Center for Environmental Health

FINAL REPORT

Tonawanda Study Area Health Outcomes Review: Birth Outcomes and Cancer Erie County, NY

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SUMMARY

The New York State Department of Health (NYS DOH) conducted a health outcomes review for Tonawanda and surrounding areas in Erie County in response to community concerns about potential health effects from exposures to emissions from the area's industries and motor vehicle traffic. Concerns were heightened after the New York State Department of Environmental Conservation (NYS DEC) released results from an air quality monitoring study in 2009. Working with community members and NYS DEC, NYS DOH developed a Tonawanda health outcomes study area, with several sub-areas, during 2010 - 2012.

A health outcomes review examines a particular group of people as a whole to see how the group compares to a group not living in the area of concern. It cannot prove that a specific environmental exposure caused a specific health effect and it cannot tell us anything about individual health problems. This health review included data from 1990 to 2009. We looked at cancer as well as birth defects and other birth outcomes such as low birth weight and preterm births for people who lived in the area when the health problems were diagnosed. We compared the rates of these health outcomes in the Tonawanda study area to the rates for people in NYS, excluding New York City (NYC), and also to rates for people in Erie and Niagara Counties.

Total cancers as well as 18 separate types of cancer for women and 16 types for men were reviewed. In the overall study area, using NYS, excluding NYC, as the comparison, lung cancer, bladder cancer, and total cancers were elevated among both males and females; esophageal cancer was elevated among males and uterine cancer was elevated among females. Two additional types of cancer were elevated, each in just one sub-area: oral cavity/pharynx cancer among males, and leukemia among females. Using Erie and Niagara Counties as the comparison area, the same cancer types showed elevations, but the elevations were reduced, and some were no longer statistically significant.

Although the kinds of chemical compounds that were detected in the air in the Tonawanda exposure area have been associated with some of these types of cancer (leukemia and pharynx) in other studies, there are many other factors that may also contribute to the development of these types of cancer. These factors include smoking, family history, and occupational exposures, as well as others. In the general population, smoking is the most important risk factor for both lung and bladder cancer. We do not know the individual medical and exposure histories for the people included in this study.

The analyses of birth outcomes in the study area compared to birth outcomes in NYS (excluding NYC) showed some elevations that were relatively smaller than the cancer elevations. Preterm births were elevated in the overall study area. Total heart defects as a group were also elevated, but major heart defects were not elevated. When we compared the birth outcomes in the study area to birth outcomes in Erie and Niagara Counties, the elevations declined substantially. This is consistent with other evidence suggesting this area has more complete reporting than elsewhere in the state, particularly for relatively minor adverse outcomes that do not generally require medical intervention.

This final report includes responses to public comments on the draft report. In this final version, a recommendation has been added for NYS DOH to work with the community to develop a proposal for a biomonitoring project to address ongoing concerns about exposures among residents of the study area.

INTRODUCTION

This health outcomes review was conducted by the New York State Department of Health (NYS DOH) in response to air monitoring data collected by the New York State Department of Environmental Conservation (NYS DEC) and community concerns about the health of Tonawanda area residents. This review examined levels of adverse birth outcomes and cancer among people living near the industrial area of Tonawanda. These levels were compared to levels among residents of New York State (excluding New York City) and to levels among residents of Erie and Niagara Counties. The study area includes areas located in the City of Tonawanda, Town of Tonawanda, Town of Grand Island, and City of Buffalo (see Figure 1).

This type of review cannot prove whether there is a causal relationship between specific exposures and health outcomes in a community, nor can it determine the cause of any specific individual's health problem. The findings of this type of review may be used, together with findings from other similar investigations, to suggest hypotheses for more in-depth research studies. The study may also be useful to residents because it provides information about levels of health outcomes in their area.

*A **health outcomes review** uses information from existing sources, such as birth certificates, to compare levels of health outcomes among residents of a specific area to levels in one or more comparison populations.*

BACKGROUND

In October 2009, the NYS Department of Environmental Conservation (NYS DEC) released the final results of the Tonawanda Community Air Quality Study (http://www.dec.ny.gov/chemical/59464.html). The study measured ambient concentrations of hazardous air pollutants at several points in the area and used air dispersion models to assess the likely impact of air pollution in a wider area. The results identified elevations of several chemicals, including benzene, linked to the Tonawanda Coke Corporation (TCC). The air quality study also identified areas with an excess lifetime cancer risk associated with TCC benzene emissions.

The TCC facility is located in a large active industrial area along the Niagara River. This area, which is surrounded by residential neighborhoods, has been the site of industrial activities for over 100 years. In addition to the TCC facility, the industrial area currently houses a coal-fired power plant, chemical manufacturers, automotive product manufacturers, and asphalt and petroleum product terminals. Residents of surrounding neighborhoods have complained about air quality in general, about odors, particulate deposition, and traffic. Residents have also expressed concerns about a variety of health outcomes, including cancer, neurological and autoimmune diseases, allergies and respiratory irritation, and asthma and other respiratory disorders. Based on the public health implications of the air quality study and requests from community members, NYS DOH conducted this health outcomes review. Additional background about potential exposures and health outcomes is provided below.

Exposure information

The NYS DEC Tonawanda Community Air Quality Study provided a large amount of information on hazardous air pollutants present during sampling of the ambient (outdoor) air in Tonawanda. Using the air quality sampling results and air dispersion models that estimated pollutant levels for larger areas, it was possible to identify the areas that were more likely to have higher concentrations of the various air pollutants. The air quality data and modeling only reflect air quality during the time of the DEC study (July 2007 - June 2008), but these data are much more comprehensive than the data that are available for other communities in New York State. Given the general decline in industrial operations in the Tonawanda area over recent years, it is likely that the results of the air quality study understated ambient air quality problems that occurred in the past.

The air quality study showed that the concentrations of benzene and formaldehyde were much higher in the Tonawanda area than in other areas with industrial and urban monitoring data in New York State, excluding New York City. The air quality study results also indicated that the TCC facility was the most important factor in the high air concentrations of benzene. Other benzene emission sources include automobile and truck traffic, the Huntley power plant, and the NOCO and Sunoco petroleum product terminals. The direct (primary) sources of formaldehyde, in order of impact, were automobile and truck traffic, local manufacturers, and the Huntley power plant. (A relatively large portion of the formaldehyde in urban air comes from the breakdown of a variety of other volatile organic chemicals, such as those emitted from the petrochemical industry. Recent studies estimate this secondary formation accounts for from 40% to 90% of the formaldehyde measured in urban air [Parrish et al., 2012; Lin et al., 2012].) The air quality measurements are indicators of exposures that occur from breathing air in the study area. Individuals may also be exposed to higher levels of benzene or formaldehyde during other activities, such as smoking or pumping gasoline.

Benzene is a naturally occurring substance and a major industrial chemical made from coal and oil. It is used as a solvent and in the manufacture of other chemicals. Benzene is also found in petroleum products such as gasoline. Studies of the offspring of animals that breathed benzene have shown low birth weights (US Department of Health and Human Services [USDHHS], Agency for Toxic Substances and Disease Registry [ATSDR], 2007). Several studies of workers exposed to elevated levels of benzene in air report an increased risk for cancer (e.g., leukemia), damage to tissues that make blood cells, and damage to the immune and nervous systems. Benzene also causes these effects in laboratory animals. Based on the increased risk for leukemia among workers exposed to elevated levels of benzene over long periods of time, benzene is classified as a human carcinogen. (USDHHS, National Toxicology Program [NTP], 2011a)

Formaldehyde is used to make fertilizer, paper, plywood, and other products. It is also produced naturally in small amounts in our bodies. It irritates the eyes, nose, throat, and respiratory system. Asthmatics may be more sensitive to the irritant effects of formaldehyde. (USDHHS, ATSDR, 1999) Laboratory rats exposed to high air concentrations of formaldehyde for their lifetimes developed nasal cancers. Studies of occupational groups, such as industrial

workers and embalmers, found elevations of nasal (nasopharyngeal and sinonasal) cancers and myeloid leukemia. Based on the results of animal and human studies, formaldehyde is classified as a known human carcinogen. (USDHHS, NTP, 2011b) Cigarettes and other tobacco products are also sources of both benzene and formaldehyde exposures.

Coke-oven emissions as a group are known to be human carcinogens, based on evidence from studies of coke-oven workers. Coke-oven emissions, which include benzene and formaldehyde, are complex mixtures that contain many additional chemicals. Exposure to coke-oven emissions is known to increase the risk for lung cancer among coke-oven workers. Some studies also show increased risk for kidney cancer. (USDHHS, NTP, 2011c) Detailed information on the additional pollutants assessed in the air quality study area is provided in the DEC Tonawanda Community Air Quality Study (http://www.dec.ny.gov/chemical/59464.html).

Health outcomes reviewed

Because benzene exposures have been associated with some types of reproductive effects (low birth weight), and benzene exposures and formaldehyde exposures have been associated with some types of cancer, this review focused on birth outcomes and cancer. This type of review is feasible because NYS DOH collects comprehensive data on birth outcomes and cancer for the NYS population. While there are other health outcomes of interest that may be associated with ambient air exposures (immune system or respiratory outcomes, for example), those health outcomes were not included in this review because similarly complete statewide data are not available.

More specifically, this review includes low birth weight births, premature births, growth restriction births, and birth defects. Growth restriction births are births that are small despite being full-term (term low birth weight - TLBW), or are small, given their gestational age (small for gestational age - SGA). We review total birth defects that are reportable to the NYS Congenital Malformations Registry. We also review a category called surveillance birth defects, which includes a group of defects that are considered to be consistently and reliably reported statewide. Cardiac (heart) defects, cleft lip, cleft palate, and choanal atresia (a defect of the nasal airway) are included as separate categories for this review because these types of defects have been elevated in some studies of volatile organic compounds, and benzene and formaldehyde are volatile organic compounds. However, the existing studies do not specifically associate either benzene or formaldehyde with these types of birth defects. (See Appendix A and Appendix B for more information on the defects and categories of defects included in this review.) All types of cancer are reviewed for males and females separately and combined. In addition, 18 individual types of cancer are reviewed for females and 16 individual types are reviewed for males. The 14 types that occur in both sexes are also reviewed for males and females combined. Additional information about risk factors associated with health outcomes examined in this report is available in Appendix C. (Appendix C includes information about the general types of adverse birth outcomes studied. Appendix C includes information about only the types of cancer that showed elevations in this investigation. For risk factor information about other types of cancer, see http://www.health.ny.gov/statistics/cancer/registry/abouts/.)

METHODS

This study examined the levels of adverse birth outcomes and cancer cases among residents near the Tonawanda industrial area and compared them to the levels in NYS (excluding NYC) and to levels in Erie and Niagara Counties. These comparisons show us whether the levels of these health outcomes are higher, lower, or about the same as would be expected taking into account the community's specific sex and age group populations during the timeframe of the investigation. Because birth certificates contain a great deal of information about the mother and infant, the analyses of birth outcomes are also able to take into account race, education, previous live births, and prenatal care.

Boundaries

We began by working with NYS DEC to identify the parts of Tonawanda that were more likely to have a high or moderate impact from benzene concentrations in the area. After identifying the U.S. Census blocks that comprised the high and moderate impact areas, we worked with community members to seek their input on the study area. Community members requested that we examine health outcomes for four smaller sub-areas within the moderate impact area. Therefore, the moderate impact area was divided into four sub-areas that are identified in this report as the Brookside Terrace sub-area, Sheridan Park sub-area, Riverside sub-area, and Grand Island sub-area. To see the study area boundaries that define these areas, see the study area map in Figure 1.

Timeframes

We examined health outcomes diagnosed during the 20 year time period, 1990-2009. The most recent data available for each health outcome vary slightly, with birth weight, prematurity, and growth restriction outcomes available for births through 2009, birth defect outcomes available for births occurring through 2006, diagnosed through 2008, and cancer data available through 2008.

Identifying and defining health outcomes

We obtained records of all births and birth defects with home addresses in ZIP codes 14072, 14150, 14207, and 14217, from NYS Vital Records and the NYS Congenital Malformations Registry. To capture records with missing ZIP code information, we also obtained the addresses for all birth and birth defect records in Erie County without a ZIP code. Using a variety of methods, we evaluated each record and assigned the individual to a location either in or out of the study area. These records were then analyzed to determine which individuals had been diagnosed with the health outcomes under study. The cancer cases were identified and mapped using similar procedures. Additional information about identifying and analyzing the adverse birth outcomes and cancer cases is available in Appendix D. To protect confidentiality, no maps of individual case locations are provided.

Demographic characteristics

The first comparison population for this review is the residents of NYS (excluding NYC). During the course of the investigation, a second, more local comparison population, residents of Erie

and Niagara Counties, was added and additional analyses were conducted. The use of comparison populations allowed us to calculate how many cases of each health outcome we would expect to occur among people living in the study area. For ease of presentation, and to reflect the order in which the analyses were conducted, this report will first present information and results of analyses using the NYS (excluding NYC) comparison population.

When making such comparisons, we need to consider the differences between the study area and the comparison areas. According to the US Census, the population of the study area (high and moderate impact areas combined) was approximately 19,000 people in both 2000 and 2010 (Tables 1a and 1b). This was a slight decrease compared to 1990, when the population was over 20,000.

There are differences between the study area and NYS (excluding NYC) for median household incomes, race, and ethnicity. The study area has a lower median income than NYS (excluding NYC) and the study area has a higher percentage of population identified as white than the comparison area. The percentage of the population in the study area who identified themselves as minority increased substantially from 1990 to 2010, from approximately 3% in 1990 to 15% in 2010. Among the sub-areas of the moderate impact area, the Sheridan Park and Riverside areas are the lowest income areas and the Grand Island sub-area is the highest income sub-area (Table 1b).

Statistical analyses

This review compares the level of specific health outcomes that actually occurred among residents of the study area (observed), and the level we would expect to see (expected) based on the levels experienced among the residents of the comparison area. We calculated either a rate ratio (for birth outcomes) or a standardized incidence ratio (for cancer) to measure the difference between the observed and expected levels of health outcomes.

> ***Rate ratios (RRs)*** *and* ***standardized incidence ratios (SIRs)*** *are measures of the association between an exposure or risk factor and a health outcome. A ratio of 1.0 means the study population and comparison are the same. A ratio greater than 1.0 means the study population had a higher level of the health outcome than the comparison group, while a ratio of less than 1.0 means the study population had a lower level than the comparison group.*

To determine whether any differences seen between the observed and expected numbers are statistically significant (unlikely due to chance alone), we also calculated 95% confidence intervals. Additional information about the statistical analyses for each type of health outcome is available in Appendix D.

