684, 9687-9691, 9695, 9698-9702, 9705, 9708-9709, 9712, 9714-9719, 9724-9729, 9735, 9737-9738, 9811-9818, 9823, 9827, 9828
Oral cavity and pharynx	C00-C14	Excluding 9050-9055, 9140, 9590-9992
Ovary	C56.9	Excluding 9050-9055, 9140, 9590-9992
Pancreas	C25	Excluding 9050-9055, 9140, 9590-9992
Salivary glands	C08	Excluding 9050-9055, 9140, 9590-9992
Skin excluding melanoma	C44	Excluding 8720-8790, 9050-9055, 9140, 9590-9992
Small intestine	C17	Excluding 9050-9055, 9140, 9590-9992
Stomach	C16	Excluding 9050-9055, 9140, 9590-9992
Thyroid	C73.9	Excluding 9050-9055, 9140, 9590-9992

Cancer data were analyzed in three time periods: 1985–1994, 1995–2004 and 2005–2017. These three time periods were used to assess cancer incidence trends over time. This analysis used the mid-time period census population (1990, 2000 and 2010 census data) for age-adjustment. Age-adjusted standardized incidence ratios (SIRs) for cancers and their 95% confidence intervals (CIs) for Washington County and Canon-McMillan School District residents were calculated respectively by gender to determine whether the residents experienced a statistically significant excess of cancer incidence compared to the rest of the Pennsylvania population. SIRs were calculated as the ratios of the number of cancer cases observed in Washington County and Canon-McMillan School District residents during three time periods compared to those expected in that population if the county and school district were experiencing the same age- and sex-specific cancer incidence rates as a reference area (the rest of Pennsylvania). An SIR greater than 1.0 indicates more cancer cases occurred than expected. An SIR is considered statistically significant if the 95% CI does not include 1.0.

# Results

## Washington County

- family of tumors (EFOT) incidence:
  - There were more EFOT incident cases in the recent period of time than in earlier time periods, but EFOT incidence rates for both males and females were lower than the rest of the state for all three time periods and were not statistically significant.
  
- Childhood cancer incidence:
  - The female childhood cancer incidence rate was 34 percent (SIR = 1.34, 95% CI: 1.03, 1.71), higher than the rest of the state in the 1985-1994 time period; however, this rate decreased during the 1995-2004 and 2005-2017 time periods and was not statistically significantly different from the rest of the state in the two later time periods.
  - The male and combined childhood cancer incidence rates were not statistically significantly different from the rest of the state during any of the three time periods.
  
- All cancers (children plus adults) incidence:
  - 1985-1994: The incidence rate for all cancers (children plus adults) was statistically significantly lower for males, females and combined.
  - 1995-2004: The incidence rate for all cancers (children plus adults) combined in Washington County was slightly higher (SIR = 1.03, 95% CI: 1.01, 1.05) than the rest of the state for females but slightly lower for males (SIR=0.98, 95% CI: 0.96, 1.01).
  - 2005-2017: The incidence rate for all cancers (children plus adults) combined was slightly lower for males (SIR=0.98, 95% CI: 0.96, 0.99) but not statistically different from the rest of the state for females or combined.
  
- Radiation-related cancer (children plus adults) incidence:
  - The female breast cancer incidence rate was slightly higher (SIR = 1.04, 95% CI: 1.01, 1.08) than the rest of the state during 2005 to 2017, but it was slightly lower during 1985 to 1994 and 1995 to 2004.
  - The male and total population's colon cancer incidence rates were 10 percent (SIR = 1.10, 95% CI: 1.03, 1.16) and 7 percent (SIR = 1.07, 95% CI: 1.03, 1.12) higher than the rest of the state during 2005 to 2017; however, rates were slightly lower for both females and males during 1985 to 1994 and were not statistically significantly different from the rest of the state during 1995 to 2004.
  - The male and total population's gallbladder cancer incidence rates were 76 percent (SIR = 1.76, 95% CI: 1.08, 2.72) and 39 percent (SIR = 1.39, 95% CI: 1.05, 1.81) higher than the rest of the state during 1995 to 2004; however, both female and male rates were not statistically significantly different from the rest of the state during the other two time periods.
  - The male leukemia incidence rate was 31 percent (SIR = 1.31, 95% CI: 1.05, 1.62) higher than the rest of the state during 1985 to 1994; however, it gradually decreased and was not statistically significantly different from the rest of the state during the last two time periods. The female leukemia incidence rates were not statistically significantly different from the rest of the state during any of the three time periods.

- The female and male lung cancer incidence rates were 8 percent (SIR = 1.08, 95% CI: 1.01, 1.15) and 14 percent (SIR = 1.14, 95% CI: 1.08, 1.21) higher than the rest of the state during 1995 to 2004 and were statistically significant; however, lung cancer incidence rates decreased during the 2005-2017 time periods when compared to the rest of the state.
- The female NHL incidence rate was 15 percent (SIR = 1.15, 95% CI: 1.03, 1.28) higher than the rest of the state during 1995 to 2004; however, it was not consistently higher during the other two time periods. The male NHL incidence rate was not statistically significantly different from the rest of the state during any of the three time periods.
- The female oral cancer incidence rate was 13 percent (SIR = 1.22, 95% CI: 1.04, 1.42) higher than the rest of the state during 2005 to 2017; however, it was not statistically significantly different from the rest of the state during the other two time periods. The male oral cancer incidence rate was not statistically significantly different from the rest of the state during any of the three time periods.
- The female ovary cancer incidence rates were 14 percent (SIR = 1.14, 95% CI: 1.01, 1.30) and 20 percent (SIR = 1.20, 95% CI: 1.06, 1.35) higher than the rest of the state during 1985 to 1994 and 1995 to 2004; however, this cancer incidence was not statistically significantly different from the rest of the state during 2005 to 2017.

