

**Addendum 2 to the
August 2016 Cancer Data Review:
Selected Zip Codes of Warminster,
Warrington and Horsham,
Pennsylvania**

**Division of
Environmental Health
Epidemiology**

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Table of Contents

Executive Summary	3
Purpose	5
Methodology	6
Results	8
SIRs Compared to the Rest of Montgomery and Bucks Counties	14
SIRs Compared to the Rest of Pennsylvania	15
Discussion	16
Conclusions	18
Limitations	19
Citations	20

Executive Summary

This update is Addendum 2 to the cancer data review for the Warminster, Warrington and Horsham communities released in August 2016. Addendum 1 to that report was released in October 2017. The Pennsylvania Department of Health (DOH) completed this update to (1) improve analytical precision by geocoding cancer cases and restricting the study area to the water service areas to account for the fact that drinking water was the major environmental medium of concern; (2) include an additional year of cancer cases now available (2014); and (3) provide comparison for cancer incidence rates in this community, not only against the rest of the state of Pennsylvania, but also to the rest of the surrounding two counties (Montgomery and Bucks). The water service areas included for analysis were the Horsham Water and Sewer Authority (HWSA), Warminster Municipal Authority (WMA), Warrington Township Water and Sewer Department (WTWSD), Warrington Township Water and Sewer Department (WTWSD)/North Wales Water Authority (NWWA), and all the four areas combined. The WTWSD/NWWA area is jointly served by WTWSD and NWWA.

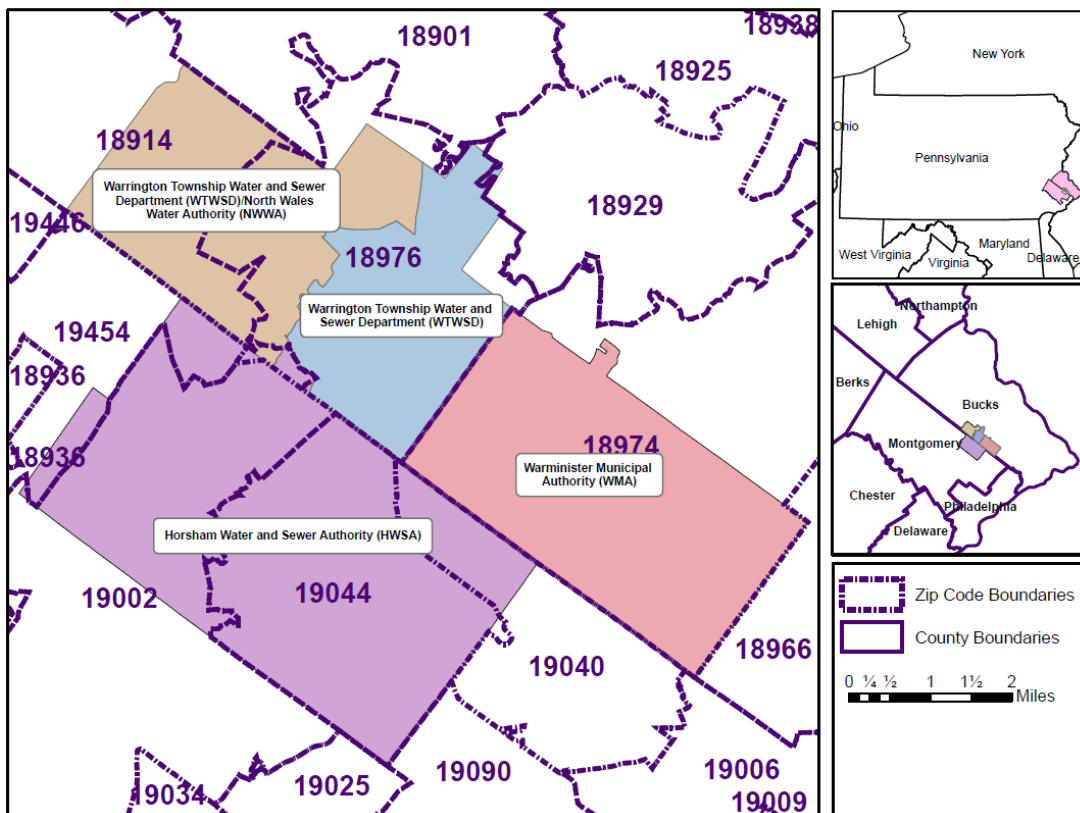
- The incidence rates for most of the cancers of concern (myeloma, non-Hodgkin lymphoma, cancers of bladder, kidney and childhood cancers) in all of the water service areas during 1995-2004 were similar to the incidence rates in the rest of Montgomery and Bucks counties and in the rest of Pennsylvania.
- During the period 2005-2014, male bladder cancer rates in the combined water service area and the HWSA area and the female bladder cancer rate in the WTWSD area were higher than the rates in the rest of Montgomery and Bucks counties. However, only the female bladder cancer rate in the WTWSD area remained higher during the same period when compared to the rate in the rest of Pennsylvania.
- The male kidney cancer rate in the WMA area and the female kidney cancer rate in the combined water service area were higher than the rates in the rest of Montgomery and Bucks counties during 2005-2014, whereas only the male kidney cancer rate in the WMA area remained higher when compared to the rate in the rest of the state.
- The incidence rate for non-Hodgkin lymphoma among males in the WTWSD area during 2005-2014 was higher than the rate in the rest of Montgomery and Bucks counties; however, it was similar to the state rate during the same period.

- Female pancreatic cancer rates in both the WTWSD area and in the combined water service area were higher than rates in the rest of Montgomery and Bucks counties during 2005-2014, but only the rate in the WTWSD area was higher in comparison to the rate in the rest of the state.
- The male childhood cancer incidence rate in the WTWSD area was higher than the rates in the rest of Montgomery and Bucks counties and in the rest of Pennsylvania during 2005-2014.
- The incidence rates for cancers of the liver and of the testis in all water service areas were similar to rates in the rest of Montgomery and Bucks counties and in the rest of Pennsylvania during both periods.
- Bladder cancer incidence rates among women in HWSA were significantly lower during 2005-2014 compared to the rest of Montgomery and Bucks counties, as well as to the rest of Pennsylvania.
- The incidence rate for myeloma among men in WMA was significantly lower compared to the rest of Pennsylvania during 2005-2014.
- During 1995-2004, prostate cancer incidence rate in the combined water service area was significantly lower compared to the rest of Montgomery and Bucks counties. Compared to the rest of Pennsylvania, the rates were significantly lower in all water service areas (including the combined area) except WTWSD/NWWA during the same period.
- Due to improvements in methodology used in this analysis, the results of prior analyses are not comparable to the results presented in this analysis (Addendum 2) and the results are considered “primary.”