> *The **95% confidence interval (95% CI)** helps us decide whether the difference between the study and comparison levels is likely due to chance. If the 95% CI excludes 1.0, the SIR or RR is considered to be statistically significant. If the 95% CI includes 1.0, the SIR or RR is not statistically significant. **Statistically significant** means that the difference between the measure in the study population and comparison population is unlikely to have occurred by chance alone, given the statistical assumptions of the test.*

RESULTS

Geocoding

The researchers identified all birth records from 1990-2009 from ZIP codes 14250, 14207, 14216, and 14217; or from Erie County but with no ZIP code. These records were mapped to find out if the mothers resided within the study area at the time of the birth. Almost all (99%) of these addresses were successfully mapped. (The records that could not be mapped were missing both a street name and a ZIP code.) This process led to the identification of 4,287 births in the study area during 1990-2009. A similar process resulted in the identification of approximately 2,300 cancer cases in the study area during 1990-2008.

Low birth weight, prematurity, and growth restriction

Table 2a shows the birth weight, prematurity, and growth restriction results for the high impact area. Because the high impact area has a population of fewer than 300 people (Table 1a), it also has very few births, a total of 45 over the 20 year study period. Because of these small numbers, it is not possible to draw conclusions from the observed adverse birth outcomes in the high impact study area. (Total birth defects for this area are also included in this table. See the next section below for more information about birth defects results.)

Table 2b shows the birth weight, prematurity, and growth restriction results for the entire Tonawanda study area. (We combined the high and moderate impact areas for the birth outcome analyses so that the high impact area could be included in these analyses that have sufficient numbers for more meaningful findings than for the high impact area alone.) There are some rate ratios greater than 1.00, and two categories of outcomes show statistically significant elevations. Preterm births and the subset of moderately preterm births show 14% and 17% elevations, respectively. It is important to note that the low birth weight and preterm categories each include two subsets. In addition, the categories are overlapping, meaning that a single birth may appear in more than one category. For example, a preterm birth may also appear as a low birth weight birth.

To view results for the moderate impact sub-areas, see Table 2c. Among the four sub-areas, the Sheridan Park area showed statistically significant elevations for both low birth weight and preterm birth categories. No other sub-areas showed statistically significant elevations or deficits.

Birth defects

Using the available data for birth defects diagnosed for births occurring through 2008, 246 infants were identified with one or more birth defects. Table 3a shows the observed and expected numbers and rate ratios for various categories of birth defects for the entire study area. The high and moderate impact areas were combined because of very small numbers in the high impact area. (Total birth defects in the high impact study area are shown on the last line of Table 2a. No separate table is provided for additional types of birth defects in the high impact area because only three infants were identified with birth defects in the high impact area during the 19-year study timeframe.)

In the entire study area (high and moderate impact areas combined), the rate ratios for total birth defects, surveillance birth defects, and total cardiac defects are statistically significantly elevated. The rate ratio for major cardiac defects is not statistically significantly elevated, however. (Major defects create significant medical problems or require specific surgical or medical treatments. Minor anomalies or malformations, on the other hand, which make up the majority of heart defects in the total cardiac category, are variations within the normal spectrum of differences and do not require medical intervention.)

Table 3b shows these outcomes for the four sub-areas of the moderate impact area. In the Brookside Terrace area, major cardiac defects show a statistically significant elevation based on four cases observed compared to about two cases expected. The Sheridan Park and Riverside areas show elevations similar to those observed for the entire study area for total reportable defects, surveillance defects, and total cardiac defects, but not for major cardiac defects.

Cancer

Table 4a shows how the observed numbers of cancer cases in the high impact area compare to the expected numbers based on rates in the comparison area (NYS excluding NYC) for 1990 through 2008. Total cancers and 18 separate types of cancer for women and 16 types for men were reviewed. Current NYSDOH confidentiality policy for sharing small numbers does not allow numbers smaller than six to be shown in this table for males or females separately. For this reason, Table 4a shows results for males and females combined. For males and females combined, no specific type of cancer is statistically significantly elevated. The analyses of males and females separately (data not shown) resulted in one type of cancer showing a statistically significantly elevation: oral cavity/pharynx cancer among males. (The total number of this type of cancer in the high impact area was fewer than six. The standardized incidence ratio [SIR] for males separately for oral cavity/pharynx cancer is 5.07, with the confidence interval [CI] estimate ranging from 1.04-13.80.)

Table 4b shows the cancer results for the moderate impact area. (We did not combine the high impact area with the moderate impact area because input from the community indicated the desire to see these results separately. The numbers are so small for the high impact area that they would not be expected to affect the findings in a combined analysis.) In the moderate impact area, total cancers, lung cancer, and bladder cancer are statistically significantly elevated among both males and females. Esophageal cancer is statistically significantly elevated among males. Uterine cancer is statistically significantly elevated among females. One type of cancer shows a deficit: kidney cancer is statistically significantly lower than expected among females.

Table 4c shows results for the sub-areas for males, and Table 4d shows sub-area results for females. For males in the Brookside sub-area, there were no statistically elevated cancer rates. For females in the Brookside sub-area, bladder cancer was statistically significantly elevated. For males in the Sheridan Park sub-area, total cancers, lung cancer, bladder cancer, and the "all other sites" category were statistically significantly elevated. For females, the Sheridan Park results are similar to the male results, with elevations for the same categories (total, lung, bladder, all other sites) and for one additional type of cancer, leukemia. In the Riverside sub-area, no type of cancer was statistically significantly elevated among males. Lung cancer was statistically significantly elevated for females. In the Grand Island sub-area, one type of cancer was statistically significantly elevated among males, esophageal cancer. Among females, uterine cancer was statistically significantly elevated.

We also evaluated cancer for males and females combined. The results were consistent with the results for males and females separately, with some SIRs for males and females combined being statistically significantly elevated, but only for types of cancer that showed statistically significant elevations among males and/or females separately in Tables 4b, 4c, or 4d. There was one additional statistically significant finding: for males and females combined, in the moderate impact area, liver cancer was statistically significantly lower than expected (SIR: 0.52, CI, 0.25-0.95) [data not shown)].

DISCUSSION

Birth outcomes

For all types of birth outcomes, the observed numbers of cases in the high impact area are too small to be able to draw conclusions from the analyses for this area. We observed an elevation of preterm births in the entire study area and elevations of preterm and low birth weight births in one sub-area, the Sheridan Park sub-area. Regarding birth defects in the entire study area, we saw elevations in the broadly defined categories, total reportable, surveillance, and total cardiac defects. The surveillance defect category includes defects thought to be most consistently reported throughout NYS, but it is possible that some areas of the state continue to have more complete reporting than other areas (Forand et al., 2002).

Regarding the total cardiac defects category, the majority of defects included in this general grouping are minor cardiac defects. These minor defects are unusual features that, in and of themselves, are not expected to cause health problems. The major defect category, which includes defects of medical significance, was not statistically significantly elevated for the entire study area (SIR: 1.18; CI, 0.65-2.12). It was statistically significantly elevated, however, in one sub-area, the Brookside Terrace sub-area (SIR: 2.82; CI, 1.06-7.52). This elevation is statistically significant, but is based on small numbers, with four cases observed compared to about two cases expected.

Heart defects have been associated in some studies with exposures to common industrial chemicals (volatile organic compounds), the general category that includes benzene and formaldehyde, but we found no studies showing associations specifically for benzene and formaldehyde. We observed no elevations in the other specific birth defect categories, cleft lip, cleft palate, and choanal atresia (a defect of the nasal airway) that have been associated with some industrial solvents and air pollutant exposures in other studies.

Cancer

Regarding cancer, the high impact area's population was too small for conclusive analyses. There was, however, one statistically significant elevation, for the category oral cavity/ pharynx cancer among men. This result was based on a very small number of cases. Nasopharyngeal and sinonasal cancers have been associated in other studies with formaldehyde exposures (USDHHS, NTP, 2011b) We reviewed the specific types of cancers diagnosed. Each observed case was a different specific type of cancer. It must be emphasized that these numbers are too small for drawing strong conclusions.

In the moderate impact area and its multiple sub-areas, a fairly consistent pattern of elevations of total, lung/bronchus and bladder cancer was observed among males and females. Smoking is the most important risk factor for both lung and bladder cancer in the general population. (See Appendix C for references to the scientific literature and additional information about risk factors.) However, exposures to air pollutants from industry and traffic may also increase risks for the same types of cancers that are associated with smoking.

This report has focused on potential exposures to benzene and formaldehyde in the study area because the NYS DEC air quality monitoring study found significantly elevated concentrations of these chemicals at one of the monitoring sites, the Grand Island Boulevard Industrial site. Benzene and formaldehyde exposures have not been consistently associated with lung cancer in human studies, but oral exposures to benzene have caused lung cancer in mice (USDHHS, NTP, 2011a; USDHHS, NTP, 2011b). There are, however, other types of potential exposures associated with industry and traffic in the study area. For example, coke- oven emissions include a variety of products of incomplete combustion, including polycyclic aromatic hydrocarbons (PAHs) (USDHHS, NTP, 2011c). Vehicle exhaust, especially from diesel engines, includes PAHs. PAHs are classified by the U.S. National Toxicology Program as reasonably anticipated to be human carcinogens. Animal studies of some types of PAHs show increased incidence of lung and bladder tumors. (USDHHS, NTP, 2011d)

Lung and bladder cancer rates are higher among whites than blacks in NYS, and this difference may affect these analyses, which did not adjust for race. However, lung cancer rates were most elevated in the Sheridan Park and Riverside areas. The 2000 and 2010 Census data indicate these two sub-areas had the lowest proportion of white populations of the four sub-areas. The percent of the population that is white is similar to that of the upstate comparison area, so white/black population distributions do not appear to have played a role in the lung cancer elevations. Bladder cancer was elevated in the Sheridan Park and Brookside Terrace sub-areas. Brookside Terrace has a higher percentage white population than the other sub-areas and the statewide comparison area, so the bladder cancer elevations in Brookside Terrace may be due to the high percentage white population.

We reviewed the ages of the people diagnosed with lung and bladder cancer to see if the age patterns appeared to be unusual. (Cancers diagnosed at unusually young ages may suggest that unusual environmental exposures have occurred.) Among females, more than 75% of lung cancer diagnoses in the two sub-areas showing elevations (Sheridan Park and Riverside) occurred among females over age 60. For males, more than 85% of cases in the elevated sub-area (Sheridan Park) occurred among males over age 60. For bladder cancer, the age patterns were similar: approximately 80% of both the female and male cases in the areas showing elevations (Sheridan Park and Brookside Terrace) were over age 60 at diagnosis. These age distributions are not unusual.

Leukemia, a type of cancer that has been associated with benzene and formaldehyde exposures in human studies, showed one statistically significantly elevation, in the Sheridan sub-area, among females. We reviewed additional information for these leukemia cases among women. The cases were nearly equally distributed among three leukemia sub-types, chronic lymphocytic, acute myeloid, and chronic myeloid leukemia. These leukemia diagnoses did not occur at unusually young ages. There were no childhood cases. Fifteen percent of the cases were younger than 60 at diagnosis and more than 50% of the cases were over age 80 at diagnosis. Smoking is also a risk factor for leukemia.

In NYS, uterine cancer rates are higher among white women than black women. This difference may have played a role in this review's findings. Uterine cancer was elevated in the overall study area and in one sub-area, Grand Island. Brookside Terrace also showed an elevation, but it was not statistically significant. Both Grand Island and Brookside Terrace's populations varied slightly, from approximately 96% to 98% white over the study timeframe, while the comparison area (NYS excluding NYC) population changed from 90% to 82% white. The distribution of ages of the uterine cancer diagnoses in the Grand Island sub-area was not unusual, with more than 60% of the cases older than age 60 at diagnosis. In Brookside Terrace, over 75% of the cases were over age 60. Environmental exposures have not been shown in other studies to be risk factors for uterine cancer (Devivo et al., 2008).

Additional analyses using local comparison area

The overall pattern of multiple positive findings and only two statistically significant deficits for any type of health outcome in this review suggest regional differences in diagnosing and reporting adverse birth outcomes and cancer may play a role in the findings. Past experience with statewide birth defects analyses has shown a tendency for higher rates in the Western Region. The higher rates are thought to be due to superior diagnostic practices leading to more comprehensive reporting, particularly the reporting of minor birth defects, rather than to increased prevalence of birth defects (Forand et al., 2002). Similarly for cancer, given the proximity of the Tonawanda study area to the Roswell Park Cancer Institute and several other hospitals in the Buffalo area, it is possible that superior screening and diagnostic practices result in more complete diagnosing and reporting of cancers in this geographic area than in other parts of NYS.

For these reasons, we conducted the analyses using a more local comparison area comprised of Erie and Niagara Counties. The demographics shown in Appendix Table 1 show Erie and Niagara Counties are more similar to the Tonawanda study area in terms of median income than the NYS excluding NYC comparison area (Table 1a). For other factors such as percent minority and percent below the poverty level, the local comparison area is similar to the NYS (excluding NYC) comparison area, with a higher percentage minority but fewer households below the poverty level than in the Tonawanda study area. The local comparison area is being used in additional analyses because it may assist with controlling for regional differences such as superior screening, diagnosing, and reporting of health outcomes, as described above. Using more than one comparison area is often recommended as a way to improve the researchers' ability to interpret the results of comparative analyses.

Local comparison area results

The results for these additional analyses are shown in the Appendix Tables. The Appendix Tables are ordered and numbered in the same sequence as the previous tables, for ease of comparison.

Birth outcomes: Review of the birth outcomes tables in the report and appendix (Report Tables 2a, 2b, 2c; 3a, and 3b; compared to Appendix Tables 2a, 2b, 2c; 3a, 3b) shows that the expected numbers of outcomes are higher in the local comparison area. As a result, most of the birth outcome categories that were that were statistically significantly elevated in the previous analyses (preterm and moderately preterm in the entire study area; low birth weight and preterm in the Sheridan Park area; total birth defects, surveillance birth defects, and total cardiac defects in the entire study area; major cardiac defects in Brookside Terrace; and total defects and total cardiac defects in Riverside) are no longer statistically significantly elevated in analyses using the local comparison area. For these outcomes, the rate ratios remain slightly, but not statistically significantly, elevated. The only birth outcomes that continue to be statistically significantly elevated are total birth defects, surveillance defects, and total cardiac defects in Sheridan Park.

Cancer: In the high impact area, the previous cancer results included a statistically significant elevation of larynx/pharyngeal cancer among males (data not shown). Using the local comparison area reduced this elevation slightly and it became non-statistically significant (SIR 4.66, CI: 0.96-13.6). For the moderate impact area and sub-areas, Appendix Tables 4b, 4c, and 4d show that using the local comparison area resulted in some reductions in the cancer elevations that were statistically significantly elevated in the prior analyses. However, most of the elevations remain statistically significant, and the elevations that are no longer statistically significant are at the borderline of statistical significance.