#### Canon-McMillan School District

- Ewing's family of tumors (EFOT) incidence:
  - There were no EFOT cases reported during the first two time periods. There were three cases reported during the 2005- 2017 time period; incidence rates based on these small number of cases were considered unstable and were not statistically significantly different from the rest of the state.
- Childhood cancer incidence:
  - Both female and male childhood cancer incidence rates were not statistically significantly different from the rest of the state during any of the three time periods.
  - Childhood cancer incidence rates in the school district decreased during the last two time periods.
- All cancers (children plus adults) incidence:
  - The male incidence rates for all cancers (children plus adults) combined were 10 percent (SIR = 0.90, 95% CI: 0.84, 0.97) and 9 percent (SIR = 0.91, 95% CI: 0.85, 0.97) lower than the rest of the state during 1985 to 1994 and 1995 to 2004; however, the all cancer rate for males was not statistically significantly different from the rest of the state during 2005 to 2017.
  - The female incidence rate for all cancers (children plus adults) combined was 11 percent (SIR = 0.89, 95% CI: 0.83, 0.96) lower than the rest of the state during 1985 to 1994; however, it was not statistically significantly different from the rest of the state during the other two time periods.
- Radiation-related cancer (children plus adults) incidence:

- The female and total population's liver cancer incidence rates were 191 percent (SIR = 2.91, 95% CI: 1.33, 5.53) and 97 percent (SIR = 1.97, 95% CI: 1.15, 3.15) higher than the rest of the state during 1985 to 1994; however, the female liver cancer incidence rate was not statistically significantly different from the rest of the state during the other two time periods. The male liver cancer incidence rate gradually decreased over the three time periods and was 47 percent lower than the rest of the state during 2005-2017 (SIR = 0.53, 95% CI: 0.31, 0.85).
- The male myeloma incidence rate was 88 percent (SIR = 1.88, 95% CI: 1.05, 3.09) higher than the rest of the state during 1985 to 1994; however, it decreased during the latter two time periods. The female myeloma incidence rate was not statistically significant different from the rest of the state during any of the three time periods.
- The male stomach cancer incidence rate gradually increased over the three time periods and it was not statistically significantly different from the rest of the state during any of the three time periods. The female stomach cancer incidence rates were consistently higher during the three time periods and it was statistically significantly higher (65 percent, SIR = 1.65, 95% CI: 1.05, 2.48) than the rest of the state during 2005 to 2017.

All childhood Ewing's family of tumors were geocoded using patients' addresses at the time of diagnosis. A case density map was created using the point density method in ArcGIS. The EFOT density distribution is consistent with the population density distribution of children in the state. More childhood EFOT cases were found in areas with more children (Figure 1. On page 13). A spatial cluster analysis using Getis-Ord General G-Statistics did not find any hotspots for childhood EFOT in the state.

For more information on results, please see the appendices starting on page 11.



## Limitations

This analysis has several limitations. There are various categories of risk factors, including demographic, genetic, behavioral and environmental factors, for cancer in general. However, most state cancer registry systems in the U.S., including the PCR, do not collect information on most of these risk factors. Therefore, the current analysis was not able to examine the association between Ewing’s family of tumors or radiation-related cancer and any environmental exposure of concern such as nuclear radiation. In addition, since different types of cancer reviewed in the current analysis have a multi-factorial etiology, it is very hard to find the cause-and-effect relationship between one chemical exposure or risk factor and the cancer type. One of the reasons for this is the long latency period (time gap between initial exposure time and diagnosis or appearance of signs and symptoms). For many cancer types, it takes decades for a cancer to develop and be diagnosed. During the latency period, people might migrate from one county or school district to another, so diagnoses made after the individual move out of Washington County and Canon-McMillan School District may not be included in this analysis. Likewise, diagnoses made just after the individual moved into Washington County and Canon-McMillan School District (with exposures happening elsewhere) will be included in this analysis. Therefore, it becomes difficult to estimate the “real” length of exposure and the “specific” source of exposure that caused a particular cancer.

## Conclusions

Based on the data we currently have, when compared to incidence rates for the rest of the Pennsylvania population, male and female incidence rates for the Ewing's family of tumors and childhood cancers in Washington County and Canon-McMillan School District were not consistently and statistically significantly higher than expected in all three time periods analyzed.

When compared to state incidence rates, rates for some types of other radiation-related cancer (such as breast cancer, colon cancer, gallbladder cancer, leukemia, lung cancer, liver cancer, myeloma, NHL, oral cancer, stomach cancer and ovary cancer) were somewhat higher than expected in Washington County or Canon-McMillan School District; however, these cancer incidence rates were not statistically significantly higher in both gender groups or consistently and significantly higher in all three time periods analyzed.