Purpose

The Pennsylvania DOH developed Addendum 2 to provide more precise information about seven cancer types of concern (myeloma, non-Hodgkin lymphoma and cancers of the bladder, kidney, liver, prostate and testis) evaluated in the **August 2016 report** and the two additional cancers (pancreatic and pediatric cancers) evaluated in the **October 2017 Addendum 1**. Improved precision is achieved by geocoding cancer cases to confirm their geographic location and by using the water service areas as the study area (see Figure 1). Addendum 2 also includes an additional year of cancer cases and provides comparisons to Bucks and Montgomery county rates and statewide rates. Both the previous two reports indicated the need for further investigation, possibly with refinement of the study area to focus on the water service areas, given that drinking water was the environmental medium of concern.

Figure 1: Public Water Service Area



Note: Shaded areas indicate public water service areas.

The seven cancers selected for analysis in the August 2016 document were based on associations in the literature of these cancer types and the historical environmental contaminants of concern in drinking water in this area. Residents have raised concerns about environmental contamination and health problems over the years in the Warminster and Willow Grove area. Specific contaminants detected in public and/or private drinking water in the area include: volatile chemicals, such as tetrachloroethylene (PCE), trichloroethylene (TCE), 1,2-dichloroethene (1,2-DCE), and carbon tetrachloride and perfluoroalkyl substances (PFAS), such as perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA).

Addendum 1 was written to respond to requests from the public to also examine the incidence rates of pancreatic and pediatric cancers (cancers in children aged 0-19 years) in the same region and over the same time period previously assessed. Previous studies have not reported firm associations between pancreatic and pediatric cancers and the contaminants of concern identified in drinking water in the area.

Methodology

The initial report published in August 2016 and the Addendum 1 published in October 2017 used relevant zip codes in Bucks and Montgomery counties as the study area and used the state as the reference for comparing cancer incidence rates adjusted for age and sex for three time periods, 1985-1994, 1995-2004 and 2005-2013. These studies included the zip codes 18974 (Warminster), 18976 (Warrington) and 19044 (Horsham), and results were presented for zip codes separately and combined.

The difference between the initial study and Addendum 1 was the addition of review of pancreatic and pediatric cancers in Addendum 1. Addendum 2 reflects a refinement in the study area. This water service area-based study added more precision to analysis by geocoding all cancer cases; however, the time periods had to be limited to 1995-2004 and 2005-2014, as data prior to 1995 needed case-by-case geocoding. The latest period in the previous two studies was 2005-2013; therefore, Addendum 2 includes an additional year of cancer data. The water service area-based study included the areas under HWSA, WMA,

WTWSD and WTWSD/NWWA. The results are presented for these areas separately and combined. The previous reports compared age and sex-adjusted cancer incidence rates to the state rate, while this water service area-based study compared age and sex-adjusted cancer incidence rates to the rest of the state, as well as to the rest of Montgomery and Bucks counties.

For a cancer incidence analysis, DOH calculated incidence rates using information reported to the Pennsylvania state cancer registry and compared this information at the water service area level to the rest of the state and to the rest of Bucks and Montgomery counties by calculating age and sex adjusted Standardized Incidence Ratios (SIRs). SIR calculation involves comparing the observed number of cancer cases to a number that would be expected if the community were experiencing the same rate of cancer as a larger comparison areas (in this case Montgomery and Bucks counties and the state of Pennsylvania). Specifically, this is done by calculating rates for the comparison area minus the study area. These rates are multiplied by the population in the study area. The final number is the expected number of cases in the study area. The observed number of cases is then divided by the expected number of cases in the study area. This ratio of observed over expected is called an SIR. A ratio greater than 1.0 indicates that more cases occurred than expected, and a ratio less than 1.0 indicates that fewer cases occurred than expected. As an example, a ratio of 1.5 is interpreted as one-and-a-half times as many cases as the expected number, and a ratio of 0.9 indicates nine-tenths as many cases as the expected number. The SIR is considered statistically significant if the 95 percent confidence interval between the lower and higher confidence limits does not include 1.0. The confidence interval helps to determine the precision of the SIR estimate. The narrower the confidence interval, the more confidence one has in the precision of the SIR estimate.

Due to small sample sizes and as was done in Addendum 1, DOH summed together cases of different cancer types in children aged 0-19 to evaluate rates of childhood cancers in this community. The cancer types analyzed were leukemia, myeloproliferative diseases and myelodysplastic diseases; lymphomas and reticuloendothelial neoplasms; CNS and miscellaneous intracranial and intra-spinal neoplasms; neuroblastoma and other peripheral nervous cell tumors; soft tissue and other extra osseous sarcomas; retinoblastoma; renal tumors; hepatic tumors; malignant bone tumors; germ cell tumors, trophoblastic tumors and

neoplasms of gonads; other malignant epithelial neoplasms and malignant melanomas; and other unspecified malignant neoplasms.

Results

The SIRs (comparing to the rest of Montgomery and Bucks counties and to the rest of the state) for cancers of the bladder, kidney, liver, myeloma, non-Hodgkin lymphoma, prostate, testis, pancreas and childhood cancers are given in Tables 1–9. These tables present the number of observed and expected cases for males and females, the SIR and the corresponding 95 percent confidence intervals. In the interest of brevity, only statistically significant results are described below.