Discussion of local comparison area results

The use of the local comparison area produced more changes in the results of the birth outcome analyses than for the cancer analyses. All the elevations for birth outcomes were reduced in magnitude and almost all of the elevations for birth outcomes became non-significant in the analyses using the local comparison area. However, it is important to note that all the rate ratios that had been significantly elevated using the NYS excluding NYC comparison area remained elevated in the analyses that used the Erie and Niagara county comparison area.

Taken as a whole, using either comparison area, the birth outcome analyses showed some elevations in the larger categories of outcomes, but not in the more severe subsets of the outcomes. For example, we saw elevations in preterm and the subset, moderately preterm births, but we saw no elevation of very preterm births. We saw elevations in total reportable birth defects as well as the subsets, surveillance birth defects and total cardiac defects in the entire study area. But we observed no elevation of major cardiac defects, the defects with medical consequences, in the entire study area. There was an elevation of major cardiac defects, in one sub-area, Brookside Terrace, using the statewide comparison area, and this elevation became non-statistically significantly elevated, using the local comparison area.

For the cancer analyses, the use of the local comparison area slightly increased the numbers of cancers expected and thereby slightly reduced the observed elevations, for many types of cancer. In the moderate impact area, lung cancer and bladder cancer were no longer statistically significantly elevated among males, but they remained statistically significantly elevated among females, using the local comparison area. In the Sheridan Park sub-area, lung cancer remained elevated for males and for females. Bladder cancer was no longer statistically significantly elevated among males in Sheridan Park, but it remained elevated for females. The leukemia elevation among females in Sheridan Park became non-statistically significant, but it was at the borderline of significance (SIR 1.85, CI: 0.99-3.17).

The statistically significant cancer elevations produced by analyses using the statewide comparison area all remained elevated, even if not statistically significant, in the analyses using the local comparison area. In addition, for both the cancer and birth outcome analyses, it is important to note that some widening of the confidence intervals, and a tendency towards losing statistical significance, would be due to using the local comparison area which

contributed fewer cases to the analyses than the statewide comparison area.

Study limitations

There are several limitations associated with this type of health outcomes review. A health outcomes review cannot take into account important personal information that may be related to health outcomes, such as medical history, dietary and lifestyle choices, and occupational exposures. In addition, we lacked information about actual individual-level exposures or specific air quality information for specific addresses. We worked with NYS DEC to use the detailed air quality monitoring data from 2007-2008 to develop boundaries for a high exposure area and moderate exposure area. We do not know how different the exposures, and the appropriate potential exposure areas, would have been in earlier years.

We also do not know if particular people moved out of or recently moved into the study area. The locations of the birth outcomes are assigned as the mother's residence at time of birth and the locations of cancer outcomes are determined by residence at time of diagnosis only. Mothers who may have moved into the study area just before their child's birth were included in the review although most of the pregnancy occurred outside of the study area. Most cancers begin to develop long before they are diagnosed (latency) and this review could not take into account how long each person lived in the study area before being diagnosed with cancer. Residential mobility is less of an issue for the birth outcomes because the nine month period before birth is much shorter than the latency period for cancer, from 5 to 40 years, between the potential first exposure or biological change that leads to cancer and diagnosis of the cancer.

There are also limitations associated with the statistical tests. For very small areas, it is unlikely that any statistically significant findings will be observed, because the numbers of outcomes are too small. On the other hand, for outcomes with sufficient numbers of cases, it is possible to observe statistically significant findings that are truly just due to chance. In an investigation such as this one, with many statistical tests, some significant results are expected to occur just by chance.

Regarding the numbers needed for statistical tests to be meaningful, the probability of observing a statistically significant doubling of incidence, if it truly exists, is about 80% when the expected number of outcomes is 12 or more. Using this benchmark, in the total study area and the moderate exposure sub-areas combined, there was sufficient statistical power to detect a doubling of most of the birth weight and prematurity outcomes, but not for specific types of birth defects. In the moderate exposure area, there was sufficient power to detect a doubling of incidence for all types of cancer among males and females combined, and for almost all types among males and females separately. However, the area selected as having the highest potential exposures had a very small population, and this severely limited our ability to analyze and draw any conclusions from the data for this exposure area.

A limitation of this type of review specific to the cancer incidence analyses is that accurate estimates of the population of small areas by sex, age, and race/ethnicity categories are

required in order to accurately estimate expected numbers for all the types of cancer reviewed. Rates for each type of cancer vary by sex and age, and some also vary by race and/or ethnicity. We drew study area boundaries that were smaller than whole census tracts or ZIP codes in order to capture the two exposure areas, but these irregular boundaries create a challenge for estimating race or ethnicity-specific population numbers. Primarily for that reason, we did not attempt to control for race in this review. As described in the discussion section and in Appendix C, there are some differences in risks for lung, bladder, uterine and other types of cancer for white versus non-white populations.

While this review showed excesses for some of the birth and cancer outcomes, this type of review does not allow conclusions to be made about whether any particular health outcome was or was not caused by ambient air exposures or living in the Tonawanda study area. It is also important to emphasize that the evidence from air sampling and modeling pointed to one high impact area and one moderate impact exposure area. The four sub-areas of the moderate impact area were developed in response to community input for the health outcome study. In these four areas, different exposures to hazardous air pollutants could be expected to occur under various meteorological conditions, but all four areas are included in the moderate impact area as defined by the Tonawanda Community Air Quality Study. Please see the NYS DEC study (http://www.dec.ny.gov/chemical/59464.html) for additional detail about these issues.

CONCLUSIONS

The analyses conducted for this investigation suggest that some adverse birth outcomes may be elevated in the study area or in one or more sub-areas. However, the absence of strong elevations of the more severe outcomes suggests the elevations may be accounted for, at least in part, by more thorough screening, diagnosis, and reporting of the less severe birth outcomes in this area. The results from analyses that used Erie and Niagara Counties as the comparison area are consistent with other evidence suggesting there is more comprehensive diagnosis and reporting of adverse birth outcomes in this region of NYS.

The birth outcome analyses adjusted for factors such as race, prenatal care, and mother's education, so the differences observed between the analyses using the statewide versus the local comparison area are likely due to regional factors. Such factors likely include improved reporting, but also may include smoking rates, occupational exposures, and other environmental exposures.

Statistically significant elevations of lung cancer, bladder cancer, and total cancers were observed among both males and females; esophageal cancer was elevated among males, and uterine cancer was elevated among females. Two additional types of cancer were elevated, each in just one sub-area: oral cavity/pharynx cancer among males in the high impact area, and leukemia among females in the Sheridan Park area. Almost all of the cancer types showing elevations are types that are associated with tobacco use, but this type of study is not able to evaluate what role smoking may have played in the elevations.

Although the kinds of chemical compounds that were detected in the air in the Tonawanda exposure area have been associated with some of these types of cancer (leukemia and pharynx) in other studies, there are many other factors that may also contribute to the development of cancer. In addition to smoking, these factors include family history and occupational exposures, as well as others. We do not know the individual medical and exposure histories for the people diagnosed with cancer.

This type of study cannot determine whether there is a causal link between possible past exposures from living in the Tonawanda study area and the excesses of cancer shown in this review. In this type of review, conclusions about the cancer excesses are limited due to the lack of information about potential individual exposure histories and individual cancer risk factors such as smoking and occupation.

NEXT STEPS

NYS DOH released a public comment version of this report on February 11, 2013 and hosted a public meeting on the report on February 26, 2013. We solicited comments on the draft report to provide an opportunity for public review of the investigation's methods and findings as well as to better understand ongoing community concerns and questions.

We received written and verbal comments during the public meeting and additional written comments during the comment period, through March 31, 2013. This final version of the report includes a **Summary of Public Comments and Responses** (Appendix E). Based on the volume of comments made during and after the meeting, NYS DOH is planning to return to the community to share this Summary and Final Report.

In response to many questions and concerns about whether people should continue to live in the study area, questions that communicated great concerns about cancer risks in particular, the responses to public comments include additional information about what the elevations of risk for some types of cancer in the study area suggest regarding a person's lifetime cancer risk. Comparative information is provided to put the investigation's findings of increased risk for some types of cancer into clearer perspective for residents. (Appendix E, question 19)

Recommendation: Based on many questions and comments expressing ongoing concerns about past and current exposures in the study area, NYS DOH is recommending that a plan be developed jointly with the community to plan and carry out a biomonitoring study among residents of the study area. NYS DOH's Center for Environmental Health and Wadsworth Center Laboratories have expertise in biomonitoring, defined as the measurement of contaminants present in the human body, by sampling blood, urine or other methods. We recommend developing the biomonitoring plan in collaboration with the community so that various options are thoroughly explored and a biomonitoring project is developed that is supported by the community and useful for residents.

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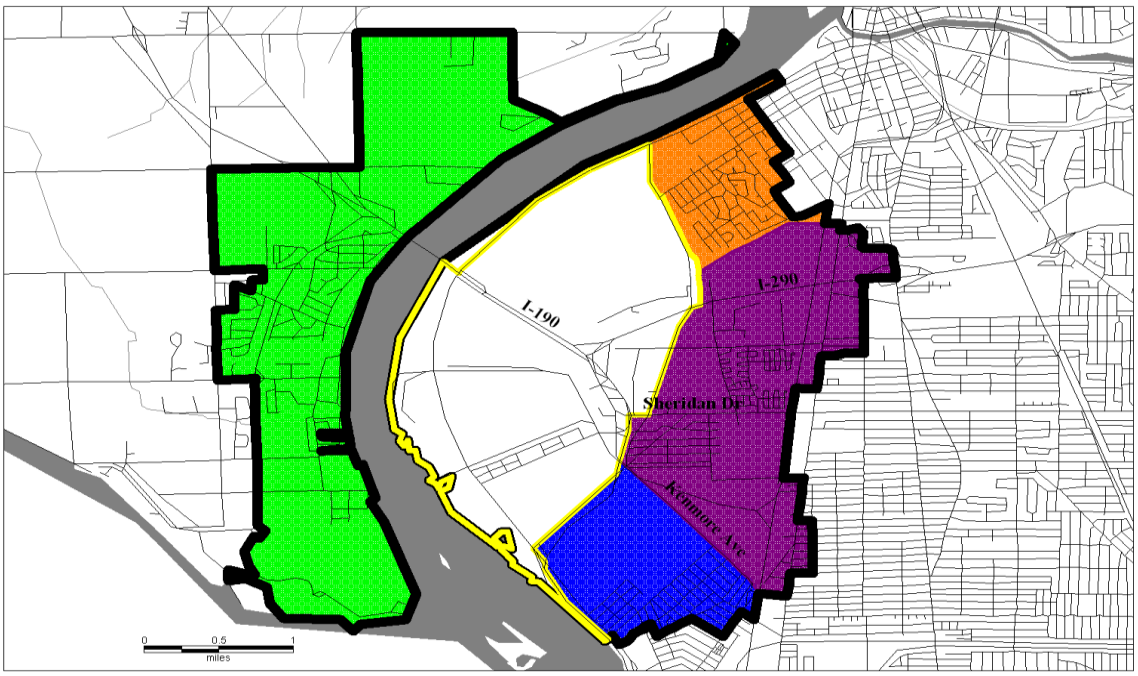
(See the report appendices for additional technical details and references.)

Figure 1

Tonawanda Health Outcomes Review Study Areas



High Potential Impact Area

Moderate Potential Impact Area

Brookside Terrace Area

Sheridan Park Area

Riverside Area

Grand Island Area

Appendix A. Birth defect groups evaluated in the Tonawanda study area

Birth Defect Group	ICD-9 Code*	Description	Additional Description
Total Reportable Defects	--	All major structural defects, chromosomal anomalies and metabolic syndromes	All defects reported to the NYS CMR**
Surveillance Defects	See Appendix B.	A subset of total birth defects thought to be consistently and reliably reported to the CMR	
Total Cardiac Defects	745.0-747.9	All cardiac defects *excluding* patent ductus arteriosus (747.0) in children weighing less than 2500g at birth	All heart defects
Major Cardiac Defects	745.0	Common truncus	Major heart defects
	745.1	Transposition of great vessels	There is a complex sequence
	745.2	Tetralogy of Fallot	of events that result in a well
	746.0	Anomalies of pulmonary valve	formed heart at birth and
	746.1	Tricuspid atresia and stenosis	disruption of any portion may
	746.3	Congenital stenosis of aortic arch	result in a defect.
	746.4	Congenital insufficiency of aortic valve	
	746.7	Hypoplastic left heart syndrome	
	747.1	Coarctation of aorta	
	747.3	Anomalies of pulmonary artery	
Choanal Atresia	748.00	Choanal atresia	Defect of nasal airway
Cleft Lip / Cleft Palate	749.00-749.04	Cleft palate	The two plates of the skull that form the roof of the mouth are not completely joined.
	749.10-749.14	Cleft lip	Facial tissues are not completely joined, appearing as a gap or indentation of the top lip or between the lip and nose.
	749.20-749.25	Cleft palate with cleft lip	

Abbreviations: X = 0 through 9

* International Classification of Diseases, Ninth Revision.

** See the *New York State Department of Health Congenital Malformations Registry Handbook*, Version 5, 2006, for more information.