Overall, there were no conclusive findings indicating that the incidence rates of Ewing's family of tumors in Washington County and Canon-McMillan School District for female and male populations were consistently and statistically significantly higher than the rest of the state over the time periods reviewed. However, DOH takes seriously the concerns about EFOT and pediatric cancers raised by this community and other communities in the commonwealth. DOH will continue to closely monitor EFOT and pediatric cancer incidence in Pennsylvania over the next several years as new data becomes available in the PCR.

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## Appendix A: Tables

**Table 1: EFOT, Childhood Cancer, and Radiation-related Cancer Incidence Rate in Washington County Compared to the Rest of State for Three Time Periods, 1985–1994, 1995–2004 and 2005–2017, PCR 1985–2017**

Cancer type	Gender	1985 to 1994				1995 to 2004				2005 to 2017			
		Obs <sup>a</sup>	Exp <sup>b</sup>	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
EFOT	Female	0	1.3	0.00	0 - 2.90	1	2.2	0.45	0.01 - 2.51	1	2.60	0.38	0.01 - 2.14
	Male	0	1.7	0.00	0 - 2.13	1	2.5	0.39	0.01 - 2.21	3	3.63	0.83	0.17 - 2.41
	Total	0	3.0	0.00	0 - 1.23	2	4.8	0.42	0.05 - 1.53	4	6.23	0.64	0.17 - 1.64
Childhood cancer	Female	64	47.8	1.34**	1.03 - 1.71	31	42.9	0.72	0.49 - 1.03	57	60.86	0.94	0.71 - 1.21
	Male	44	48.9	0.90	0.65 - 1.21	44	46.5	0.95	0.69 - 1.27	70	68.10	1.03	0.80 - 1.30
	Total	108	96.8	1.12	0.92 - 1.35	75	89.4	0.84	0.66 - 1.05	127	128.92	0.99	0.82 - 1.17
Bone	Female	13	9.6	1.35	0.72 - 2.31	5	9.1	0.55	0.18 - 1.29	14	12.89	1.09	0.59 - 1.82
	Male	10	11.6	0.86	0.41 - 1.58	13	11.4	1.14	0.61 - 1.95	18	15.85	1.14	0.67 - 1.79
	Total	23	21.2	1.08	0.69 - 1.63	18	20.4	0.88	0.52 - 1.39	32	28.74	1.11	0.76 - 1.57
Bile duct	Female	23	22.5	1.02	0.65 - 1.54	39	31.0	1.26	0.90 - 1.72	56	53.49	1.05	0.79 - 1.36
	Male	34	23.5	1.44	1.00 - 2.02	37	32.5	1.14	0.80 - 1.57	62	59.38	1.04	0.80 - 1.34
	Total	57	45.9	1.24	0.94 - 1.61	76	63.4	1.20	0.94 - 1.5	118	112.82	1.05	0.87 - 1.25
Bladder	Female	152	161.6	0.94	0.80 - 1.10	183	182.0	1.01	0.87 - 1.16	247	239.74	1.03	0.91 - 1.17
	Male	472	450.0	1.05	0.96 - 1.15	524	504.9	1.04	0.95 - 1.13	769	719.25	1.07	0.99 - 1.15
	Total	624	607.3	1.03	0.95 - 1.11	707	684.8	1.03	0.96 - 1.11	1016	958.63	1.06	1.00 - 1.13
Brain	Female	76	73.3	1.04	0.82 - 1.30	86	77.4	1.11	0.89 - 1.37	130	127.74	1.02	0.85 - 1.21
	Male	90	86.1	1.05	0.84 - 1.28	88	87.7	1.00	0.81 - 1.24	139	148.62	0.94	0.79 - 1.10
	Total	166	159.3	1.04	0.89 - 1.21	174	165.0	1.05	0.90 - 1.22	269	276.28	0.97	0.86 - 1.10
Breast	Female	1672	1875.9	0.89*	0.85 - 0.94	2151	2178.9	0.99	0.95 - 1.03	3235	3102.65	1.04**	1.01 - 1.08
Colon	Female	830	911.0	0.91*	0.85 - 0.98	963	907.3	1.06	1.00 - 1.13	974	931.67	1.05	0.98 - 1.11
	Male	902	942.1	0.96	0.90 - 1.02	912	916.4	1.00	0.93 - 1.06	1064	970.56	1.10**	1.03 - 1.16
	Total	1732	1848.9	0.94*	0.89 - 0.98	1875	1822.9	1.03	0.98 - 1.08	2038	1901.60	1.07**	1.03 - 1.12