Table 1. Age and Sex-Adjusted Standardized Incidence Ratios (SIR) and 95 Percent Confidence Intervals (CI) for **Bladder Cancer** (1995-2004 and 2005-2014) by Water Service Area, Compared to the Rest of Montgomery and Bucks Counties and to the Rest of Pennsylvania

Water service area	Sex	Bladder															
		Comparing to the Rest of Montgomery and Bucks Counties								Comparing to the Rest of Pennsylvania							
		1995-2004				2005-2014				1995-2004				2005-2014			
		Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI
Horsham Water and Sewer Authority (HWSA)	Male	32	40.70	0.79	0.54 - 1.11	70	53.41	1.31**	1.02 - 1.66	32	43.55	0.73	0.50 - 1.04	70	57.64	1.21	0.95 - 1.53
	Female	9	12.39	0.73	0.33 - 1.38	7	17.94	0.39*	0.16 - 0.8	9	13.37	0.67	0.31 - 1.28	7	19.59	0.36*	0.14 - 0.74
Warrington Township Water and Sewer Department (WTWSD)/North Wales Water Authority (NWWA)	Male	6	8.24	0.73	0.27 - 1.58	21	19.53	1.08	0.67 - 1.64	6	8.79	0.68	0.25 - 1.49	21	21.03	1.00	0.62 - 1.53
	Female	3	2.48	1.21	0.25 - 3.53	3	5.69	0.53	0.11 - 1.54	3	2.66	1.13	0.23 - 3.29	3	6.24	0.48	0.10 - 1.4
Warrington Township Water and Sewer Department (WTWSD)	Male	81	74.93	1.08	0.86 - 1.34	136	115.45	1.18	0.99 - 1.39	81	79.86	1.01	0.81 - 1.26	136	124.07	1.10	0.92 - 1.3
	Female	34	24.75	1.37	0.95 - 1.92	43	27.87	1.54**	1.12 - 2.08	34	26.73	1.27	0.88 - 1.78	43	30.17	1.43**	1.03 - 1.92
Warminster Municipal Authority (WMA)	Male	17	18.04	0.94	0.55 - 1.51	27	28.46	0.95	0.63 - 1.38	17	19.46	0.87	0.51 - 1.4	27	30.64	0.88	0.58 - 1.28
	Female	9	5.90	1.53	0.70 - 2.90	4	8.70	0.46	0.13 - 1.18	9	6.38	1.41	0.64 - 2.68	4	9.49	0.42	0.11 - 1.08
Combined	Male	136	141.91	0.96	0.80 - 1.13	254	216.85	1.17**	1.03 - 1.32	136	151.65	0.90	0.75 - 1.06	254	233.38	1.09	0.96 - 1.23
	Female	55	45.52	1.21	0.91 - 1.57	57	60.19	0.95	0.72 - 1.23	55	49.15	1.12	0.84 - 1.46	57	65.49	0.87	0.66 - 1.13

**Statistically significant, higher relative to the comparison area; *Statistically significant, lower relative to the comparison area

Data source: PA Cancer Registry, U.S. Census Bureau

Table 2. Age and Sex-Adjusted Standardized Incidence Ratios (SIR) and 95 Percent Confidence Intervals (CI) for **Kidney Cancer** (1995-2004 and 2005-2014) by Water Service Area, Compared to the Rest of Montgomery and Bucks Counties and to the Rest of Pennsylvania

Water service area	Sex	Kidney															
		Comparing to the Rest of Montgomery and Bucks Counties								Comparing to the Rest of Pennsylvania							
		1995-2004				2005-2014				1995-2004				2005-2014			
		Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI
Horsham Water and Sewer Authority (HWSA)	Male	17	21.03	0.81	0.47 - 1.29	29	30.58	0.95	0.64 - 1.36	17	21.38	0.80	0.46 - 1.27	29	33.53	0.86	0.58 - 1.24
	Female	13	10.52	1.24	0.66 - 2.11	21	15.99	1.31	0.81 - 2.01	13	11.95	1.09	0.58 - 1.86	21	20.25	1.04	0.64 - 1.59
Warrington Township Water and Sewer Department (WTWSD)/North Wales Water Authority (NWWA)	Male	3	4.32	0.69	0.14 - 2.03	14	10.87	1.29	0.7 - 2.16	3	4.39	0.68	0.14 - 2	14	12.01	1.17	0.64 - 1.96
	Female	1	2.13	0.47	0.01 - 2.61	4	5.47	0.73	0.2 - 1.87	1	2.41	0.41	0.01 - 2.31	4	6.96	0.57	0.16 - 1.47
Warrington Township Water and Sewer Department (WTWSD)	Male	42	36.10	1.16	0.84 - 1.57	48	52.37	0.92	0.68 - 1.22	42	36.29	1.16	0.83 - 1.56	48	57.35	0.84	0.62 - 1.11
	Female	24	19.26	1.25	0.8 - 1.85	33	23.85	1.38	0.95 - 1.94	24	21.88	1.10	0.7 - 1.63	33	29.56	1.12	0.77 - 1.57
Warminster Municipal Authority (WMA)	Male	13	9.81	1.33	0.71 - 2.27	30	16.96	1.77**	1.19 - 2.53	13	10.03	1.30	0.69 - 2.22	30	18.44	1.63**	1.1 - 2.32
	Female	3	5.05	0.59	0.12 - 1.74	13	8.43	1.54	0.82 - 2.64	3	5.77	0.52	0.11 - 1.52	13	10.72	1.21	0.65 - 2.07
Combined	Male	75	71.26	1.05	0.83 - 1.32	121	110.78	1.09	0.91 - 1.31	75	72.09	1.04	0.82 - 1.3	121	121.34	1.00	0.83 - 1.19
	Female	41	36.97	1.11	0.8 - 1.5	71	53.74	1.32**	1.03 - 1.67	41	42.01	0.98	0.7 - 1.32	71	67.48	1.05	0.82 - 1.33

**Statistically significant, higher relative to the comparison area

Data source: PA Cancer Registry, U.S. Census Bureau

Table 3. Age and Sex-Adjusted Standardized Incidence Ratios (SIR) and 95 Percent Confidence Intervals (CI) for **Liver Cancer** (1995-2004 and 2005-2014) by Water Service Area, Compared to the Rest of Montgomery and Bucks Counties and to the Rest of Pennsylvania