Appendix B. Surveillance birth defects used for analysis.*

Birth Defect	ICD-9	Birth Defect	ICD-9
Amniotic bands	658.8	Atresia and stenosis of rectum or anus	751.2
Anencephalus	740.X	Hirschsprung's disease	751.3
Spina bifida with/without hydrocephalus	741.0X/741.9X	Biliary atresia	751.61
Encephalocele	742.0	Hypospadias/epispadias	752.6 or 752.61 & 752.62
Reduction deformities of brain	742.2	Indeterminate sex	752.7
Congenital hydrocephalus (=>2500g)	742.3	Renal agenesis and dysgenesis	753.0
Other spec anomalies spinal cord	742.5X	Cystic kidney disease	753.11-19
An/microphthalmus	743.0X/.1X	Obstructive defects renal pelvis and ureter	753.2, 753.4
Congenital cataract	743.3X	Exstrophy of urinary bladder	753.5
Coloboma of lens/iris	743.3X/.4X	Atresia/stenosis urethra and bladder neck	753.6
Spec anomalies of anterior chamber	743.44	Talipes equinovarus	754.51
Aniridia	743.45	Reduction deformities of upper limb	755.2X
Anomalies of ear causing impairment of hearing	744.0X	Reduction deformities of lower limb	755.3X
Common truncus	745.0	Other upper limb	755.53, .54, .55, .58
Transposition of great vessels	745.1X	Other lower limb	755.63, .67
Tetralogy of Fallot	745.2/746.09	Anomalies of skull and face bones	756.0
Common ventricle	745.3	Chondrodystrophy	756.4
Ventricular septal defect	745.4	Osteodystrophies	756.5X
Atrial septal defect – secundum type	745.5	Diaphragmatic hernia	756.6
Endocardial cushion defects	745.6X	Omphalocele, gastroschisis	756.7 or 756.79
Cor bilocurare	745.7	Ehler-Danlos syndrome	756.83

Appendix B continued on next page

Appendix B. (continued) Surveillance birth defects used for analysis.*

Birth defect	ICD-9	Birth defect	ICD-9
Atresia/stenosis of pulmonary valve	746.01/.02	Ichthyosis congenita	757.1
Insufficiency of pulmonary valve	746.09	Down syndrome	758.0
Tricuspid atresia/stenosis/hypoplasia	746.1	Patau syndrome	758.1
Ebstein's anomaly	746.2	Edwards syndrome	758.2
Congenital stenosis of aortic valve	746.3	Autosomal deletion	758.3
Hypoplastic left heart syndrome	746.7	Gonadal dysgenesis	758.6
Other spec obstructive anomalies	746.81-87	Klinefelter's syndrome	758.7
Patent ductus arteriosus (=>2500 g)	747.0	Situs inversus	759.3
Coarctation/interuption of aorta	747.10/.11	Conjoined twins	759.4
Atresia/stenosis of aorta	747.22	Tuberous sclerosis	759.5
Total/partial anomalous pulmonary venus connection	747.41/.42	Other hamartoses	759.6
Choanal atresia	748.0	Other syndromes	759.81, .82,.83,.89
Agenesis/hypoplasia, of lung	748.5	Fetal alcohol syndrome	760.71
Oral clefts	749.0X/.1X/.2X	Congenital rubella	771.0
Tracheoesophageal fistula, etc.	750.3	Congenital cytomegalovirus infection	771.1
Congenital hypertrophic pyloric stenosis	750.5	Other congenital infections	771.2
Atresia/stenosis of small intestine	751.1		

* Revised according to Holmes (1999)
X = 0 through 9

Reference: Holmes LB. 1999. Need for inclusion and exclusion criteria for the structural abnormalities recorded in children born from exposed pregnancies. Teratology. Jan;59(1):1-2.

Appendix C: Risk factors associated with the health outcomes examined in this report

Low birth weight: Cigarette smoking is the single largest risk factor for fetal growth restriction and low birth weight in non-premature infants (Kramer, 1987). Studies have also found a persistent association between low birth weight and measures of socioeconomic status, including occupation, income, and education (Hughes and Simpson, 1995). Poverty can be associated with reduced access to health care, poor nutrition, and an increased risk of behavioral risk factors such as smoking. Poor nutritional status of the mother at conception and inadequate nutritional intake during pregnancy can result in term low birth weight births (Kramer, 1987). Although mother's education is not a direct measure of socioeconomic status, birth certificates contain information about mother's education that is often used as an indicator for a variety of low socio-economic status risk factors.

Small for gestational age: There are various reasons that babies might be born underweight for their gestational age (small for gestational age), including restricted fetal growth during pregnancy or smaller than average size parents. Small for gestational age babies can have low birth weight because something slowed or halted their growth in the uterus (Robinson et al., 2000). Small for gestational age births are an important health outcome because babies who are small for gestational age are more likely to have health problems as newborns and children.

Maternal cigarette smoking is a major risk factor for having a small for gestational age baby. In fact, a 2004 report from the Surgeon General indicates that there is sufficient evidence to infer a cause and effect relationship between maternal smoking and fetal growth restriction and low birth weight (USDHHS, 2004). When expectant mothers have poor nutrition, smoke, or use alcohol or illegal drugs, their babies have an increased chance of being small for gestational age (Resnick, 2002).

Other factors also influence the risk of having a small for gestational age baby. If a baby has birth defects, is a twin or triplet, has fetal infections or has an abnormality of the placenta, the baby's chances of being small for gestational age may increase. Maternal diseases or medical conditions that reduce the blood flow to the fetus may account for 25 – 30 percent of small for gestational age births (Resnick, 2002). Health care provider visits before becoming pregnant and during pregnancy are helpful for identifying and controlling these medical conditions (NYS DOH, 2006a). Prenatal care is also essential for determining whether a baby is growing normally. In some cases, fetal growth can be improved by treating any medical condition in the mother (such as high blood pressure) that may be a contributing factor (March of Dimes, 2005).

Preterm birth: Preterm birth babies are born before 37 weeks gestation. Preterm birth is an important health outcome because it causes the greatest risk for infant mortality (death before one year of age). Unfortunately, little is known about the specific causes of preterm birth. Significant differences exist among groups, with African-American women having a greater risk than white women for preterm delivery, even in studies that control for socio-economic differences. Visits to a healthcare provider before pregnancy and seeking early and regular prenatal care may help reduce the risk of delivering a baby preterm (March of Dimes, 2004).

Birth defects: While scientists have been able to identify some causes of specific birth defects, the cause of most birth defects is unknown. In fact, about 40 – 60 percent of birth defects are of unknown origin (Kalter and Walkany, 1983). Genetic and environmental factors can cause birth defects. Twenty percent of birth defects may be due to a combination of heredity and other factors, eight percent to single gene mutations, six percent to chromosomal abnormalities, and five percent to maternal illnesses, such as diabetes, infections, or anticonvulsant drugs (Kalter and Walkany, 1983; Nelson and Holmes, 1989). Radiation exposure and the use of certain drugs, such as thalidomide or Accutane, are associated with birth defects. Women who smoke, use alcohol or illegal drugs while pregnant have a higher risk of having a baby with a birth defect.

There are ways to reduce a baby's risk for birth defects and to ensure early treatment if a birth defect is found. Pre-pregnancy visits with health care providers may identify genetic or other maternal health conditions which can be treated. A woman's daily use of a multivitamin with 400 micrograms of the B vitamin, folic acid, before and during pregnancy, also helps prevent some types of birth defects (Eichholzer et al., 2006). Women are advised to talk to their health care providers about any medications they take and refrain from smoking, drinking alcohol, or taking illegal drugs while trying to become pregnant or during pregnancy (NYS DOH, 2006a). Despite all of these efforts, birth defects may still occur. To improve health outcomes, certain medical screenings during pregnancy may assist early identification of any birth defects and lead to early infant treatment.

No consistent pattern has been observed for associations between race, ethnicity, or socioeconomic status, and the risk of birth defects as a group or for heart defects specifically. A case-control study by Carmichael et al. (2003) found an increased risk of transposition of the great arteries associated with low socioeconomic status (SES), but a reduced risk of tetralogy of Fallot associated with low SES. However, the number of infants in each group was small and none of the results were statistically significant. Several studies have found no association between SES and all heart defects combined (Botto et al., 1996; Correa-Villasenor et al., 1991; Heinonen, 1976). While a large British study reported a positive association between all heart defects combined and lower socioeconomic deprivation scores, the association was not statistically significant (Vrijheid et al., 2000). The same study did report a significant association between defects of the cardiac septa and lower socioeconomic deprivation; however, other cardiac defects examined were not significantly elevated. The Baltimore Washington Infant Study, one of the largest birth defects studies in this country, found that the relationship between SES and heart defects varied by type of defect examined (Ferencz et al., 1997; Correa-Villasenor et al., 1991).

Cancer: A review of cancer risk factors for all types of cancer is beyond the scope of this report because cancer is not a single disease, but more than 100 different diseases. Cancer is characterized by the abnormal growth of cells in the body. Cancer types are usually labeled based on the type of cell that has grown abnormally to form a tumor. A tumor is malignant, or cancerous, if it is able to spread to other tissues or organs in the body.

Generally, each type of cancer has its own spectrum of risk factors, symptoms, outlook for cure, and methods of treatment. A family history of cancer is a strong risk factor. There are some known carcinogens that increase risk for more than one type of cancer, such as X-rays and tobacco. Other carcinogens include sunlight and certain chemicals that may be found in the air, water, food, drugs, and workplace. Personal habits, lifestyle, and diet may contribute to many cancers. It is estimated that about 30 percent of cancer deaths are due to tobacco. Most types of cancer develop slowly in people. They may appear from 5 to 40 years after exposure to a carcinogen. For example, cancer of the lung may not occur until 30 years after a person starts smoking. This long latency period is one of the reasons it is difficult to determine what causes cancer in humans (NYS DOH 2006b). For more information about the cancers described below, see http://www.health.ny.gov/statistics/cancer/registry/abouts/. The information provided below is taken from the fact sheets on this website.

Lung and bronchus cancer

Lung cancer is one of the most common cancers among New Yorkers. Lung cancer is known to be caused by smoking. Choosing not to smoke, or stopping smoking, will make it much less likely a person will get lung cancer. More men than women get lung cancer because more men than women smoke. But since women started smoking in larger numbers, more women are getting lung cancer. Among men, lung cancer rates are higher among white and black men, compared to men who are Asian, Pacific Islander or Hispanic. Non-Hispanic white women have higher lung cancer rates than other racial or ethnic groups.

While smoking is the most common cause of lung cancer and one that is under our control, research studies show that exposure to other peoples' cigarettes (second-hand smoke), exposure to radon gas, and exposure to asbestos also increase the risk for lung cancer. Other studies show that lung cancer is associated with working with certain chemicals, such as arsenic and chromium. Studies also show a possibility that exposure to silica, substances in foundries, processing coal, and some other chemicals may increase the risk of lung cancer, especially among smokers. An association has also been shown between having a medical history of some lung diseases and getting lung cancer. Diets low in fruits and vegetables might increase the risk of lung cancer among people who smoke. Air pollution may also increase lung cancer risk slightly, but much less than smoking.

Bladder cancer

Bladder cancer is the fourth most common cancer among men and the ninth most common cancer among women in the United States. It is estimated that one in 25 men and one in 85 women will develop bladder cancer sometime during their life. In recent years, the incidence of bladder cancer has leveled off and mortality from the disease is decreasing slightly. Improvements in care have led to better survival for people with bladder cancer.

Cancer of the bladder is more common in older people. More than 70% of people newly diagnosed with bladder cancer in New York State are age 65 and over. Bladder cancer is more common among men than among women. It also occurs more frequently in whites than in blacks. Reoccurrence of bladder cancer is also common. As a result, the prevalence of bladder

cancer is high.

At this time, we do not know exactly what causes cancer of the bladder. We do know that smoking is the greatest risk factor for getting bladder cancer. People who smoke have more than twice the risk of getting bladder cancer than non-smokers. Researchers believe that smoking is responsible for between 30% and 50% of bladder cancers. Occupation is the second greatest risk factor for bladder cancer. Studies show that workers in the dye, rubber, textile, leather or chemical industries have a higher risk of getting bladder cancer. It is believed that 20% of bladder cancers are associated with exposures in the workplace.

Uterine cancer

In New York State, cancer of the uterus is the fourth most common cancer among women. Cancer of the uterus is rare before age 45. The incidence of uterine cancer rises sharply between the ages of 45 and 65. Uterine cancer also occurs more frequently among white women than African-American women. During the 1970s, there was a peak in the incidence of uterine cancer. This peak may be linked to the use of high dose hormone replacement therapy without progesterone by women experiencing menopause.

At this time, scientists do not know exactly what causes cancer of the uterus. We do know that certain personal characteristics increase a woman's chances of developing uterine cancer. Cancer of the uterus has some of the same risk factors as breast cancer. These include never having given birth, having few children, and late age at menopause. Other factors that may be associated with increased uterine cancer risk include obesity, use of hormone replacement therapy without progesterone, and possibly a diet high in fat.

Leukemia

Leukemia is cancer of the blood cells. When someone has leukemia, the body makes large numbers of abnormal blood cells. In most types of leukemia, the abnormal cells are white blood cells. Leukemia cells look different from normal blood cells and do not work as they should.

The most common types of leukemia are:

- acute lymphocytic leukemia (ALL) – the most common type of leukemia in children. It also affects adults, especially those age 65 and older.
- acute myeloid leukemia (AML) – this disease occurs in both adults and children and is sometimes called acute non-lymphocytic leukemia.
- chronic lymphoid leukemia (CLL) – this disease most commonly affects adults over age 55 and rarely occurs in children.
- chronic myeloid leukemia (CML) – this disease occurs mainly in adults, but a small number of children also get this form of leukemia.

Although it is often thought of as a children's disease, most cases of leukemia occur in older adults. Leukemia is ten times more common in adults than in children and more than half of all leukemia cases occur in people over the age of 65.

At this time, we do not know exactly what causes most leukemias. People with Down syndrome and certain other genetic abnormalities get leukemia more frequently. Certain unusual forms of leukemia are caused by a rare virus. Long-term workplace exposure to benzene and exposure to high doses of ionizing radiation (such as atomic bombs) have been associated with the development of leukemia. People treated with certain anti-cancer drugs or radiation treatment are at greater risk of getting leukemia. Researchers believe that up to 20% of acute myeloid leukemias (AMLs) are caused by smoking

Oral cavity/pharynx

The oral cavity is made up of the mouth, pharynx and salivary glands. Almost four percent of cancers occur in the oral cavity. The tongue, floor of the mouth, gums, lip, tonsil and lower pharynx are where most oral cavity cancers occur. Cancer of the salivary glands is relatively rare. However, when it does occur, it most frequently starts in the parotid gland. Cancer of the oral cavity is two to three times more common among males than females. Black men are more likely to get oral cavity cancer than white men, and are almost twice as likely to die from the disease.

The most common risk factors for getting cancer of the oral cavity are tobacco use (both cigarette smoking and smokeless/chewing tobacco) and drinking alcoholic beverages in excess. Each of these activities increases a person's risk for developing cancer of the oral cavity. In combination, tobacco and excess alcohol use significantly increase the risk for getting oral cavity cancer. It is estimated that as much as 75% of all oral cavity cancers may be due to these two risk factors. Certain parts of the oral cavity also have their own risk factors. For example, cancer of the lip is associated with outdoor occupations, such as farming and fishing. This may be due to excess exposure to sunlight. Cancer of the salivary gland has been associated with exposure to ionizing radiation (X rays). It also is associated with working as a farmer or in the rubber-making industry.

Esophagus

Adenocarcinoma, usually found in the lower part of the esophagus, is the most common type of esophageal cancer and its incidence in NYS has been increasing since the 1980's. Squamous cell carcinoma, usually found in the upper part of the esophagus, accounts for less than half of all cancers of the esophagus.

Most people are over age 65 when diagnosed with esophageal cancer, and men are three to four times more likely to get this cancer than women. In New York State, esophageal cancer occurs more frequently among whites and blacks than among Asians. Tobacco and alcohol use raise the risk of this cancer. Combining smoking and drinking alcohol raises the risk of esophageal cancer much more than using either alone. Having acid reflux, and especially the presence of Barrett's esophagus, which results from acid reflux, increase the risk of adenocarcinoma of the esophagus. Being obese also increases the risk of adenocarcinoma of the esophagus.

Chemical exposures in certain workplaces may lead to an increased risk of esophageal cancer.