Cancer type	Gender	1985 to 1994				1995 to 2004				2005 to 2017			
		Obs <sup>a</sup>	Obs <sup>a</sup>	Obs <sup>a</sup>	Obs <sup>a</sup>	Obs <sup>a</sup>	Exp <sup>b</sup>	SIR	95% CI	Obs <sup>a</sup>	Exp <sup>b</sup>	SIR	95% CI
Esophagus	Female	24	32.6	0.74	0.47 - 1.09	35	33.5	1.04	0.73 - 1.45	44	46.26	0.95	0.69 - 1.28
	Male	100	92.7	1.08	0.88 - 1.31	95	111.1	0.86	0.69 - 1.05	169	165.44	1.02	0.87 - 1.19
	Total	124	124.7	0.99	0.83 - 1.19	130	144.3	0.90	0.75 - 1.07	213	211.37	1.01	0.88 - 1.15
Gallbladder	Female	27	29.5	0.92	0.60 - 1.33	35	28.1	1.24	0.87 - 1.73	37	32.74	1.13	0.80 - 1.56
	Male	10	12.0	0.83	0.40 - 1.53	20	11.4	1.76**	1.08 - 2.72	14	14.62	0.96	0.52 - 1.61
	Total	37	41.6	0.89	0.63 - 1.23	55	39.5	1.39**	1.05 - 1.81	51	47.38	1.08	0.80 - 1.42
Leukemia excluding chronic	Female	52	58.5	0.89	0.66 - 1.17	81	66.9	1.21	0.96 - 1.50	98	86.35	1.13	0.92 - 1.38
	Male	85	64.8	1.31**	1.05 - 1.62	93	80.5	1.16	0.93 - 1.42	112	103.07	1.09	0.89 - 1.31
	Total	137	123.0	1.11	0.93 - 1.32	174	147.3	1.18**	1.01 - 1.37	210	189.39	1.11	0.96 - 1.27
Liver	Female	26	24.4	1.07	0.70 - 1.56	51	38.7	1.32	0.98 - 1.73	89	78.64	1.13	0.91 - 1.39
	Male	47	44.2	1.06	0.78 - 1.41	81	85.0	0.95	0.76 - 1.18	178	211.74	0.84*	0.72 - 0.97
	Total	73	68.3	1.07	0.84 - 1.34	132	123.5	1.07	0.89 - 1.27	267	289.62	0.92	0.81 - 1.04
Lung	Female	571	618.7	0.92	0.85 - 1.00	876	811.2	1.08**	1.01 - 1.15	1277	1214.19	1.05	0.99 - 1.11
	Male	1173	1111.6	1.06	1.00 - 1.12	1248	1091.8	1.14**	1.08 - 1.21	1426	1353.86	1.05	1.00 - 1.11
	Total	1744	1722.9	1.01	0.97 - 1.06	2124	1901.1	1.12**	1.07 - 1.17	2703	2567.93	1.05**	1.01 - 1.09
Myeloma	Female	75	63.3	1.18	0.93 - 1.48	91	75.8	1.20	0.97 - 1.47	90	113.23	0.79*	0.64 - 0.98
	Male	68	64.3	1.06	0.82 - 1.34	82	78.4	1.05	0.83 - 1.30	122	134.84	0.90	0.75 - 1.08
	Total	143	127.4	1.12	0.95 - 1.32	173	154.0	1.12	0.96 - 1.30	212	248.03	0.85*	0.74 - 0.98
Melanoma	Female	78	102.0	0.76*	0.60 - 0.95	104	213.0	0.49*	0.40 - 0.59	385	550.00	0.70*	0.63 - 0.77
	Male	121	133.2	0.91	0.75 - 1.09	193	281.9	0.68*	0.59 - 0.79	513	732.06	0.70*	0.64 - 0.76
	Total	199	234.7	0.85*	0.73 - 0.97	297	494.1	0.60*	0.53 - 0.67	898	1281.77	0.70*	0.66 - 0.75
NHL	Female	257	233.3	1.10	0.97 - 1.25	351	305.0	1.15**	1.03 - 1.28	428	433.75	0.99	0.90 - 1.08
	Male	227	256.7	0.88	0.77 - 1.01	353	338.3	1.04	0.94 - 1.16	491	516.78	0.95	0.87 - 1.04
	Total	484	489.2	0.99	0.90 - 1.08	704	642.7	1.10**	1.02 - 1.18	919	950.28	0.97	0.91 - 1.03
Oral	Female	80	83.5	0.96	0.76 - 1.19	90	84.6	1.06	0.86 - 1.31	166	135.67	1.22**	1.04 - 1.42
	Male	170	175.4	0.97	0.83 - 1.13	175	177.2	0.99	0.85 - 1.15	334	304.21	1.10	0.98 - 1.22
	Total	250	258.2	0.97	0.85 - 1.10	265	261.4	1.01	0.90 - 1.14	500	439.11	1.14**	1.04 - 1.24