Water service area	Sex	Liver															
		Comparing to the Rest of Montgomery and Bucks Counties								Comparing to the Rest of Pennsylvania							
		1995-2004				2005-2014				1995-2004				2005-2014			
		Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI
Horsham Water and Sewer Authority (HWSA)	Male	9	6.99	1.29	0.59 - 2.44	14	13.77	1.02	0.56 - 1.71	9	8.23	1.09	0.5 - 2.08	14	17.11	0.82	0.45 - 1.37
	Female	3	2.62	1.14	0.24 - 3.34	5	5.70	0.88	0.28 - 2.05	3	2.99	1.00	0.21 - 2.93	5	6.04	0.83	0.27 - 1.93
Warrington Township Water and Sewer Department (WTWSD)/North Wales Water Authority (NWWA)	Male	0	1.42	0.00	-	6	4.65	1.29	0.47 - 2.81	0	1.67	0.00	-	6	5.70	1.05	0.39 - 2.29
	Female	1	0.53	1.87	0.05 - 10.44	0	1.81	0.00	-	1	0.60	1.66	0.04 - 9.23	0	1.96	0.00	-
Warrington Township Water and Sewer Department (WTWSD)	Male	10	11.90	0.84	0.4 - 1.54	33	23.21	1.42	0.98 - 2.00	10	13.79	0.72	0.35 - 1.33	33	28.22	1.17	0.8 - 1.64
	Female	8	5.10	1.57	0.68 - 3.09	12	8.64	1.39	0.72 - 2.43	8	5.76	1.39	0.6 - 2.73	12	9.04	1.33	0.69 - 2.32
Warminster Municipal Authority (WMA)	Male	1	3.28	0.31	0.01 - 1.7	8	7.52	1.06	0.46 - 2.1	1	3.89	0.26	0.01 - 1.43	8	9.36	0.85	0.37 - 1.68
	Female	1	1.24	0.81	0.02 - 4.49	4	2.88	1.39	0.38 - 3.55	1	1.43	0.70	0.02 - 3.89	4	3.10	1.29	0.35 - 3.3
Combined	Male	20	23.60	0.85	0.52 - 1.31	61	49.14	1.24	0.95 - 1.59	20	27.57	0.73	0.44 - 1.12	61	60.39	1.01	0.77 - 1.3
	Female	13	9.50	1.37	0.73 - 2.34	21	19.03	1.10	0.68 - 1.69	13	10.79	1.21	0.64 - 2.06	21	20.15	1.04	0.65 - 1.59

Data source: PA Cancer Registry, U.S. Census Bureau
SIRs not calculated when no cases were reported.

Table 4. Age and Sex-Adjusted Standardized Incidence Ratios (SIR) and 95 Percent Confidence Intervals (CI) for **Myeloma** (1995-2004 and 2005-2014) by Water Service Area, Compared to the Rest of Montgomery and Bucks Counties and to the Rest of Pennsylvania

Water service area	Sex	Myeloma															
		Comparing to the Rest of Montgomery and Bucks Counties								Comparing to the Rest of Pennsylvania							
		1995-2004				2005-2014				1995-2004				2005-2014			
		Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI
Horsham Water and Sewer Authority (HWSA)	Male	7	5.68	1.23	0.5 - 2.54	7	9.01	0.78	0.31 - 1.6	7	6.91	1.01	0.41 - 2.09	7	10.53	0.66	0.27 - 1.37
	Female	4	4.97	0.81	0.22 - 2.06	6	6.76	0.89	0.33 - 1.93	4	5.66	0.71	0.19 - 1.81	6	8.57	0.70	0.26 - 1.52
Warrington Township Water and Sewer Department (WTWSD)/North Wales Water Authority (NWWA)	Male	4	1.15	3.48	0.95 - 8.9	4	3.20	1.25	0.34 - 3.2	4	1.40	2.85	0.78 - 7.3	4	3.83	1.04	0.28 - 2.68
	Female	1	0.99	1.01	0.03 - 5.63	4	2.25	1.78	0.49 - 4.56	1	1.12	0.89	0.02 - 4.96	4	2.86	1.40	0.38 - 3.58
Warrington Township Water and Sewer Department (WTWSD)	Male	11	10.01	1.10	0.55 - 1.97	19	17.38	1.09	0.66 - 1.71	11	12.36	0.89	0.44 - 1.59	19	20.59	0.92	0.56 - 1.44
	Female	6	9.87	0.61	0.22 - 1.32	11	10.25	1.07	0.54 - 1.92	6	11.20	0.54	0.2 - 1.17	11	13.23	0.83	0.42 - 1.49
Warminster Municipal Authority (WMA)	Male	4	2.60	1.54	0.42 - 3.94	1	4.80	0.21	0.01 - 1.16	4	3.13	1.28	0.35 - 3.27	1	5.69	0.18*	0 - 0.98
	Female	3	2.35	1.28	0.26 - 3.73	2	3.47	0.58	0.07 - 2.08	3	2.69	1.11	0.23 - 3.25	2	4.39	0.46	0.06 - 1.64
Combined	Male	26	19.43	1.34	0.87 - 1.96	31	34.38	0.90	0.61 - 1.28	26	23.80	1.09	0.71 - 1.6	31	40.63	0.76	0.52 - 1.08
	Female	14	18.18	0.77	0.42 - 1.29	23	22.72	1.01	0.64 - 1.52	14	20.68	0.68	0.37 - 1.14	23	29.05	0.79	0.5 - 1.19

*Statistically significant, lower relative to the comparison area
Data source: PA Cancer Registry, U.S. Census Bureau

Table 5. Age and Sex-Adjusted Standardized Incidence Ratios (SIR) and 95 Percent Confidence Intervals (CI) for **Non-Hodgkin Lymphoma** (1995-2004 and 2005-2014) by Water Service Area, Compared to the Rest of Montgomery and Bucks Counties and to the Rest of Pennsylvania