Studies show that workers in the rubber, automobile, cement, plastics, dye and dry cleaning industries have a higher risk of getting this cancer. Specific exposures tentatively linked to esophageal cancer include metal dust, asbestosis, silica dust, combustion products, organic solvents (particularly perchloroethylene [PERC] in dry cleaning industries), and polycyclic aromatic hydrocarbons (PAHs), by-products of incomplete combustion.

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Appendix D. Health outcome data acquisition, evaluation and analysis

Birth outcomes:
NYS DOH used birth certificate data for 1990-2009 (20 years) to determine if the study area had an unusual number or pattern of adverse birth outcomes. Only singleton births (one baby) were included in this study because multiple births (e.g., twins, triplets) have a much higher risk of some adverse birth outcomes. The birth certificate data include the infant's birth weight, gestational age, and gender. In addition, information is available on the mother's age, race, ethnicity, years of education, the number of previous births (parity), and the week of pregnancy when she had her first prenatal visit.

Birth outcomes are divided into three groups: birth weight, prematurity, and growth restriction. The birth weight outcomes are: low birth weight (LBW) (<2500 g), moderately LBW (≥1500g and <2500g), and very LBW (<1500g). Birth records with missing birth weight or birth weight outside a reasonable range (<100g or >8000g) were excluded from the analysis. The prematurity outcomes are: pre-term births (<37 weeks gestation), moderately pre-term births (≥32 and <37 weeks gestation), and very pre-term births (<32 weeks gestation). Birth records missing gestational age or with gestational ages outside the reasonable range (<20 weeks or >44 weeks) were excluded from the analysis. Two measures of growth restriction were studied: small for gestational age (SGA) births and term LBW. SGA is defined as a birth weight below the 10th percentile of the NYS (excluding NYC) birth weight distribution of singleton births by gestational week, gender, and five-year time period (Alexander et al., 1996). Term LBW was defined as $\geq$ 37 weeks gestation and birth weights < 2500 g.

Birth records for the comparison areas were used to calculate expected number of births with each type of birth outcome. Using all singleton births during the study period, statewide annual age-group rates for each outcome were calculated. Nine maternal age groups were used: 10-14, 15-17, 18-19, 20-24, 25-29, 30-34, 35-39, 40-44 and 45 and older. The annual expected number of births with the birth outcome is the annual statewide age-specific rate multiplied by the number of singleton births in the study area for that age group and year. The annual expected numbers are then summed across age groups and study years to get the total expected number. Observed and expected numbers for each birth outcome are presented. When the observed number is greater (or less) than the expected number, this is called an excess (or deficit). This process adjusts for differences due to the distribution of age and year of birth in the study area and the comparison population.

Several outcomes being studied, including LBW and pre-term birth, have been linked to lower socioeconomic status. The study area is somewhat different from the comparison areas in measures of socioeconomic status, race, and ethnicity. Therefore, the analyses used information about the mother and the pregnancy to take some of these differences into account. We do not have any direct measure of socioeconomic status however. Poisson regression analysis was used to analyze the risk of each birth outcome with respect to the potential exposure. Mothers living inside the study area boundary are considered exposed. The following information from the birth certificate was included in the models as potential

confounders: baby's gender and year of birth, mother's age (less than 19, 19-34, 35+ years), education (less than high school, high school to some college, 4+ years college), race (white, non-white), number of previous live births (0, 1, 2, 3+), and prenatal care. The modified Kessner Index, which combines the month the mother first got prenatal care and the number of prenatal visits she had, was used to classify her prenatal care into one of three categories: adequate, intermediate, and inadequate (Kessner et al., 1973). For each outcome, we present the rate ratio (RR) and its 95% confidence interval (95% CI) for exposure status. A RR above (or below) 1.0 with a 95% CI that does not include 1.0 is considered a statistically significant excess (or deficit).

Birth defects:

Records of birth defects diagnosed through 2008 for singleton births occurring during 1990-2006 were obtained from the NYS DOH Congenital Malformations Registry (CMR). Using this information, we identified specific infants with birth defects diagnosed during the 19-year period. The expected number of total birth defects reportable to the NYS CMR for the same timeframe for the comparison area was calculated and compared to the total number of birth defects observed. The pattern of types of birth defects was also reviewed to look for unusual patterns in the number and types of defects, with specific attention to the defects associated in the literature with VOC exposures. These defects include cardiac defects, cleft lip and cleft palate, and choanal atresia (a defect of the nasal airway). Some of the specific diagnoses included in the "total reportable defects" category have changed slightly over time, but this grouping is primarily made up of the structural birth defects, ICD-9 Codes 740-759 (See NYS DOH 2006 and Appendix A).

Cancer:

Cancer incidence was evaluated for 18 individual cancers in females and 16 in males and all cancers combined for the entire time period 1990-2008. Cancer incidence was evaluated for females and males separately and for both sexes combined. To compute the expected numbers of cancer cases, age- and sex-specific rates of individual cancers were calculated based on rates of cancer in the comparison area obtained from the NYS Cancer Registry and population counts by sex in nine age groups (0-14, 15-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84 and 85+ years) for that same area and timeframe provided by the National Cancer Institute. Gender- and age-adjusted SIRs were calculated by dividing the observed number of cancer cases by the expected number of cancer cases. An SIR greater than 1.0 (or SIR less than 1.0) with a 95% CI that does not include 1.0 is considered a statistically significant excess (or deficit).

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APPENDIX E. Summary of Public Comments and Responses

This summary was prepared to address comments and questions on the public comment draft of the Tonawanda Study Area Health Outcomes Review. The public was invited to review the draft during the public comment period which ran from February 11 through March 31, 2013. We solicited comments on the draft report to provide an opportunity for public review of the investigation's methods and findings as well as to better understand ongoing community concerns and questions. We received written and verbal comments during the NYS DOH public meeting on February 26, 2013 and additional written comments from individuals during the remainder of the comment period.

In the following summary of comments, we provide written responses to comments and questions about the health outcomes review. Some of the comments expressing similar concerns or questions were grouped together in the summary.

If you have any questions about this responsiveness summary, please contact James Bowers of NYS DOH at 518-402-7950.

A. Comments About Methods

1. **Comment: Who was included in the study? Are people who work but don't live in the study area included? What about illnesses diagnosed before or after the study time period?**

Only those health outcomes that were diagnosed among residents of the study area during the years covered by the study were included in the analysis. Available data provide residential address at diagnosis, so individuals who were diagnosed after moving out of the study area are not included, despite the possibility of exposure to site-related contaminants. Similarly, individuals who were diagnosed after recently moving into the study area were included, despite the decreased likelihood of exposure to site-related contaminants. Individuals who didn't live in the study area were not included in the analysis.

2. **Comment: What streets were in the study area? How were the study areas selected?**

The study areas were developed after cooperation between NYS DOH and NYS DEC with input and approval from community members. Additional information about the study area boundaries is available on page 5. The map of the study area is available on page 18 of the report.

3. **Comment: Why is New York City excluded from the comparison population? Why were Erie and Niagara Counties used as another comparison population? Was the study area population subtracted from the Erie and Niagara County comparison population?**

The population of the five boroughs of New York City is routinely excluded from the comparison populations in these kinds of studies because of the large differences (race and ethnicity differences, for example) between the populations of those areas and the rest of the state.

Among the community's initial comments on the study design was a request for a separate local comparison area. The population of Erie and Niagara Counties was used as that comparison. In addition, the report explains, on p. 12, that a local comparison area may be more appropriate to use than the upstate comparison area because superior screening and diagnostic practices in some areas result in more complete diagnosing and reporting of cancers and other conditions. Using a local comparison area also may assist with controlling for cultural or regional characteristics or behaviors, such as smoking rates, that affect disease rates.

Regarding subtraction of the study area population from the comparison area population, the answer differs for the two sets of health outcomes. For the birth outcomes analyses, the individual-level analyses (Poisson regression) compared the study area births to the rest of the upstate comparison births or the local comparison area births in an exclusive way; i.e., the study area births were not also present in the comparison birth data. For cancer, however, the upstate comparison expected numbers and county comparison expected numbers do include the study area cancers among the data used for the estimation. Because the study area population is very small compared to the comparison area populations, this should not have a substantive effect on the cancer incidence results. If there were an effect on the findings, it would bias the findings towards the "null," meaning it would bias the findings slightly towards finding no elevation or deficits in the study area. The approach of estimating expected numbers without subtracting the specific study area population is a standard approach, and is the approach used by the NYS DOH Cancer Surveillance Program as well as the NYS DOH Center for Environmental Health.

4. **Comment: When was this study conducted? Were all residents contacted and questioned?**

Work on this study began in 2010. At that time, public meetings were held to discuss the community's interest in a health outcomes review. Additionally in 2010, NYS DOH and NYS DEC worked together to identify areas of potential risk from hazardous air contaminant levels. Those areas of potential risk became the basis for the study areas.

No individuals were contacted or questioned directly in the course of conducting this study. This type of study uses health outcome information routinely collected by New York State and retrieved from the NYS Cancer Registry, Congenital Malformations Registry, and Vital Records. Additional information on the study process is available on page 30, Appendix D of the Report.

5. **Comment: What about other health outcomes like blood disorders, asthma and other respiratory illnesses, miscarriages, autoimmune disorders, and neurological problems?**

Statewide databases and health registries with comprehensive, complete, and accurate information do not exist for many other health outcomes, such as those listed in the comment, making these health outcomes difficult to study. We need complete and accurate disease incidence data to conduct studies of specific study areas and to be able to compare incidence in the study area to incidence in a comparison area.

6. **Comment: Please publish a map of all the cases included in the study.**

Patient confidentiality, including patient addresses, is protected by Federal and State laws and regulations. Access to information from the Cancer Registry, Congenital Malformations Registry, and Vital Records is strictly limited. Researchers with access to this information are held to rigorous confidentiality and ethics training requirements and use restrictions. To protect patient confidentiality, maps of cases cannot be published.

7. **How can the Clean Air Coalition of Western New York (CACWNY) obtain the health data used in this review?**

This review used several types of health data, which reside in different databases within the New York State Department of Health (NYSDOH). Different programs within the Department are responsible for oversight of the various databases. For the types of analyses conducted for this review, we used individual-level data which we cannot share because of laws and regulations regarding the protection of health information. There may be health data in aggregated form that would be of interest to CACWNY. The processes by which various programs review data requests and provide data continue to evolve, so these are the types of issues best addressed by following up with each program.

For more information about requesting cancer data, contact the New York State Cancer Registry at nyscr@health.state.ny.us. Most research studies involving cancer data must be reviewed by NYSDOH's Institutional Review Board. Birth and death certificate data are part of Vital Records within NYSDOH's Bureau of Biometrics and Health Statistics (BBHS) at bio-info@health.state.ny.us. Again, most types of research studies must be reviewed by the NYSDOH's Institutional Review Board. For more information about availability and to request numbers of birth defects in specific categories, contact the Congenital Malformations Registry (CMR) at beoe@health.state.ny.us. An additional resource for exploring the availability of health data for NYS is the Health Data NY website, https://health.data.ny.gov/.

8. **Comment: What about individual risk factors for cancer and birth outcomes? Can you address limitations to your study design?**

NYS DOH does not have routine access to information about family medical history, diet, lifestyle (including smoking habits), occupation, or many of the other factors that affect the health status of individuals and communities. This type of investigation using readily available data is unable to take most of those factors into account. For the adverse birth outcome analyses, many individual-level factors were taken into account. For the cancer analyses, we only included adjustments for age and sex.

Based on our reading of the series of comments related to individual risk factors and study design limitations, we believe these commenters are hoping that a follow-up study could gather enough additional information to draw stronger conclusions about whether exposures occurring in the study area caused the health outcomes in this study population. Unfortunately, even with perfect knowledge of individual risk factors, such as smoking history, this type of study would not be able to draw strong conclusions about the role played by local exposures to pollutants because we do not have individual-level information about such exposures. At best, such a study might be able to produce stronger evidence about whether residence in the study area versus other personal risk factors appears to be more strongly associated with risk for specific types of health outcomes.

9. **Comment: What is needed to be able to make a definitive statement of cause and effect?**

In the field of human epidemiology, it is extremely rare for one study alone to have findings that are generally accepted as proof of a cause and effect link. An example of such a single study is the 1971 report of multiple cases of an extremely rare type of cancer (vaginal cancer) in a group of young women whose mothers had been exposed to diethylstilbestrol during pregnancy (Herbst et al., 1971). On the other hand, the link between smoking and cancer required the conduct of many studies before a consensus was reached about the cause and effect link. Because of the lack of needed information, especially about exposures over a lifetime, the variability of human beings, and many other reasons, the accumulation of consistent findings from many studies, preferably using various methods, is needed to build a case for or against a cause and effect link.

Some of the things scientists look for as evidence of a cause and effect link between an exposure or risk factor and a health outcome are:

(1) a very strong increase in the health outcome of interest;
(2) similar findings by different scientists studying different populations;
(3) the lack of other likely explanations for the increase in the health problem;
(4) evidence that the causal factor or exposure happened before the health outcome;
(5) higher levels of exposures associated with higher levels of outcomes.

10. Comment: Some potential confounders such as smoking or low socioeconomic status can interact with each other and with air pollution. Low SES can be linked to higher smoking rates. Smoking can increase the health effects of air pollution.

The report notes that smoking is a known cause for many of the health outcomes included in this review. Cancer Registry data do not have sufficient information about smoking, so we were not able to control for smoking or evaluate interactions or combined effects with air pollution. For the adverse birth outcomes, the analyses were adjusted for some factors associated with socioeconomic status, including mother's education and the level of prenatal care.

11. Comment: Was the study done in an impartial manner? Is there Federal oversight of the study process? Were the study results shared with Federal & State Agencies, and elected officials?

This type of study is scientifically rigorous. We conduct this type of study with these same methods repeatedly, so many of the data management and programmatic steps are standardized. A variety of staff are involved in gathering the health outcome data from databases and routine procedures are used to analyze the data. Analyses are re-run by different staff to make sure the findings are correct. We believe this ensures analyses are done in an impartial manner. For this particular investigation, we looked especially closely at the leukemia findings because leukemia is associated with exposures to benzene. The NYS DEC Tonawanda Air Study had indicated that exposures to benzene were a concern in the study area.

There was no specific Federal oversight of this study. However, the U.S. Agency for Toxic Substances and Disease Registry was kept informed about the progress of the study and the study results were shared with elected officials and agency representatives at the Federal, State, and local levels. All NYS DOH employees involved in this type of study are required to maintain certification in the protection of human subjects.

12. Comment: Statistical significance is not the only criterion for the importance of a result. Results that are close to significant may still be important.

Yes, we agree. We do use statistical significance as a tool for interpreting findings, but we do not solely rely on statistical significance for interpretation. We look for patterns of elevations as well as statistically significant differences when drawing conclusions from results. In addition, when outcomes are rare, or the study population is very small, we report findings carefully so that the reader is aware that it is very difficult to draw conclusions from small numbers, especially when there is very little chance of producing statistically significant results.