Cancer type	Gender	1985 to 1994				1995 to 2004				2005 to 2017			
		Obs <sup>a</sup>	Exp <sup>b</sup>	SIR	95% CI	Obs <sup>a</sup>	Exp <sup>b</sup>	SIR	95% CI	Obs <sup>a</sup>	Exp <sup>b</sup>	SIR	95% CI
Ovary	Female	250	218.4	1.14**	1.01 - 1.3	272	226.4	1.20**	1.06 - 1.35	256	249.18	1.03	0.91 - 1.16
Pancreas	Female	102	125.7	0.81*	0.66 - 0.98	175	155.8	1.12	0.96 - 1.30	226	262.19	0.86*	0.75 - 0.98
	Male	119	116.7	1.02	0.84 - 1.22	133	150.8	0.88	0.74 - 1.05	242	263.80	0.92	0.81 - 1.04
	Total	221	242.2	0.91	0.8 - 1.04	308	306.5	1.01	0.90 - 1.12	468	525.83	0.89*	0.81 - 0.97
Salivary gland	Female	5	2.6	1.96	0.64 - 4.57	5	2.6	1.92	0.62 - 4.47	6	3.66	1.64	0.60 - 3.57
	Male	1	3.5	0.28	0.01 - 1.57	2	3.5	0.57	0.07 - 2.07	7	4.89	1.43	0.58 - 2.95
	Total	6	6.1	0.99	0.36 - 2.15	7	6.1	1.15	0.46 - 2.37	13	8.55	1.52	0.81 - 2.6
Skin excluding melanoma	Female	44	86.4	0.51*	0.37 - 0.68	18	15.5	1.16	0.69 - 1.83	25	25.74	0.97	0.63 - 1.43
	Male	57	98.7	0.58*	0.44 - 0.75	21	19.6	1.07	0.66 - 1.64	31	37.42	0.83	0.56 - 1.18
	Total	101	184.6	0.55*	0.45 - 0.66	39	35.1	1.11	0.79 - 1.52	56	63.17	0.89	0.67 - 1.15
Small intestine	Female	12	16.9	0.71	0.37 - 1.24	24	22.1	1.08	0.69 - 1.61	43	42.91	1.00	0.73 - 1.35
	Male	20	18.6	1.08	0.66 - 1.66	21	25.0	0.84	0.52 - 1.29	57	48.10	1.18	0.90 - 1.54
	Total	32	35.4	0.90	0.62 - 1.28	45	47.1	0.96	0.70 - 1.28	100	91.00	1.10	0.89 - 1.34
Stomach	Female	102	89.3	1.14	0.93 - 1.39	89	83.1	1.07	0.86 - 1.32	101	92.57	1.09	0.89 - 1.33
	Male	148	144.8	1.02	0.86 - 1.20	143	131.1	1.09	0.92 - 1.28	157	162.28	0.97	0.82 - 1.13
	Total	250	233.2	1.07	0.94 - 1.21	232	213.9	1.08	0.95 - 1.23	258	254.71	1.01	0.89 - 1.14
Thyroid	Female	63	69.8	0.90	0.69 - 1.16	118	164.0	0.72*	0.60 - 0.86	444	426.70	1.04	0.95 - 1.14
	Male	24	27.5	0.87	0.56 - 1.30	43	51.3	0.84	0.61 - 1.13	151	144.33	1.05	0.89 - 1.23
	Total	152	97.3	0.89	0.72 - 1.10	161	215.0	0.75*	0.64 - 0.87	595	571.22	1.04	0.96 - 1.13
All cancers	Female	6001	6277.5	0.96*	0.93 - 0.98	7157	6968.9	1.03**	1.01 - 1.05	10358	10159.0	1.02	1.00 - 1.04
	Male	5853	6238.4	0.94*	0.91 - 0.96	6925	7035.6	0.98	0.96 - 1.01	9559	9801.4	0.98*	0.96 - 0.99
	Total	11854	12478.7	0.95*	0.93 - 0.97	14082	13996.9	1.01	0.99 - 1.02	19917	19956.3	1.00	0.98 - 1.01

<sup>a</sup>Obs = Observed number of cancer cases

<sup>b</sup>Exp = Expected number of cancer cases

\*SIR is statistically significantly lower than 1.0.

\*\*SIR is statistically significantly higher than 1.0.

Source: Pennsylvania Cancer Registry, 1985-2017

**Table 2: EFOT, Childhood Cancer, and Radiation-related Cancer Incidence Rate in Canon McMillan School District Compared to the Rest of State for Three Time Periods, 1985–1994, 1995–2004 and 2005–2017, PCR 1985–2017**