Water service area	Sex	Non-Hodgkin Lymphoma															
		Comparing to the Rest of Montgomery and Bucks Counties								Comparing to the Rest of Pennsylvania							
		1995-2004				2005-2014				1995-2004				2005-2014			
		Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI
Horsham Water and Sewer Authority (HWSA)	Male	31	29.63	1.05	0.71 - 1.49	45	39.38	1.14	0.83 - 1.53	31	32.59	0.95	0.65 - 1.35	45	43.56	1.03	0.75 - 1.38
	Female	30	23.73	1.26	0.85 - 1.8	29	33.57	0.86	0.58 - 1.24	30	24.64	1.22	0.82 - 1.74	29	36.39	0.80	0.53 - 1.14
Warrington Township Water and Sewer Department (WTWSD)/North Wales Water Authority (NWWA)	Male	8	6.09	1.31	0.57 - 2.59	13	14.27	0.91	0.49 - 1.56	8	6.70	1.19	0.52 - 2.35	13	15.71	0.83	0.44 - 1.42
	Female	3	4.75	0.63	0.13 - 1.85	11	10.96	1.00	0.5 - 1.8	3	4.93	0.61	0.13 - 1.78	11	11.93	0.92	0.46 - 1.65
Warrington Township Water and Sewer Department (WTWSD)	Male	61	50.07	1.22	0.93 - 1.56	96	75.15	1.28**	1.03 - 1.56	61	54.73	1.11	0.85 - 1.43	96	82.32	1.17	0.94 - 1.42
	Female	47	44.80	1.05	0.77 - 1.4	59	49.77	1.19	0.9 - 1.53	47	46.28	1.02	0.75 - 1.35	59	54.33	1.09	0.83 - 1.4
Warminster Municipal Authority (WMA)	Male	16	13.67	1.17	0.67 - 1.9	20	21.16	0.95	0.58 - 1.46	16	15.12	1.06	0.6 - 1.72	20	23.43	0.85	0.52 - 1.32
	Female	8	11.37	0.70	0.3 - 1.39	11	16.87	0.65	0.33 - 1.17	8	11.85	0.68	0.29 - 1.33	11	18.23	0.60	0.3 - 1.08
Combined	Male	116	99.45	1.17	0.96 - 1.4	174	149.97	1.16	0.99 - 1.35	116	109.14	1.06	0.88 - 1.27	174	165.01	1.05	0.9 - 1.22
	Female	88	84.65	1.04	0.83 - 1.28	110	111.16	0.99	0.81 - 1.19	88	87.71	1.00	0.8 - 1.24	110	120.88	0.91	0.75 - 1.1

**Statistically significant, higher relative to the comparison area

Data source: PA Cancer Registry, U.S. Census Bureau

Table 6. Age and Sex-Adjusted Standardized Incidence Ratios(SIR) and 95 Percent Confidence Intervals (CI) for **Prostate Cancer** (1995-2004 and 2005-2014) by Water Service Area, Compared to the Rest of Montgomery and Bucks Counties and to the Rest of Pennsylvania – Males Only

Water service area	Sex	Prostate															
		Comparing to the Rest of Montgomery and Bucks Counties								Comparing to the Rest of Pennsylvania							
		1995-2004				2005-2014				1995-2004				2005-2014			
		Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI
Horsham Water and Sewer Authority (HWSA)	Male	143	165.78	0.86	0.73 - 1.02	181	190.10	0.95	0.82 - 1.1	143	180.89	0.79*	0.67 - 0.93	181	194.76	0.93	0.8 - 1.08
Warrington Township Water and Sewer Department (WTWSD)/North Wales Water Authority (NWWA)	Male	35	33.37	1.05	0.73 - 1.46	68	66.13	1.03	0.8 - 1.3	35	36.38	0.96	0.67 - 1.34	68	67.96	1.00	0.78 - 1.27
Warrington Township Water and Sewer Department (WTWSD)	Male	284	306.93	0.93	0.82 - 1.04	324	335.26	0.97	0.86 - 1.08	284	335.74	0.85*	0.75 - 0.95	324	348.52	0.93	0.83 - 1.04
Warminster Municipal Authority (WMA)	Male	61	74.36	0.82	0.63 - 1.05	102	109.18	0.93	0.76 - 1.13	61	81.04	0.75*	0.58 - 0.97	102	111.30	0.92	0.75 - 1.11
Combined	Male	523	580.44	0.90*	0.83 - 0.98	675	700.67	0.96	0.89 - 1.04	523	634.05	0.82*	0.76 - 0.9	675	722.55	0.93	0.87 - 1.01

*Statistically significant, lower relative to the comparison area

Data source: PA Cancer Registry, U.S. Census Bureau

Table 7. Age and Sex-Adjusted Standardized Incidence Ratios (SIR) and 95 Percent Confidence Intervals (CI) for **Testicular Cancer** (1995-2004 and 2005-2014) by Water Service Area, Compared to the Rest of Montgomery and Bucks Counties and to the Rest of Pennsylvania – Males Only

Water service area	Sex	Testis															
		Comparing to the Rest of Montgomery and Bucks Counties								Comparing to the Rest of Pennsylvania							
		1995-2004				2005-2014				1995-2004				2005-2014			
		Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI
Horsham Water and Sewer Authority (HWSA)	Male	14	9.26	1.51	0.83 - 2.54	5	9.03	0.55	0.18 - 1.29	14	9.09	1.54	0.84 - 2.58	5	8.77	0.57	0.19 - 1.33
Warrington Township Water and Sewer Department (WTWSD)/North Wales Water Authority (NWWA)	Male	4	2.01	1.99	0.54 - 5.09	4	2.92	1.37	0.37 - 3.51	4	1.97	2.03	0.55 - 5.2	4	2.87	1.39	0.38 - 3.57
Warrington Township Water and Sewer Department (WTWSD)	Male	9	10.90	0.83	0.38 - 1.57	16	11.22	1.43	0.81 - 2.32	9	10.80	0.83	0.38 - 1.58	16	10.82	1.48	0.84 - 2.4
Warminster Municipal Authority (WMA)	Male	2	4.38	0.46	0.06 - 1.65	4	4.85	0.82	0.22 - 2.11	2	4.29	0.47	0.06 - 1.69	4	4.69	0.85	0.23 - 2.18
Combined	Male	29	26.55	1.09	0.73 - 1.57	29	28.02	1.03	0.69 - 1.49	29	26.14	1.11	0.74 - 1.59	29	27.17	1.07	0.71 - 1.53