B. Comments About Findings & Health Concerns

13. Comment: Were there trends over time in the cases?

The health outcomes evaluated in this report were analyzed both for the entire study period, as well as for shorter timeframes. No unusual patterns of clustering in time were identified for these shorter time periods.

14. Comment: Some specific health outcomes included in the report were not mentioned in your presentation.

Details about findings for specific health outcomes are available in the "Findings" section of the report. The presentation at the public meeting included a very brief summary of findings and emphasized the health outcomes with elevations, as these were the findings expected to be of most interest and concern to people attending the meeting. In addition, the presentation was planned to be very short to provide time for responding to questions and comments because the full report had been made available to the community approximately two weeks prior to the meeting.

Staff provided some additional information about findings during the discussion. For example, during the meeting, DOH staff pointed out that total cancers, as well as 18 separate types for women, and 16 types for men were reviewed, and that most of these specific types of cancer were not elevated in the study area. For leukemia, which is known to be associated with benzene exposures, there was no evidence of an elevation for the study area as a whole or any specific sub-area for males. For leukemia among females, there was no strong evidence of an elevation (no statistically significant excess) for the study area as a whole. In one of the sub-areas, there was a statistically significant elevation of leukemia among females; but in the other sub-areas, there were no statistically significant elevations of leukemia among females. In fact, in two of the sub-areas, there were fewer leukemia cases than expected, although these findings were not statistically significant.

Among the low birth weight outcomes, only total preterm births and the subset of moderately preterm births showed statistically significantly elevations in the study area as a whole. The low birth weight outcomes were not statistically significantly elevated in the study area as a whole, but the elevations were near the borderline of statistical significance. The outcome term low birth weight, which includes births that are not premature but that do have low birth weights, also showed a slight elevation that was near the borderline of statistical significance. However, the outcome small for gestational age, which takes account of gestational age and birth weight together, showed no elevation.

15. **Comment: The statement on page 15 that the 4 subareas "do not represent known or estimated differences in exposure concentration" is not true. DEC air monitors and wind directions indicate that exposure is greater in NE areas of study area compared to Grand Island.**

Based on the Aermod risk modeling of hazardous air pollutant concentrations and meteorological data by NYS DEC in 2010, the statement has been rewritten to read, "The four sub-areas of the moderate impact area were developed in response to community input for the health outcome study. In these four areas, different exposures to hazardous air pollutants could be expected to occur under various meteorological conditions, but all four areas are included in the moderate impact area as defined by the Tonawanda Community Air Quality Study." Please see the NYS DEC study (http://www.dec.ny.gov/chemical/59464.html) for additional detail about these issues.

16. **Comment: Are there plans for additional studies of the area?**

We received requests for several additional studies in the area including a review of health outcomes among residents during an earlier time period, evaluation of hospitalization data, a comprehensive area survey, and biomonitoring. We will work with the community to further discuss these options. We believe a biomonitoring study could be the most useful of these suggestions, and we have added a recommendation regarding biomonitoring to the report.

Regarding biomonitoring, in July 2009 we met with representatives of CACWNY to discuss the possibility of conducting a biomonitoring study. The concept of a biomonitoring study is that area residents would be tested for chemicals related to area industries. At that time, we did not have the resources necessary to conduct such a study. Since then, with the help of the NYS DOH Wadsworth Laboratory, we have been able to identify resources and some funding to do some sampling. We would like to work with the community to formulate plans and move forward with biomonitoring, if there is continued interest. If there is interest in a larger project than NYS DOH resources can support, we may need to seek additional funding. See the Recommendations section of the report, which has been revised to include this recommendation (p. 16).

17. **Comment: What was the purpose of the study? How will the results be used? Why do you conduct studies with limitations? Why do you do studies without a plan for afterwards?**

Our goal for this study was to determine if the residents of the study area were experiencing health outcomes at different rates from people in the rest of update New York as well as Erie and Niagara counties. While not making a cause and effect determination, the findings have been used to help answer some of the community's health concerns and provide information to drive discussions of possible future work. We presented this study's findings to the community

as the next step in the process of addressing community concerns. The public meeting's goal was to focus discussion on the study methods and findings. With the release of this final version of the report, we are adding recommendations for next steps, but the specific plan for next steps needs to be decided with input from and discussion with community members.

18. Comment: If the western part of the state shows higher levels of birth defects, is it possibly due to the outcomes being more frequent there, rather than better reported?

Yes, a higher level of birth defects compared to other areas of the state could reflect a higher rate of occurrence, rather than better reporting. Our study did not focus specifically on the levels of birth defects in the entire western part of the state, the subject of the comment. We stated that there may be better reporting of birth defects in some regions of the state, including the western part of the state, in the discussion sections on pages 9 and 12 of the report. We cited a published study that suggested some areas of the state may have more complete reporting of birth defects than other areas. Our interpretation of the birth defect findings noted the statistically significant elevations for the entire study area for **total** heart defects but not for **major** heart defects as support for the suggestion there may be better reporting of the minor birth defects that do not require medical attention. The major heart defect category did show a slight elevation but the elevation was not statistically significant (12 cases observed, versus 9.9 expected; Standardized Incidence Ratio of 1.18; Confidence Interval, 0.65-2.12 [See Table 3A). Our interpretation is that the lack of statistical significance for this small elevation of major defects suggests there may be no actual elevation of heart defects in the study area. We made some minor revisions to the Birth Outcomes Discussion section, on page 10 of the report, to clarify this point, since the lack of statistical significance is the basis for the interpretation.

The revised report states (additions are italicized):
"Regarding the total cardiac defects category, the majority of defects included in this general grouping are minor cardiac defects. These minor defects are unusual features that, in and of themselves, are not expected to cause health problems. The major defect category, which includes defects of medical significance, was not *statistically significantly* elevated for the entire study area *(SIR: 1.18; CI, 0.65-2.12)*. It was *statistically significantly* elevated, however, in one sub-area, the Brookside Terrace sub-area *(SIR: 2.82, CI; 1.06-7.52).* This statistically significant elevation is based on small numbers, with four cases observed compared to about two cases expected."

19. Is it safe to live here? Where can I move to be safe? Would you live here?

Recent air monitoring results from NYS DEC show substantial improvements in air quality compared to the findings reported by NYS DEC in 2009. The earlier monitoring results (2009) produced estimates showing increased lifetime cancer risk in the study area. These findings were used to guide the selection of the health outcome study boundaries.

In January 2013, NYS DEC provided updated information based on more recent air monitoring. (*January 2013 Update, Tonawanda Community Air Quality Study;* http://www.dec.ny.gov/chemical/88968.html). The information sheet and full data report describe the reduced ambient concentrations of benzene and other air pollutants in the area. The 2013 information sheet states that the recent benzene results at the residential monitor (Brookside Terrace Residential Site) produced an estimated excess annual lifetime cancer risk that is **below** that estimated in most urban locations in New York State.

Cancer is a concern for everyone, no matter where one lives. Nationally, and in NYS, one in two men and one in three women are diagnosed with some type of cancer in their lifetime. The health outcomes review can be used to estimate the increased risk of cancer for people in the study area. It may be useful to put this estimated increased cancer risk into the context of a "usual" risk for cancer. The actual risk of cancer for an individual depends on personal factors that are not taken into account in this investigation, such as family history and whether the person smokes. National data are available that estimate lifetime cancer risks (American Cancer Society, from federal SEER data, http://www.cancer.org/ cancer/cancerbasics/lifetime-probability-of-developing-or-dying-from-cancer).

The lifetime risk for U.S. males of developing any type of cancer over an entire lifetime is 45%, which is usually expressed by rounding it up to 50%, or one in two males. Simply put, one in two men will develop some type of cancer in their lifetime. Many cancers are curable, and there are competing causes of death, so the risk of dying from cancer among males is one in four, much smaller than the risk of developing cancer. For women, the risk of being diagnosed with any type of cancer over their lifetime is slightly less than for men, 38%, which is usually expressed as one in three women. The risk of dying from cancer, for females, is 19%, or one in five.

To get an idea of how the estimated increased cancer risk shown in this review for those living in the study area would affect a person's overall lifetime cancer risk, we can apply this current investigation's estimate of the increased risk for being diagnosed with any type of cancer while living in the study area (.10 or 10%, Table 4B) to national estimates of lifetime risk. (These lifetime estimates may be slightly different from estimates specific for the study area, but the national estimates are used here because they are readily available.) For all types of cancer for men, the 10% increased risk estimated for the Tonawanda study area means that the lifetime risk increases from about 45% to 49%, which continues to fall within the rounded estimate of 50%, or "one in two men."

For lung cancer among men, the current investigation's estimate of the increased risk for males in the study area of 24% results in an increase in the risk of developing lung cancer from 1 in 13 to 1 in 10. (The actual risk for an individual depends on whether the person smokes.) For bladder cancer among men, the current investigation's estimate of the increased risk for males in the study area of 24% (Table 4B) results in an increase in the risk of developing bladder cancer from 1 in 26 to 1 in 21 over a person's entire lifetime.

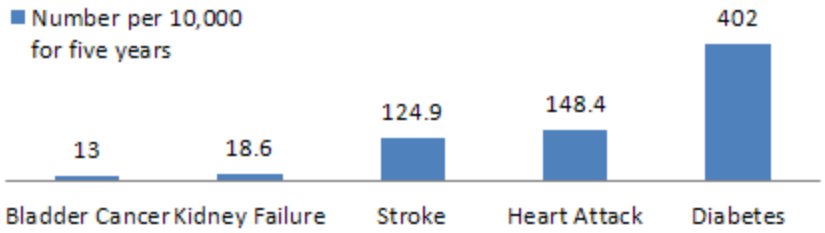
Similarly for females, for all types of cancer, the health outcomes review estimated an increased risk of 10% (Table 4B) for those living in the study area. This results in lifetime risk for all types of cancer increasing from 38% to 42%. This increase results in a rounded estimate that is now closer to the male estimate of one in two, rather than one in three.

For lung cancer among women, the current investigation's estimate of the increased risk for women living in the study area of 29% results in an increase in the risk of developing lung cancer from 1 in 16 to 1 in 12. For bladder cancer among women, the current investigation's estimate of the increased risk for females in the study area of 81% results in an increase in the risk of developing bladder cancer over an entire lifetime from 1 in 87 to 1 in 48.

These examples are provided to show how the estimated cancer elevations shown by the health outcomes review affect the estimated risks for particular types of cancer. If a particular type of cancer is rare in the general population, a relatively large increased risk, such as for bladder cancer among women (81% elevation in the health outcomes review) contributes to an increase in risk, but the risk may still be relatively low. The 81% elevation of bladder cancer estimated for women in the study area by the health outcomes review analysis does not mean that people in the study area have an 81% chance of getting that type of cancer. Rather, the risk increases by 81%, from about 1% to about 2%, expressed as 1 in 87 women in the general population versus 1 in 48 women in the study area.

These examples are not provided to downplay the estimated elevations in levels of cancer in the Tonawanda study area, but rather to add perspective on what the elevations mean for individuals in terms of their actual risks for various types of cancer or other outcomes over a lifetime. Some additional information for comparing risks for cancer with risks for other types of health outcomes in NYS is available on the NYS DOH Environmental Facilities and Cancer Mapping web application (https://apps.health.ny.gov/statistics/cancer/environmental_facilities/mapping/map/). This application shows areas in NYS where specific types of cancer show patterns of elevations, and compares the cancer rates to other disease rates, as in the graphic shown below. See the website for more information about the details of the data used for this comparison.

How common is Bladder cancer compared to other chronic diseases in New York State?



20. Should the government be helping people to relocate? Please advise residents about how to take precautions to live safer in the high impact areas. Could you identify safer neighborhoods? Could residents get incentives to move out of the High Impact Area?

As described in the report, the health outcomes review findings are not able to be used to conclude that living in the study area caused the observed cancer elevations. Smoking, for example, is a known risk factor for most of the health outcomes that show elevations in this review, so if more people are smokers in the study area than in the comparison area, this could have contributed to the elevations. In addition, as stated in the previous answer, air quality appears to be improving substantially in the study area. Recent data indicate that current ambient air quality in the residential areas may be similar to, or better than, other urban areas in NYS.

Due to the types of cancer elevations shown in the review, primarily smoking-related cancers, an important precaution for reducing cancer risk if you smoke is to quit smoking. Smoking is known to cause lung and other types of cancer. In addition, smoking might increase a person's susceptibility to the effects of ambient air pollution. For assistance with quitting smoking, there are now a great variety of ways smokers can be helped to quit. We encourage smokers to call the New York State Quit line at 1-866-NY-Quits (1-866-697-8487) or visit this website, www.nysmokefree.com.

People in the high impact areas, just like people living elsewhere, can reduce their risk for cancer and other health problems by striving for a healthy lifestyle, including good nutrition, exercise and healthy body weight. Eating foods such as vegetables, fruits, lean meats, whole grains and reducing salt and sugar are part of a healthy diet. Regular exercise helps keep us fit and heart healthy. Diet and exercise in turn are the keys to having a healthy body weight.

21. Comment: I have concerns about the health of myself and my relatives.

The DOH staff involved in this health outcome review focused on group-level data that provided summary information about entire communities or groups of people. The review showed that for the study area as a whole, some types of cancer occurred more frequently than expected. This does not tell us what the risk for a health problem for any specific individual might be. For concerns about an individual's or family member's health, we encourage you to discuss your concerns with a health care provider who can address your personal health issues.

22. Comment: Will there be clinics or financial help for the sick?

New York State has numerous health care programs that promote access to essential health services for lower-income residents including Medicaid, Child Health Plus, Family Health Plus, Healthy New York, Prenatal Care Assistance Program and others. We encourage individuals eligible for these programs to participate. Additional information regarding eligibility criteria and enrollment can be found on the Erie County Health Department website, or by calling 716-858-7690. Information is also available at http://www.health.state.ny.us.

NYS DOH encourages individuals to discuss their cancer screening concerns with their health care provider. Because many individual factors, such as age, gender, smoking status, and personal and familial medical history, should be considered prior to recommendation of cancer screening activities, seeking professional medical advice tailored to your individual situation helps to ensure appropriate cancer screenings. Assistance with getting free cancer screenings and other cancer services for people without health insurance or people who are Medicaid-eligible is available from the Cancer Services Program of Western NY which is funded by NYS DOH. Information about these programs is available at http://www.cspwny.org/index.html or by calling 1-716-886-9201.

Breast cancer, cervical cancer and colon cancer were not elevated in the study area. However, breast cancer among women and colon cancer among men and women are relatively common cancers. Routine screening for these three types of cancer can be life-saving because screening helps find the cancer early when treatment is most helpful.