Cancer type	Gender	1985 to 1994				1995 to 2004				2005 to 2017			
		Obs <sup>a</sup>	Exp <sup>b</sup>	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
EFOT	Female	0	0.2	0.00	0 - 23.91	0	0.3	0.00	0 - 12.26	1	0.42	2.38	0.06 - 13.26
	Male	0	0.2	0.00	0 - 17.26	0	0.3	0.00	0 - 11.03	2	0.55	3.66	0.44 - 13.23
	Total	0	0.4	0.00	0 - 10.01	0	0.6	0.00	0 - 5.793	3	0.96	3.11	0.64 - 9.09
Childhood cancer	Female	9	5.8	1.54	0.71 - 2.93	4	5.8	0.69	0.19 - 1.77	7	9.76	0.72	0.29 - 1.48
	Male	6	5.9	1.02	0.37 - 2.22	4	6.3	0.64	0.17 - 1.63	7	11.11	0.63	0.25 - 1.30
	Total	15	11.7	1.28	0.72- 2.11	8	12.1	0.66	0.29 - 1.31	14	20.86	0.67	0.37 - 1.13
Bone	Female	3	1.2	2.45	0.51 - 7.16	0	1.2	0.00	0 - 3.00	4	2.01	1.99	0.54 - 5.10
	Male	1	1.5	0.68	0.02 - 3.80	1	1.6	0.64	0.02 - 3.59	6	2.45	2.45	0.90 - 5.33
	Total	4	2.7	1.49	0.41 - 3.81	1	2.8	0.36	0.01 - 2.00	10	4.45	2.25	1.08 - 4.13
Bile duct	Female	3	2.8	1.06	0.22 - 3.09	4	4.1	0.98	0.27 - 2.51	11	8.04	1.37	0.68 - 2.45
	Male	4	2.9	1.36	0.37 - 3.49	2	4.4	0.46	0.06 - 1.65	7	9.03	0.78	0.31 - 1.60
	Total	7	5.8	1.21	0.49 - 2.50	6	8.4	0.71	0.26 - 1.55	18	17.06	1.05	0.63 - 1.67
Bladder	Female	14	20.5	0.68	0.37 - 1.15	30	24.0	1.25	0.84 - 1.78	37	36.03	1.03	0.72 - 1.42
	Male	63	55.8	1.13	0.87 - 1.44	70	67.9	1.03	0.80 - 1.30	123	109.10	1.13	0.94 - 1.35
	Total	77	76.5	1.01	0.79 - 1.26	100	91.3	1.10	0.89 - 1.33	160	144.59	1.11	0.94 - 1.29
Brain	Female	8	9.4	0.85	0.37 - 1.67	12	10.6	1.13	0.58 - 1.98	18	20.21	0.89	0.53 - 1.41
	Male	13	11.0	1.18	0.63 - 2.02	16	12.2	1.32	0.75 - 2.14	15	23.38	0.64	0.36 - 1.06
	Total	21	20.4	1.03	0.64 - 1.57	28	22.7	1.23	0.82 - 1.78	33	43.62	0.76	0.52 - 1.06
Breast	Female	198	241.4	0.82*	0.71 - 0.94	297	297.0	1.00	0.89 - 1.12	496	487.82	1.02	0.93 - 1.11
Colon	Female	95	115.2	0.82	0.67 - 1.01	137	119.4	1.15	0.96 - 1.36	147	140.77	1.04	0.88 - 1.23
	Male	102	116.7	0.87	0.71 - 1.06	116	123.5	0.94	0.78 - 1.13	172	148.30	1.16	0.99 - 1.35
	Total	197	232.1	0.85*	0.73 - 0.98	253	242.6	1.04	0.92 - 1.18	319	289.26	1.10	0.99 - 1.23
Esophagus	Female	3	4.1	0.72	0.15 - 2.12	3	4.4	0.68	0.14 - 1.97	6	6.98	0.86	0.32 - 1.87
	Male	16	11.6	1.37	0.79 - 2.23	20	15.0	1.33	0.81 - 2.05	24	25.08	0.96	0.61 - 1.42
	Total	19	15.8	1.20	0.72 - 1.88	23	19.4	1.19	0.75 - 1.78	30	32.18	0.93	0.63 - 1.33

Cancer type	Gender	1985 to 1994				1995 to 2004				2005 to 2017			
		Obs <sup>a</sup>	Exp <sup>b</sup>	SIR	95% CI	Obs <sup>a</sup>	Exp <sup>b</sup>	SIR	95% CI	Obs <sup>a</sup>	Exp <sup>b</sup>	SIR	95% CI
Gallbladder	Female	4	3.7	1.08	0.29 - 2.76	4	3.7	1.08	0.29 - 2.76	8	4.90	1.63	0.70 - 3.22
	Male	1	1.5	0.68	0.02 - 3.79	4	1.5	2.61	0.71 - 6.69	5	2.21	2.26	0.73 - 5.28
	Total	5	5.2	0.97	0.31 - 2.25	8	5.2	1.52	0.66 - 3.00	13	7.11	1.83	0.97 - 3.13
Leukemia excluding chronic	Female	6	7.4	0.81	0.30 - 1.75	14	9.1	1.54	0.84 - 2.59	16	13.39	1.20	0.68 - 1.94
	Male	11	8.2	1.35	0.67 - 2.41	8	11.0	0.72	0.31 - 1.43	17	15.94	1.07	0.62 - 1.71
	Total	17	15.6	1.09	0.63 - 1.74	22	20.1	1.10	0.69 - 1.66	33	29.27	1.13	0.78 - 1.58
Liver	Female	9	3.1	2.91**	1.33 - 5.53	6	5.2	1.16	0.43 - 2.53	14	12.03	1.16	0.64 - 1.95
	Male	8	5.5	1.45	0.62 - 2.85	10	11.6	0.86	0.41 - 1.59	17	32.11	0.53*	0.31 - 0.85
	Total	17	8.6	1.97**	1.15 - 3.15	16	16.7	0.96	0.55 - 1.56	31	44.29	0.70*	0.48 - 0.99
Lung	Female	66	79.2	0.83	0.64 - 1.06	128	108.4	1.18	0.99 - 1.4	186	185.43	1.00	0.86 - 1.16
	Male	131	139.4	0.94	0.79 - 1.11	159	148.2	1.07	0.91 - 1.25	234	205.02	1.14	1.00 - 1.30
	Total	197	219.0	0.90	0.78 - 1.03	287	255.8	1.12	1.00 - 1.26	420	389.96	1.08	0.98 - 1.19
Myeloma	Female	7	8.1	0.87	0.35 - 1.78	8	10.1	0.79	0.34 - 1.57	14	17.17	0.82	0.45 - 1.37
	Male	15	8.0	1.88**	1.05 - 3.09	6	10.6	0.57	0.21 - 1.23	13	20.49	0.63	0.34 - 1.08
	Total	22	16.1	1.37	0.86 - 2.07	14	20.6	0.68	0.37 - 1.14	27	37.64	0.72	0.47 - 1.04
Melanoma	Female	9	13.2	0.68	0.31 - 1.30	16	29.3	0.55*	0.31 - 0.89	86	86.69	0.99	0.79 - 1.23
	Male	12	16.9	0.71	0.37 - 1.24	20	38.5	0.52*	0.32 - 0.80	80	111.77	0.72*	0.57 - 0.89
	Total	21	30.2	0.70	0.43 - 1.06	36	67.6	0.53*	0.37 - 0.74	166	198.15	0.84*	0.72 - 0.98
NHL	Female	27	29.8	0.91	0.60 - 1.32	41	40.8	1.01	0.72 - 1.36	67	66.07	1.01	0.79 - 1.29
	Male	27	32.2	0.84	0.55 - 1.22	36	46.1	0.78	0.55 - 1.08	72	79.07	0.91	0.71 - 1.15
	Total	54	62.1	0.87	0.65 - 1.14	77	86.7	0.89	0.70 - 1.11	139	145.09	0.96	0.81 - 1.13
Oral	Female	12	10.7	1.12	0.58 - 1.96	14	11.4	1.23	0.67 - 2.06	18	21.06	0.85	0.51 - 1.35
	Male	23	22.2	1.04	0.66 - 1.56	23	24.3	0.95	0.60 - 1.42	46	46.63	0.99	0.72 - 1.32
	Total	35	33.0	1.06	0.74 - 1.48	37	35.7	1.04	0.73 - 1.43	64	67.94	0.94	0.73 - 1.20
Ovary	Female	28	28.2	0.99	0.66 - 1.43	36	31.0	1.16	0.81 - 1.61	39	38.68	1.01	0.72 - 1.38