Data source: PA Cancer Registry, U.S. Census Bureau

Table 8. Age and Sex-Adjusted Standardized Incidence Ratios (SIR) and 95 Percent Confidence Intervals (CI) for **Pancreatic Cancer** (1995-2004 and 2005-2014) by Water Service Area, Compared to the Rest of Montgomery and Bucks Counties and to the Rest of Pennsylvania

Water service area	Sex	Pancreas															
		Comparing to the Rest of Montgomery and Bucks Counties								Comparing to the Rest of Pennsylvania							
		1995-2004				2005-2014				1995-2004				2005-2014			
		Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI
Horsham Water and Sewer Authority (HWSA)	Male	21	13.04	1.61	0.99 - 2.46	20	18.89	1.06	0.65 - 1.64	21	13.51	1.55	0.96 - 2.38	20	20.54	0.97	0.59 - 1.5
	Female	15	10.03	1.50	0.84 - 2.47	18	19.99	0.90	0.53 - 1.42	15	11.12	1.35	0.76 - 2.23	18	20.72	0.87	0.51 - 1.37
Warrington Township Water and Sewer Department (WTWSD)/North Wales Water Authority (NWWA)	Male	5	2.66	1.88	0.61 - 4.38	4	6.90	0.58	0.16 - 1.49	5	2.74	1.82	0.59 - 4.25	4	7.40	0.54	0.15 - 1.38
	Female	1	1.99	0.50	0.01 - 2.79	6	6.27	0.96	0.35 - 2.08	1	2.20	0.45	0.01 - 2.53	6	6.52	0.92	0.34 - 2
Warrington Township Water and Sewer Department (WTWSD)	Male	23	23.66	0.97	0.62 - 1.46	37	37.74	0.98	0.69 - 1.35	23	24.26	0.95	0.6 - 1.42	37	40.38	0.92	0.65 - 1.26
	Female	23	20.53	1.12	0.71 - 1.68	52	30.53	1.70**	1.27 - 2.23	23	22.56	1.02	0.65 - 1.53	52	31.76	1.64**	1.22 - 2.15
Warminster Municipal Authority (WMA)	Male	4	5.95	0.67	0.18 - 1.72	9	10.36	0.87	0.4 - 1.65	4	6.19	0.65	0.18 - 1.65	9	11.17	0.81	0.37 - 1.53
	Female	10	4.77	2.10**	1.01 - 3.85	8	9.51	0.84	0.36 - 1.66	10	5.31	1.88	0.9 - 3.46	8	9.96	0.80	0.35 - 1.58
Combined	Male	53	45.31	1.17	0.88 - 1.53	70	73.89	0.95	0.74 - 1.2	53	46.70	1.13	0.85 - 1.48	70	79.50	0.88	0.69 - 1.11
	Female	49	37.32	1.31	0.97 - 1.74	84	66.29	1.27**	1.01 - 1.57	49	41.19	1.19	0.88 - 1.57	84	68.95	1.22	0.97 - 1.51

**Statistically significant, higher relative to the comparison area

Data source: PA Cancer Registry, U.S. Census Bureau

Table 9. Age and Sex-Adjusted Standardized Incidence Ratios (SIR) and 95 Percent Confidence Intervals (CI) for **Childhood Cancers** (1995-2004 and 2005-2014) by Water Service Area, Compared to the Rest of Montgomery and Bucks Counties and to the Rest of Pennsylvania

Water service area	Sex	Childhood Cancer															
		Comparing to the Rest of Montgomery and Bucks Counties								Comparing to the Rest of Pennsylvania							
		1995-2004				2005-2014				1995-2004				2005-2014			
		Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI	Observed	Expected	SIR	95% CI
Horsham Water and Sewer Authority (HWSA)	Male	8	7.09	1.13	0.49 - 2.22	7	7.79	0.90	0.36 - 1.85	8	7.45	1.07	0.46 - 2.12	7	8.32	0.84	0.34 - 1.73
	Female	10	6.20	1.61	0.77 - 2.96	9	8.01	1.12	0.51 - 2.13	10	6.72	1.49	0.71 - 2.74	9	7.98	1.13	0.52 - 2.14
Warrington Township Water and Sewer Department (WTWSD)/North Wales Water Authority (NWWA)	Male	1	1.78	0.56	0.01 - 3.12	1	3.62	0.28	0.01 - 1.54	1	1.93	0.52	0.01 - 2.88	1	3.91	0.26	0.01 - 1.43
	Female	3	1.47	2.03	0.42 - 5.95	2	3.52	0.57	0.07 - 2.05	3	1.58	1.90	0.39 - 5.54	2	3.52	0.57	0.07 - 2.05
Warrington Township Water and Sewer Department (WTWSD)	Male	9	9.00	1.00	0.46 - 1.9	17	9.23	1.84**	1.07 - 2.95	9	9.41	0.96	0.44 - 1.82	17	9.88	1.72**	1.01 - 2.76
	Female	7	7.93	0.88	0.35 - 1.82	10	9.82	1.02	0.49 - 1.87	7	8.55	0.82	0.33 - 1.69	10	9.75	1.03	0.49 - 1.89
Warminster Municipal Authority (WMA)	Male	2	3.70	0.54	0.07 - 1.95	3	4.25	0.71	0.15 - 2.06	2	3.87	0.52	0.06 - 1.86	3	4.55	0.66	0.14 - 1.93
	Female	4	3.14	1.27	0.35 - 3.26	6	4.13	1.45	0.53 - 3.16	4	3.39	1.18	0.32 - 3.02	6	4.10	1.46	0.54 - 3.18
Combined	Male	20	21.57	0.93	0.57 - 1.43	28	24.88	1.13	0.75 - 1.63	20	22.67	0.88	0.54 - 1.36	28	26.65	1.05	0.7 - 1.52
	Female	24	18.75	1.28	0.82 - 1.91	27	25.49	1.06	0.7 - 1.54	24	20.25	1.19	0.76 - 1.76	27	25.37	1.06	0.7 - 1.55

** Statistically significant, higher relative to the comparison area

Data source: PA Cancer Registry, U.S. Census Bureau

SIRs Compared to the Rest of Montgomery and Bucks Counties

1995-2004

The incidence rates of cancers (for both sexes) of the bladder, kidney, liver, myeloma, non-Hodgkin lymphoma and childhood cancers in each of the water service areas and the combined water service area during 1995-2004 were similar to those of the rest of Montgomery and Bucks counties (Tables 1-5 and Table 9). The incidence rate of testicular cancer (Table 7) was also similar to that of the rest of Montgomery and Bucks counties during this period. Prostate cancer incidence rate was 10 percent lower (SIR 0.90) in the combined water service area during 1995-2004 compared to the rest of Montgomery and Bucks counties (Table 6). The pancreatic cancer incidence rate among women was 110 percent higher (SIR 2.10) in the WMA area compared to the rest of Montgomery and Bucks counties during 1995-2004 (Table 8).