Some additional tools for fighting cancer are two specific vaccinations that can prevent cancer. The Human Papilloma Virus (HPV) is the most common sexually transmitted infection in the U.S. HPV is a major cause of cervical cancer, anal cancer, and throat cancer, making this vaccine an anti-cancer vaccine. Talk to your health care provider to get additional information on the HPV vaccine.

HBV is the vaccine for Hepatitis B. Hepatitis B is a serious infection that affects the liver. It is caused by the hepatitis B virus. Each year about 2,000 to 4,000 people die in the U.S. from cirrhosis or liver cancer caused by hepatitis B. Talk to your health care provider to get additional on the HBV vaccine.

23. Comment: How can we find physicians that are educated in environmental impacts on health?

There are experts in occupational and environmental medicine affiliated with the NYS Occupational Health Clinic Network. For general information about the Clinic Network, see the general website, http:///www.nyhealth.gov/nysdoh/environ/occupate.htm. For assistance in your area, please contact Finger Lakes Occupational Health Services affiliated with the University of Rochester at 800-925-8615 or 585-244-4771. More information is available at www2.envmed.rochester.edu/envmed/occmed/fingerlakeswelcome.html or via e-mailing FLOHS@urmc.rochester.edu.

24. Comment: Community health services, including smoking cessation programs, should be improved.

Information about available community health services is available from the Erie County Department of health at 716-858-7690. The County Health Department and Western Regional Office of the NYS DOH welcome information you can provide about gaps in public health

services and suggestions for improving public health services. You can reach the Western Regional office of NYS DOH at 716-847-4501.

25. Comment: Are there any studies of the health of pets in the area? Please consider animal surveillance for cancer and other environmentally related diseases.

We are unaware of any studies of pet health in the area.

26. Comment: NYS DOH should try to get residents of the Tonawanda area included in the NHANES survey so they can be tested for contaminants identified by EPA's Toxic Release Inventory and the NYS DEC Tonawanda Air Study. DOH should prioritize grants and funding opportunities to further investigate the health impacts of environmental pollution in the Tonawanda area and structure continued research collaborative opportunities with the University at Buffalo. NYS DOH should provide funding for research into the link between environmental pollutants and health outcomes, as well as programs to educate the public about the effect of air quality on their health.

The geographic areas and populations covered by the federal National Health and Nutrition Examination Survey (NHANES) are determined by a rigorous sampling scheme, and, to our knowledge, NYS DOH would not be able to influence such decisions to ensure inclusion of the Tonawanda area. In addition, the NHANES biomonitoring results are reported at the group-level for large regions of the U.S., such as the Northeast region, but are not reported for specific states, cities, or smaller areas. However, NYS DOH is proposing to conduct a biomonitoring study to test for contaminants among Tonawanda area residents. (See Comment 16, p. 37, and the recommendations on p. 16.) Such a biomonitoring project would seek to address potential health impacts of environmental pollution in the Tonawanda area by measuring body burdens of contaminants. Such a project may also be able to play a role in providing useful information to the community about the effects of air quality on health.

NYS DOH does not currently have funding available to provide to other organizations to support research into the link between environmental pollutants and health outcomes. NYS DOH frequently applies for federal funds to assist with expanding our activities that address environmental health issues. NYS DOH routinely seeks opportunities to collaborate with academic researchers and community groups when conducting research or developing programs to reduce exposures.

C. Comments about environmental issues

27. Comment: Has environmental sampling been done in the area? What are the next steps to clean up the area? Is the soot that settles on houses something to be concerned about?

Questions regarding environmental sampling, planned environmental remediation, and other local environmental concerns should be directed to NYS DEC Region 9 at (716) 851-7200.

28. Comment: Did the clean-up and air quality improvements at Tonawanda Coke make a difference for local air quality?

Recent information from DEC air monitoring shows air quality improvements in the local area. For more information, please access the NYS DEC January 2013 update at: www.dec.ny.gov/chemical/88968.html.

29. Comment: What is the impact of environmental contamination on wildlife in the area?

We are unaware of any studies of this topic.

30. The government demolished a whole area along the Niagara River by Westside because of contamination. Then after a cleanup they rebuilt housing. This was around 1997-1998. What does it take to get that done in other areas along the river such as Riverside/Tonawanda?

We recommend contacting NYS DEC Region 9 at 716- 851-7200 for specific questions about local environmental activities, plans and community involvement.

31. Comment: Who makes enforcement action decisions regarding Tonawanda Coke? Will the study result in additional enforcement activities at Tonawanda Coke? Why aren't emissions at Tonawanda Coke better controlled?

NYS DEC and US EPA are involved with enforcement and permitting activities related to Tonawanda Coke. Questions related to those activities should be directed to NYS DEC Region 9 at (716) 851-7200 and US EPA Region 2, Buffalo office, at 716-551-4410.

32. Comment: I would like to see a stronger philosophical endorsement and strategic alignment between the NYS DOH and the EPA's Environmental Justice initiative.

An overview of some NYS DOH work on environmental justice is available on our website at: http://www.health.ny.gov/environmental/investigations/environmental_justice/.

33. Comment: OSHA should be involved to make sure area workplaces are safe.

Specific concerns about workplace safety in the area can be directed to OSHA's
Buffalo Area Office, U. S. Dept. of Labor/OSHA,
130 S. Elmwood Avenue, Suite 500, Buffalo, NY 14202-2465
(716) 551-3053

34. Comment: The Town of Tonawanda Development Corp. is planning public waterfront access, parkland and redevelopment near Tonawanda Coke. We need clean, healthy air before this plan can be successful.

Concerns about this plan should be directed to the Town of Tonawanda Development Corporation. Information can be found at http://www.tonawanda.ny.us/index.aspx?NID=641.

35. Comment: NYS DOH and NYS DEC should establish and participate in a working group to reduce environmental exposures and prevent illness related to such exposures.

NYS DOH and NYS DEC currently work closely on a variety of programs where the reduction of environmental exposures and illness prevention are interconnected. Examples include the Fish Advisory Program and the Hazardous Waste Site Remediation Program. This comment's suggestion for a working group will be shared with NYS DOH and NYS DEC leadership.

36. Comment: The toll plaza at the Grand Island Bridge should be eliminated. Economic development funding should be allocated to pollution prevention projects. Polluting industries should be prohibited from obtaining government subsidies.

Regarding environmental and health issues beyond the scope of this health outcomes review, we recommend residents continue to support and participate in their local organizations to address environmental health concerns and pursue follow-up actions. There is currently a collaborative effort underway to improve the environmental quality of the area through the E3—Economy, Energy, and Environment Program. E3 is a coordinated federal, state and local voluntary technical assistance initiative that helps communities work in conjunction with their manufacturing base to adapt and thrive in a new business era focused on sustainability while using green technology. More information about this program can be found at the following websites: http://www.epa.gov/r02earth/capp/TCC/tonawanda-e3charter.pdf and http://www.tonawanda.ny.us/index.aspx?NID=691.

At least two local environmental organizations, including the Clean Air Coalition of Western NY and the Tonawanda Community Fund, played critical roles in requesting and planning this health outcomes review. In addition, as suggested in a prior response, we recommend contacting the NYS DEC Region 9 office at (716) 851-7200 with comments and suggestions about local environmental concerns. In addition, the NYS DEC Citizen Participation webpage contains information about how to become involved in NYS DEC activities (http://www.dec.ny.gov/public/51805.html).

References for Responses to Comments

Herbst AL, Ulfelder H, Poskanzer Dc (1971) Adenocarcinoma of the vagina. Association of maternal stilbestrol therapy with tumor appearance in young women. N Engl J Med 284(15):878-881.

Table 1a. Demographics of the Tonawanda study area and New York State (excluding New York City): 1990, 2000, and 2010

Demographics	Tonawanda high impact area			Tonawanda moderate impact area			New York State, excluding NYC		
	1990[1,2]	2000[3,4]	2010[5,6]	1990[1,2]	2000[3,4]	2010[5,6]	1990[1,2]	2000[3,4]	2010[5,6]
Total Population	395	283	253	20,088	18,813	18,495	10,667,891	10,968,179	11,202,969
Males	50%	54%	50%	48%	48%	49%	49%	49%	49%
Age (years)									
<6	8%	4%	6%	9%	8%	7%	8%	8%	7%
6-19	14%	17%	16%	18%	20%	19%	19%	20%	19%
20-64	60%	59%	55%	59%	57%	59%	59%	58%	60%
>64	18%	20%	23%	13%	15%	15%	13%	14%	15%
Race and ethnicity									
White	97%	94%	93%	98%	95%	88%	90%	85%	82%
Black	3%	4%	1%	<1%	2%	4%	7%	8%	9%
Native American	<1%	<1%	2%	<1%	<1%	1%	<1%	<1%	<1%
Asian*	<1%	1%	<1%	<1%	<1%	1%	2%	2%	3%
Pacific Islander*	--	<1%	<1%	--	<1%	<1%	--	<1%	<1%
Other	<1%	<1%	<1%	<1%	<1%	2%	1%	2%	3%
Multi-Racial	--	<1%	3%	--	1%	2%	--	2%	2%
Percent Minority**	4%	7%	10%	3%	7%	15%	13%	18%	23%
Percent Hispanic	1%	<1%	6%	1%	2%	7%	7%	6%	10%
Income									
Median household income	$32,321	$35,511	$42,876	$28,075	$34,972	$42,303	$35,711	$47,517	$59,994
% below poverty level	6%	13%	8%	11%	14%	19%	9%	10%	11%

* Asian and Pacific Islander categories are combined for 1990 Census.

** Percent minority includes the non-white and white Hispanic categories.

1. U.S. Bureau of the Census. 1990 Census of population and housing summary tape file 1 (STF1). U.S. Department of Commerce. 1991.
2. U.S. Bureau of the Census. 1990 Census of population and housing summary tape file 3 (STF3). U.S. Department of Commerce. 1992
3. U.S. Bureau of the Census. 2000 Census of population and housing summary file 1(SF1). U.S. Department of Commerce. 2001.
4. U.S. Bureau of the Census. 2000 Census of population and housing summary file 3 (SF3). U.S. Department of Commerce. 2002.
5. U.S. Bureau of the Census. 2010 Census of population and housing summary file 1 (SF1). U.S. Department of Commerce. 2011.
6. 2005-2009 American Community Survey Data.

Table 1b. Demographics of the Tonawanda moderate impact sub-areas

Demographics	Tonawanda moderate impact sub-areas												New York State, excluding NYC		
	Brookside Terrace			Sheridan Park			Riverside			Grand Island					
	1990[1,2]	2000[3,4]	2010[5]	1990[1,2]	2000[3,4]	2010[5]	1990[1,2]	2000[3,4]	2010[5]	1990[1,2]	2000[3,4]	2010[5]	1990[1,2]	2000[3,4]	2010[5]
Total Population	4,363	3,928	3,784	5,884	5,242	5,017	4,923	4,753	5,017	4,918	4,890	4,677	10,667,891	10,968,179	11,202,969
Males	47.3%	47.1%	48.5%	47.8%	47.7%	47.5%	49.1%	48.0%	49.5%	48.9%	48.3%	48.7%	49%	49%	49%
Age (years)															
<6	7.5%	6.8%	5.6%	10.8%	9.1%	8.9%	9.0%	9.1%	8.9%	8.8%	8.5%	6.2%	8%	8%	7%
6-19	17.8%	17.6%	15.9%	18.2%	20.1%	17.8%	16.4%	19.7%	21.1%	21.0%	20.7%	18.9%	19%	20%	19%
20-64	59.5%	53.3%	58.2%	58.6%	56.3%	56.8%	57.1%	56.6%	60.1%	61.9%	59.7%	61.1%	59%	58%	60%
>64	15.2%	22.2%	20.4%	12.4%	14.6%	16.4%	17.4%	14.6%	9.9%	8.2%	11.1%	13.8%	13%	14%	15%
Race and ethnicity															
White	98.8	97.9%	96.1%	98.0%	90.6%	87.4%	97.9%	93.8%	77.1%	98.4%	97.1%	95.7%	90%	85%	82%
Black	0.2%	0.7%	1.1%	0.8%	5.6%	6.6%	0.2%	1.6%	7.9%	1.0%	0.9%	1.0%	7%	8%	9%
Native American	0.4%	0.3%	0.5%	0.2%	0.5%	0.7%	0.8%	1.4%	2.6%	0.2%	0.3%	0.6%	<1%	<1%	<1%
Asian*	0.5%	0.5%	0.8%	0.4%	0.5%	0.7%	0.5%	0.5%	3.1%	0.4%	0.4%	1.5%	2%	2%	3%
Pacific Islander*	--	0%	0%	--	0%	0%	--	0%	0.1%	--	0%	0%	--	<1%	<1%
Other	0.1%	0.2%	0.2%	0.6%	0.6%	1.3%	0.6%	1.1%	5.4%	0.1%	0.3%	0.2%	1%	2%	3%
Multi-Racial	--	0.4%	1.4%	--	2.2%	3.4%	--	1.7%	4.0%	--	1.0%	1.0%	--	2%	2%
Percent Minority**	1.8%	2.6%	5.5%	2.7%	11.2%	15.8%	3.5%	8.5%	31.3%	2.6%	3.8%	5.8%	13%	18%	23%
Percent Hispanic	0.7%	1.0%	2.3%	1.3%	3.0%	5.3%	2.1%	3.7%	16.7%	1.1%	1.4%	1.9%	7%	6%	10%
Income															
Median household income	$32,272	$39,471	$52,129	$22,259	$26,467	$31,354	$22,790	$27,965	$33,255	$41,473	$49,910	$71,717	$35,711	$47,517	$59,994
% below poverty level	7.6%	4.7%	7.5%	17.7%	22.7%	30.5%	12.4%	20.1%	29.6%	2.9%	4.2%	5.5%	9%	10%	11%

* Asian and Pacific Islander categories are combined for 1990 Census.

** Percent minority includes the non-white and white Hispanic categories.

1. U.S. Bureau of the Census. 1990 Census of population and housing summary tape file 1 (STF1). U.S. Department of Commerce. 1991.
2. U.S. Bureau of the Census. 1990 Census of population and housing summary tape file 3 (STF3). U.S. Department of Commerce. 1992
3. U.S. Bureau of the Census. 2000 Census of population and housing summary file 1(SF1). U.S. Department of Commerce. 2001.
4. U.S. Bureau of the Census. 2000 Census of population and housing summary file 3 (SF3). U.S. Department of Commerce. 2002.
5. U.S. Bureau of the Census. 2010 Census of population and housing summary file 1 (SF1). U.S. Department of Commerce. 2011.
6. 2005-2009 American Community Survey Data.