Cancer type	Gender	1985 to 1994				1995 to 2004				2005 to 2017			
		Obs <sup>a</sup>	Exp <sup>b</sup>	SIR	95% CI	Obs <sup>a</sup>	Exp <sup>b</sup>	SIR	95% CI	Obs <sup>a</sup>	Exp <sup>b</sup>	SIR	95% CI
Pancreas	Female	8	15.9	0.50*	0.22 - 0.99	26	20.5	1.27	0.83 - 1.86	28	39.25	0.71	0.47 - 1.03
	Male	16	14.5	1.10	0.63 - 1.79	21	20.3	1.03	0.64 - 1.58	31	39.95	0.78	0.53 - 1.10
	Total	24	30.5	0.79	0.50 - 1.17	47	40.8	1.15	0.85 - 1.53	59	79.33	0.74*	0.57 - 0.96
Salivary gland	Female	1	0.3	3.02	0.08 - 16.85	2	0.4	5.61	0.68 - 20.26	1	0.57	1.75	0.04 - 9.73
	Male	0	0.4	0.00	0 - 8.39	0	0.5	0.00	0 - 7.76	2	0.75	2.65	0.32 - 9.57
	Total	1	0.8	1.30	0.03 - 7.23	2	0.8	2.41	0.29 - 8.69	3	1.32	2.26	0.47 - 6.62
Skin excluding melanoma	Female	7	10.9	0.64	0.26 - 1.32	2	2.1	0.95	0.11 - 3.43	1	3.94	0.25	0.01 - 1.41
	Male	6	12.2	0.49	0.18 - 1.07	4	2.6	1.51	0.41 - 3.87	2	5.73	0.35	0.04 - 1.26
	Total	13	23.2	0.56*	0.30 - 0.96	6	4.7	1.27	0.47 - 2.76	3	9.63	0.31*	0.06 - 0.91
Small intestine	Female	1	2.1	0.47	0.01 - 2.59	2	3.0	0.68	0.08 - 2.44	8	6.63	1.21	0.52 - 2.38
	Male	2	2.3	0.86	0.10 - 3.09	5	3.4	1.48	0.48 - 3.46	6	7.39	0.81	0.30 - 1.77
	Total	3	4.5	0.67	0.14 - 1.95	7	6.3	1.11	0.44 - 2.28	14	14.03	1.00	0.55 - 1.67
Stomach	Female	15	11.3	1.33	0.74 - 2.19	14	10.9	1.29	0.70 - 2.16	23	13.91	1.65**	1.05 - 2.48
	Male	16	17.9	0.89	0.51 - 1.45	18	17.7	1.02	0.60 - 1.61	33	24.67	1.34	0.92 - 1.88
	Total	31	29.3	1.06	0.72 - 1.50	32	28.4	1.13	0.77 - 1.59	56	38.61	1.45**	1.10 - 1.88
Thyroid	Female	5	9.1	0.55	0.18 - 1.28	20	23.3	0.86	0.52 - 1.33	67	70.73	0.95	0.73 - 1.20
	Male	5	3.5	1.41	0.46 - 3.30	4	7.2	0.56	0.15 - 1.42	32	22.84	1.40	0.96 - 1.98
	Total	10	12.7	0.79	0.38 - 1.45	24	30.4	0.79	0.51 - 1.17	99	93.14	1.06	0.86 - 1.29
All cancers	Female	718	805.1	0.89*	0.83 - 0.96	978	941.0	1.04	0.98 - 1.11	1562	1577.7	0.99	0.94 - 1.04
	Male	701	777.2	0.90*	0.84 - 0.97	868	955.2	0.91*	0.85 - 0.97	1500	1492.5	1.01	0.95 - 1.06
	Total	1419	1583.2	0.90*	0.85 - 0.94	1846	1891.9	0.98	0.93 - 1.02	3062	3068.1	1.00	0.96 - 1.03