2005-2014

During 2005-2014, the bladder cancer incidence rate among men (Table 1) was 31 percent higher in the HWSA area (SIR 1.31) and 17 percent higher in the combined water service area (SIR 1.17). However, among women, during the same period, the bladder cancer incidence rate was 61 percent lower (SIR 0.39) in the HWSA area and 54 percent higher (SIR 1.54) in the WTWSD area than those in the rest of Montgomery and Bucks counties. With respect to kidney cancer (Table 2), the incidence rates were 77 percent higher among men in the WMA area (SIR 1.77) and 32 percent higher among females in the combined water service area (SIR 1.32). The incidence rates of liver cancer (both sexes), myeloma (both sexes), prostate cancer and testicular cancer during 2005-2014 were similar to those of the rest of Montgomery and Bucks counties (Tables 3-4 and Tables 6-7). However, men had a 28 percent higher non-Hodgkin lymphoma incidence rate in the WTWSD area compared to the rest of Montgomery and Bucks counties during the same period (Table 5). Pancreatic cancer among women (Table 8) and childhood cancers among boys (Table 9) also showed a higher incidence during the period of 2005-2014. The pancreatic cancer incidence rates among women were 70 percent (SIR 1.70) and 27 percent (SIR 1.27) higher than the rest of Montgomery and Bucks counties

in the WTWSD area and in the combined water service area, respectively, during 2005-2014. Boys in the WTWSD area had an 84 percent (SIR 1.84) higher incidence of childhood cancers than those in the rest of Montgomery and Bucks counties during 2005-2014.

SIRs Compared to the Rest of Pennsylvania

1995-2004

The incidence rates of cancers (for both sexes) of the bladder, kidney, liver, myeloma, non-Hodgkin lymphoma (Tables 1-5), pancreas (Table 8) and childhood cancers (Table 9) in each of the water service areas and the combined water service area during 1995-2004 were similar to those in the rest of Pennsylvania. The incidence rates of testicular cancer (Table 7) in each of the water service areas and the combined water service area were also similar to those in the rest of Pennsylvania during this period. The incidence rates of prostate cancer (Table 6) were significantly lower in all water service areas including the combined water service area, except in the area of WTWSD/NWWA; the rates were 21 (SIR 0.79), 15 (SIR 0.85), 25 (SIR 0.75) and 18 percent (SIR 0.82) lower in the HWSA, WTWSD, WMA and combined water service areas, respectively, than in the rest of Pennsylvania during 1995-2004.

2005-2014

During 2005-2014, the incidence of bladder cancer among women was 64 percent lower (SIR 0.36) in the HWSA area and 43 percent higher (SIR 1.43) in the WTWSD area in comparison to the rest of the state (Table 1). The kidney cancer incidence rate (Table 2) among men was 63 percent higher (SIR 1.63) in the area of WMA compared to the rest of the state during the same period. The incidence rates for both sexes for cancers of the liver (Table 3) and non-Hodgkin lymphoma (Table 5) in all water service areas, including the combined water service area, were similar to rates in the rest of the state during 2005-2014. Prostate (Table 6) and testicular cancer (Table 7) rates in all water service areas were also similar to state rates during this period. The myeloma incidence rate (Table 4) among men was 82 percent (SIR 0.18) lower in the WMA area compared to the rest of the state during 2005-2014. Regarding pancreatic

cancer (Table 8), the rate among females was 64 percent higher (SIR 1.64) in the WTWSD area in comparison to the rest of the state during this period. Boys in the WTWSD area had a 72 percent (SIR 1.72) higher incidence of childhood cancers (Table 9) than those in the rest of Pennsylvania during 2005-2014.

Discussion

The analysis performed to generate Addendum 2 was a refinement to the analytical strategy used in the previous two documents with respect to study area and confirmation of the geographic location of cancer cases. There are other differences between this study and the previous two studies. The current analysis included comparison with the immediate surrounding area (i.e., Montgomery and Bucks counties) and with the rest of the state to better understand the situation. The previous two studies compared the zip code level incidence rates to the state rates, whereas the current one used water service areas. It is to be noted that the water service area boundaries do not match exactly with the zip code boundaries used in prior analyses. Also, the previous reports had analyzed three time periods (1985-1994, 1995-2004, and 2005-2013) versus the two periods (1995-2004 and 2005-2014) used in the current analysis.

During 1995-2004, the incidence rates for all cancers examined, with the exception of female pancreatic cancer in the WMA area and prostate cancer in the combined water service area, were statistically similar to the rates both in the rest of Montgomery and Bucks counties and in the rest of Pennsylvania. Female pancreatic cancer in the WMA area showed a significant increase in rate compared to the rate in the rest of Montgomery and Bucks counties during 1995-2004. However, this SIR was based on 10 incident cases and 4.8 expected cases, suggestive of an unstable rate. The prostate cancer incidence rate in the combined water service area was significantly lower than the rate in the rest of Montgomery and Bucks counties during this period. When compared to the state rate, prostate cancer rates were significantly lower in all but one water service area during 1995-2004.

In contrast to 1995-2004, during 2005-2014, the rates for cancers of the bladder, kidney, non-Hodgkin lymphoma, pancreas and childhood cancer were higher compared to the rates in the rest of Montgomery and Bucks counties in one or more water service areas among one or both sexes. Among these, the rates for bladder and pancreatic cancers in females and male childhood cancers in the WTWSD area and male kidney cancer rate in the WMA area were significantly higher than the rates in the rest of the state during this period.