<sup>a</sup>Obs = Observed number of cancer cases

<sup>b</sup>Exp = Expected number of cancer cases

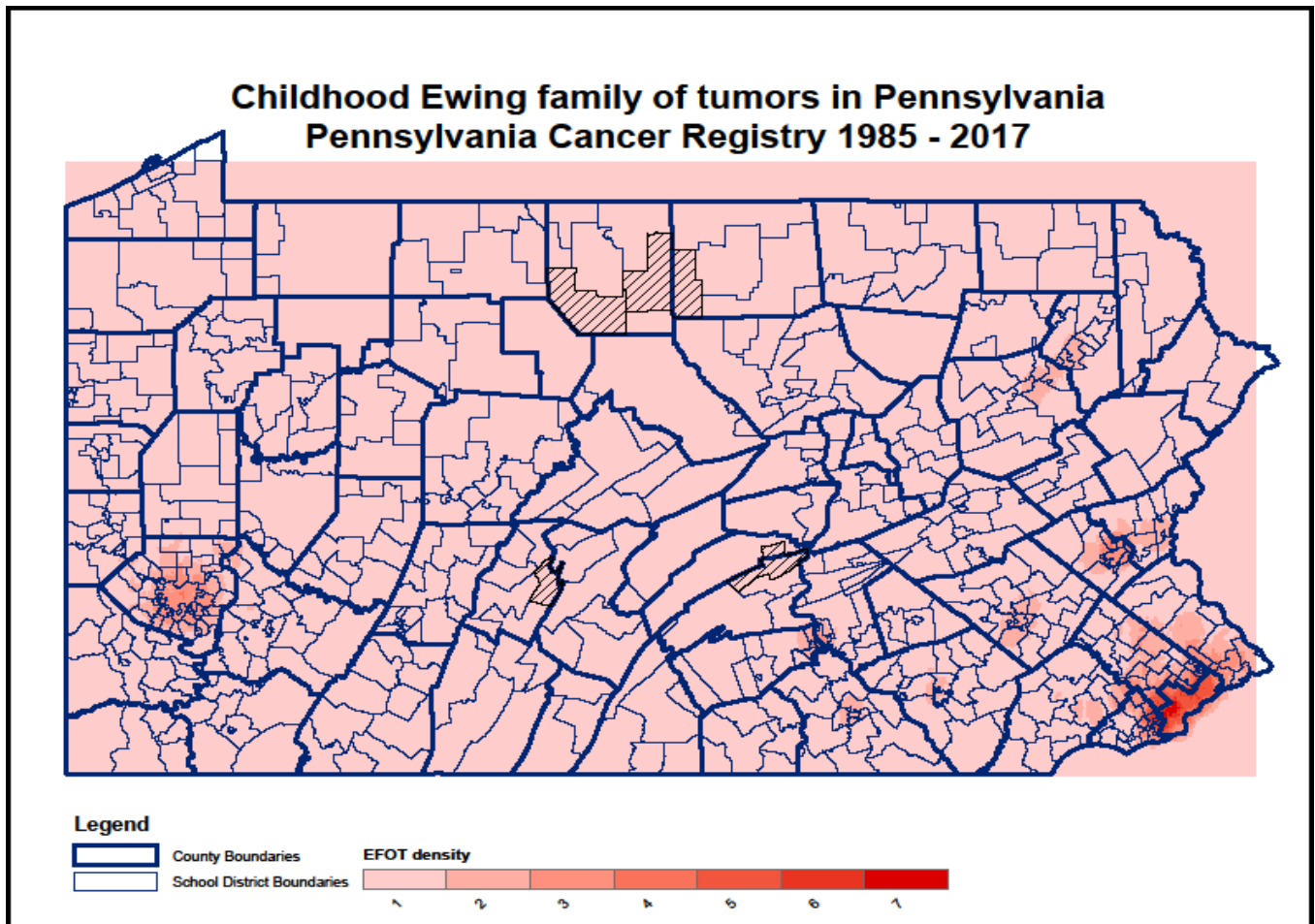
\*SIR is statistically significantly lower than 1.0.

\*\*SIR is statistically significantly higher than 1.0.

Source: Pennsylvania Cancer Registry, 1985-2017

## Appendix B: Figure

Figure 1. Childhood EFOT in Pennsylvania, PCR 1985-2017



Source: Pennsylvania Cancer Registry, 1985-2017