Various occupational and environmental risk factors have been suggested for the types of cancers (non-Hodgkin lymphoma and cancers of bladder, kidney and pancreas) that showed elevated incidence rates in this analysis. However, information on these risk factors was not available from the data sources used in this analysis. Cigarette smoking is a major risk factor for bladder cancer. However, genetic alterations leading to bladder cancer development that are linked to environmental factors other than cigarette smoking have also been identified, accounting for a significant portion of bladder cancer cases in non-smokers.¹ Other factors strongly associated with bladder cancer are exposure to arsenic in drinking water and occupational exposure to aromatic amines.² With public water hookups, arsenic was not a drinking water contaminant of concern in this analysis.

Exposure, mostly through occupational means, to arsenic and inorganic arsenic compounds, cadmium and cadmium compounds, perfluorooctanoic acid and TCE has been linked to kidney cancer. There is epidemiologic evidence linking TCE to renal cell cancer risk; risk increases with increasing levels of exposure.³ Studies in humans also suggest that exposure to PCE might lead to a higher risk of getting bladder cancer, multiple myeloma or non-Hodgkin lymphoma. Other known risk factors for renal cell cancer include cigarette smoking, obesity and hypertension. The C8 Science Panel⁴ that studied the Mid-Ohio Valley communities, which were affected by the releases of PFOA emitted since the 1950s from the Washington Works plant in Parkersburg, West Virginia, concluded that PFOA exposure was associated with kidney and testicular cancer in this population. Although the kidney cancer rates showed some elevation in this Pennsylvania analysis, the rates for testicular cancer remained similar to the rates in the rest of Montgomery and Bucks counties and in the rest of Pennsylvania during both comparison periods. In general, the incidence of testicular cancer was lower than that of many

other types of cancers included in this analysis, resulting in unstable rates as observed in the prior review.

Occupational exposures to benzene and TCE are considered risk factors for non-Hodgkin lymphoma, although evidence has been inconsistent.⁵ An elevated incidence rate for this type of cancer was observed one time in this analysis. Exposure to PCE is also linked to an elevated risk for developing bladder cancer, multiple myeloma and non-Hodgkin lymphoma.

Various risk factors for pancreatic cancer have been reported. These include higher age, male gender, obesity, diabetes, chronic pancreatitis, genetic factors and cigarette smoking. There is only limited information indicating a link between pancreatic cancer and chemical exposures. Benzene and chlorinated hydrocarbons are linked to pancreatic cancer and were drinking water contaminants of concern in the past in this area. However, exposures to these chemicals in drinking water were addressed via public water hookups and treatment systems in the 1990s. A link between PFAS, which is a major contaminant of concern in the study area, and pancreatic cancer has not been established. Please see Addendum 1 for additional discussion of the scientific literature on PFAS exposure and pancreatic cancer.

The causes of most childhood cancers are not known. Lifestyle factors usually take many years to influence cancer risk, and they are not thought to play much of a role in childhood cancers. Most childhood cancers have not been shown to have environmental causes, although research is ongoing on this issue. Other risk factors, such as birth weight, parental age, birth defects and genetic factors, are associated with childhood cancers.⁶

Conclusions

This refined analysis presents elevated incidence rates for some types of cancers in comparison to the rest of Montgomery and Bucks counties and to the rest of the state of Pennsylvania. However, as with the prior reviews of cancer information for this area, these results do not show a consistent pattern. While it is possible to have different levels of contaminants of concern in the water supply in different water service areas depending on the

source of water, the current results do not indicate consistently higher incidence rates in all service areas for any cancer type. The results also do not indicate consistently higher incidence rates for a given cancer in both sexes. Sex is not a known risk factor for any of the cancer types included in this analysis (except cancers of the prostate and testis).

Limitations

People with certain risk factors may be more likely than others to develop cancers. For instance, the risk factors for pancreatic cancer include smoking, diabetes, pancreatitis and obesity, among others. Tobacco use is a major risk factor for bladder cancer as well. However, the current analysis was not able to consider the prevalence of these risk factors in the populations studied, as these types of data are not available in the cancer registry. Other pertinent information, such as the length of residence in the area and whether the individual was employed at the Warminster or Willow Grove bases, was also not available in the cancer registry for analysis. Cancer has a long latency period. For many cancer types, it may take decades for a cancer to develop and be diagnosed. People also migrate from one location to another, from one state to another, or even from one country to another, and, therefore, it becomes difficult to find the source of exposure that may have caused a particular cancer. Cancers diagnosed in Pa. residents are only reported to the Pa. cancer registry. Diagnoses made after the individual moved out of state may not be included in the Pa. cancer registry. Likewise, diagnoses made among people who have recently moved into the commonwealth (with exposures happening elsewhere) will be included in the Pa. cancer registry. However, cancers diagnosed in Pa. residents who receive medical care outside of Pa. are included in the Pa. cancer registry. It is important to note that the submission of all cancer data from all the Veteran Affairs facilities in the commonwealth is not guaranteed at this time, especially the diagnoses made after 2005. Even when a statistically significant increase in cancer incidence is detected, determining the validity of an association between an environmental agent and the development of cancer is difficult, as behavioral (e.g., nutrition, physical activity and substance use), genetic (e.g., inherited mutations, hormones and immune conditions) and environmental (e.g., chemicals, radiation, pathogens and other contaminants) factors interact and affect cancer growth. These factors may act together or in sequence to initiate or promote cancer.

Some of the highest PFAS in drinking water in this area occurred among residents who used private drinking water wells but were within the geographical area of public water service. However, in this analysis, no distinction was made between public water users and private well water users.

Another difficulty in most cancer cluster investigations is that the population under study is typically a community (e.g., a water service agency area) and is usually very small, resulting in fewer cancer cases. The small number of cases yield wide confidence intervals, meaning that the SIR is not as precise as desired. Epidemiologists try to minimize this limitation by expanding the study area and/or using data from multiple years. In the current analysis, data from two 10-year periods were used to address the small sample size issue. Even using 10-year periods, the numbers of cancer cases were not large. SIRs based on small numbers of cases tend to be more unstable.

Citations

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