Table 2a. Low birth weight, prematurity & growth restriction (1990-2009), and total birth defects (1990-2008), high impact area compared to NYS (excluding NYC): Tonawanda health outcomes review

Health Outcome	Number of Cases		RR[a]	95% CI[b]	
	Observed	Expected		Lower	Upper
Low birth weight (LBW)	4	2.4	1.30	0.42	4.02
Moderately LBW	2	2.0	1.03	0.26	4.14
Very LBW	2	0.4	2.63	0.37	18.6
Preterm birth	4	3.0	1.06	0.34	3.28
Moderately preterm	2	2.5	0.84	0.21	3.34
Very preterm	2	0.5	2.26	0.32	16.1
Term low birth weight	1	0.8	1.18	0.17	8.40
Small for gestational age	4	4.1	1.05	0.39	2.81
Total birth defects	3	2.0	1.58	0.51	4.91

Notes:
[a]RR = The adjusted rate ratio takes into account year of birth, mother's age (<19, 19-34, 35+ years), sex of baby, education (<high school, high school-some college, 4+ years college), race (white, other), total previous live births (0, 1, 2, 3+), and prenatal care (adequate, intermediate, inadequate). This adjustment can result in a rate ratio estimate that differs from the rate ratio estimate calculated as observed divided by expected, which adjusts only for mother's age (not shown).
[b]95% CI = 95% confidence interval.

Table 2b. Low birth weight, prematurity & growth restriction, entire study area (high impact and moderate impact areas combined) compared to NYS (excluding NYC): 1990-2009, Tonawanda health outcomes review

Health Outcome	Number of Cases		RR[a]	95% CI[b]	
	Observed	Expected		Lower	Upper
Low birth weight (LBW)	245	232	1.09	0.96	1.23
Moderately LBW	201	189	1.10	0.96	1.26
Very LBW	44	43	1.02	0.74	1.39
Preterm birth	331	291	**1.14**	**1.02**	**1.27**
Moderately preterm	281	241	**1.17**	**1.04**	**1.31**
Very preterm	50	50	0.98	0.73	1.32
Term low birth weight	87	80	1.12	0.91	1.39
Small for gestational age	366	399	0.95	0.85	1.05

Notes:
[a] RR = The adjusted rate ratio takes into account year of birth, mother's age (<19, 19-34, 35+ years), sex of baby, education (<high school, high school-some college, 4+ years college), race (white, other), total previous live births (0, 1, 2, 3+), and prenatal care (adequate, intermediate, inadequate). This adjustment can result in a rate ratio estimate that differs from the rate ratio estimate calculated as observed divided by expected, which adjusts only for mother's age (not shown).
[b] 95% CI = 95% confidence interval.

Table 2c. Low birth weight, prematurity & growth restriction, moderate impact sub-areas compared to NYS (excluding NYC), 1990-2009: Tonawanda health outcomes review

	Brookside Terrace			Sheridan Park			Riverside			Grand Island		
	Cases		Adjusted Rate	Cases		Adjusted Rate	Cases		Adjusted Rate	Cases		Adjusted Rate
	Obs[a]	Exp[a]	Ratio (CI)[b] **	Obs	Exp	Ratio (CI)	Obs	Exp	Ratio (CI)	Obs	Exp	Ratio (CI)
Low birth weight (LBW)	29	35	0.93 (0.64-1.35)	99	80	**1.24 (1.02-1.51)**	70	67	1.00 (0.78-1.27)	43	49	1.03 (0.76-1.40)
Moderately LBW	24	28	0.97 (0.65-1.44)	83	65	**1.28 (1.03-1.59)**	59	54	1.05 (0.81-1.36)	33	40	0.94 (0.66-1.33)
Very LBW	5	6	0.78 (0.29-2.07)	16	15	1.07 (0.65-1.78)	11	12	0.74 (0.38-1.42)	10	9	1.51 (0.81-2.81)
Preterm birth	45	44	1.09 (0.81-1.47)	127	99	**1.23 (1.03-1.47)**	92	83	1.06 (0.86-1.30)	63	62	1.12 (0.87-1.44)
Moderately preterm	39	36	1.14 (0.83-1.56)	109	82	**1.27 (1.05-1.54)**	81	69	1.15 (0.92-1.42)	50	52	1.05 (0.79-1.39)
Very preterm	6	7	0.83 (0.34-1.99)	18	17	1.04 (0.64-1.67)	11	14	0.63 (0.33-1.21)	13	10	1.55 (0.88-2.74)
Term low birth weight	14	12	1.36 (0.80-2.29)	33	27	1.19 (0.84-1.68)	26	23	1.09 (0.74-1.62)	13	17	0.87 (0.50-1.54)
Small for gestational age	55	60	1.02 (0.78-1.33)	126	137	0.92 (0.77-1.10)	114	115	0.95 (0.79-1.15)	67	84	0.92 (0.72-1.17)

[a] obs = observed cases; exp = expected cases; [b]CI = 95% confidence interval.

**Adjusted analysis - Poisson regression models were adjusted for sex, mother's age (<19, 19-34, 35+ years), education (<high school, high school +), race (white, other), total previous live births (0,1,2+), and adequate prenatal care (modified Kessner index: adequate, intermediate, inadequate). Adjustment can result in a rate ratio that differs from the crude rate ratio of observed over expected. Crude rate ratios are not provided here.

Bold / shaded – indicates statistically significant elevation compared to statewide rates (excluding New York City).

Table 3a. Birth defects, entire study area (high impact and moderate impact areas combined) compared to NYS (excluding NYC): 1990-2008, Tonawanda health outcomes review

Birth Defect Group	Observed Number	Expected Number	Adjusted Analysis**		
			Rate Ratio	95% Confidence Interval	
				Lower	Upper
Total Reportable Birth Defects	246	194	**1.30**	**1.14**	**1.47**
Surveillance Birth Defects	132	107	**1.22**	**1.02**	**1.45**
Total Cardiac Defects	70	43.9	**1.66**	**1.31**	**2.10**
Major Cardiac Defects	12	9.9	1.18	0.65	2.12
Cleft Lip/Cleft Palate	4	4.5	0.66	0.21	2.06
Choanal Atresia	2	0.6	3.57	0.89	14.4

**Adjusted analysis - Poisson regression models were adjusted for sex, mother's age (<19, 19-34, 35+ years), education (<high school, high school +), race (white, other), total previous live births (0,1,2+), and adequate prenatal care (modified Kessner index: adequate, intermediate, inadequate).

Bold – indicates statistically significant elevation (or deficit) compared to statewide rates (excluding New York City).

Table 3b. Birth defects, moderate impact sub-areas compared to NYS (excluding NYC), 1990-2008: Tonawanda health outcomes review

	Brookside Terrace			Sheridan Park			Riverside			Grand Island		
	Cases		Adjusted Rate	Cases		Adjusted Rate	Cases		Adjusted Rate	Cases		Adjusted Rate
Birth Defects	Obs[a]	Exp[a]	Ratio (CI)[b] **	Obs	Exp	Ratio (CI)	Obs	Exp	Ratio (CI)	Obs	Exp	Ratio (CI)
Total Reportable	27	30	0.96 (0.66-1.40)	100	65	**1.54 (1.27-1.89)**	72	55	**1.29 (1.02-1.63)**	44	42	1.12 (0.83-1.52)
Surveillance	12	17	0.73 (0.41-1.29)	57	36	**1.59 (1.22-2.08)**	40	30	1.26 (0.91-1.74)	20	23	0.86 (0.55-1.34)
Total Cardiac	6	6.9	0.94 (0.42-2.10)	33	15	**2.26 (1.59-3.22)**	23	12	**1.92 (1.28-2.90)**	7	9.5	0.82 (0.39-1.71)
Major Cardiac	4	1.6	**2.82 (1.06-7.52)**	2	3.3	0.31 (0.04-2.24)	5	2.8	1.80 (0.75-4.32)	1	2.1	---
Cleft Lip/Palate	0	0.7	---	2	1.5	0.66 (0.09-4.72)	0	1.3	---	2	1.0	2.11 (0.53-8.44)
Choanal Atresia	0	0.1	---	0	0.2	---	1	0.2	---	1	0.1	---

[a] obs = observed cases; exp = expected cases; [b]CI = 95% confidence interval.

**Adjusted analysis - Poisson regression models were adjusted for sex, mother's age (<19, 19-34, 35+ years), education (<high school, high school +), race (white, other), total previous live births (0,1,2+), and adequate prenatal care (modified Kessner index: adequate, intermediate, inadequate).). This adjustment can result in a rate ratio estimate that differs from the rate ratio estimate calculated as observed divided by expected, which adjusts only for mother's age (not shown).

--- When the observed number is 0-1, no adjusted rate ratio or confidence interval is shown.

Bold / shaded– indicates statistically significant elevation compared to statewide rates (excluding New York City).

Table 4a. Cancer incidence, high impact area compared to NYS (excluding NYC): 1990-2008, males and females combined, Tonawanda health outcomes review

	# Cases		SIR[b]	LCI	UCI
	Obs[a]	Exp[a]			
TOTAL CANCERS	35	41.90	0.84	0.58	1.16
Oral cavity/pharynx	3	0.84	3.57	0.74	10.43
Esophagus	0	0.47	---	---	---
Stomach	2	0.71	2.81	0.34	10.16
Colorectal	8	4.78	1.67	0.72	3.30
Liver/intrahepatic bile duct	0	0.41	---	---	---
Pancreas	2	1.07	1.87	0.23	6.77
Lung/bronchus	3	6.42	0.47	0.10	1.37
Female breast	1	5.13	---	---	---
Cervix uteri	0	0.28	---	---	---
Uterus	2	1.13	1.77	0.21	6.39
Ovary	0	0.62	---	---	---
Prostate	2	7.24	0.28	0.03	1.00
Testis	0	0.18	---	---	---
Urinary bladder	2	2.36	0.85	0.10	3.06
Kidney/renal pelvis	0	1.16	---	---	---
Brain/other nervous system	1	0.55	---	---	---
Thyroid	0	0.59	---	---	---
Hodgkin's lymphoma	0	0.22	---	---	---
Non-Hodgkin's lymphoma	1	1.63	---	---	---
Leukemias	2	1.12	1.79	0.22	6.48
All other sites	6	3.88	1.54	0.57	3.36

Notes:

[a] Obs= observed, Exp= expected.

[b] SIR = standardized incidence ratio, adjusted for age.

[c] For 95% confidence intervals, LCI= lower confidence interval, UCI= upper confidence interval.

---- SIRs & 95% CI are not shown when 0-1 cases are observed.

BOLD = statistically significant elevation or deficit.

Table 4b. Cancer incidence, moderate impact area compared to NYS (excluding NYC): 1990-2008

	Males					Females				
	# Cases		SIR[b]	LCI[c]	UCI[c]	# Cases		SIR[b]	LCI[c]	UCI[c]
	Obs[a]	Exp[a]				Obs[a]	Exp[a]			
TOTAL CANCERS	**1,138**	**1,031**	**1.10**	**1.04**	**1.17**	**1,097**	**993**	**1.10**	**1.04**	**1.17**
Oral cavity/pharynx	37	26	1.41	0.99	1.94	16	14	1.16	0.66	1.88
Esophagus	**30**	**16**	**1.92**	**1.30**	**2.74**	9	6	1.62	0.74	3.07
Stomach	22	21	1.05	0.66	1.59	13	12	1.04	0.55	1.78
Colorectal	117	115	1.02	0.84	1.22	115	115	1.00	0.83	1.20
Liver/intrahepatic bile duct	7	13	0.53	0.21	1.10	--	--	0.48	0.10	1.40
Pancreas	32	25	1.29	0.88	1.82	30	27	1.13	0.76	1.61
Lung/bronchus	**199**	**160**	**1.24**	**1.08**	**1.43**	**178**	**138**	**1.29**	**1.11**	**1.49**
Female breast						301	290	1.04	0.92	1.16
Cervix uteri						14	17	0.82	0.45	1.37
Uterus						**78**	**62**	**1.26**	**1.00**	**1.57**
Ovary						31	35	0.89	0.60	1.26
Prostate	293	298	0.98	0.87	1.10					
Testis	11	10	1.07	0.53	1.91					
Urinary bladder	**96**	**77**	**1.24**	**1.01**	**1.52**	**52**	**29**	**1.81**	**1.35**	**2.37**
Kidney/renal pelvis	37	34	1.09	0.77	1.51	*12*	*21*	*0.56*	*0.29*	*0.98*
Brain/other nervous system	15	16	0.96	0.54	1.59	15	13	1.14	0.64	1.87
Thyroid	10	9	1.16	0.55	2.13	18	25	0.71	0.42	1.11
Hodgkin's lymphoma	10	7	1.51	0.73	2.78	6	6	1.00	0.37	2.17
Non-Hodgkin's lymphoma	33	42	0.79	0.54	1.11	42	38	1.09	0.79	1.48
Leukemias	33	32	1.05	0.72	1.47	28	24	1.16	0.77	1.68
All other sites	109	99	1.10	0.91	1.33	108	92	1.17	0.96	1.41

Notes:

[a] Obs= observed, Exp= expected.

[b] SIR = standardized incidence ratio, adjusted for age.

[c] For 95% confidence intervals, LCI= lower confidence interval, UCI= upper confidence interval.

-- Observed and expected numbers smaller than six are not presented to protect individuals' confidentiality.

---- SIRs & 95% CI are not shown when 0-1 cases are observed.

BOLD = statistically significant elevation compared to statewide (excluding NYC).

Italics = statistically significant deficit compared to statewide (excluding NYC).

Table 4c. Cancer incidence among males, moderate impact sub-areas compared to NYS (excluding NYC): 1990-2008, Tonawanda Health Outcomes Review

	Brookside Terrace			Sheridan Park			Riverside			Grand Island		
	# of cases		SIR (CI)[b]	# of cases		SIR (CI)	# of cases		SIR (CI)	# of Cases		SIR (CI)
	Obs[a]	Exp[a]		Obs	Exp		Obs	Exp		Obs	Exp	
Total Cancer	293	280	1.05 (0.93-1.17)	**316**	**269**	**1.17 (1.05-1.31)**	267	244	1.10 (0.97-1.23)	262	238	1.10 (0.97-1.24)
Oral cavity/pharynx	7	6.8	1.02 (0.41-2.11)	11	6.7	1.64 (0.82-2.93)	9	6.1	1.46 (0.67-2.78)	10	6.5	1.53 (0.73-2.81)
Esophagus	7	4.3	1.64 (0.66-3.38)	7	4.0	1.73 (0.70-3.57)	6	3.6	1.65 (0.60-3.58)	**10**	**3.7**	**2.72 (1.31-5.00)**
Stomach	8	5.7	1.41 (0.61-2.77)	6	5.5	1.10 (0.40-2.39)	--	--	0.80 (0.22-2.05)	--	--	0.84 (0.23-2.15)
Colorectal	32	31	1.02 (0.70-1.44)	31	30	1.03 (0.70-1.46)	28	27	1.02 (0.68-1.48)	26	26	1.00 (0.65-1.47)
Liver/intrahepatic bile duct	--	--	0.57 (0.07-2.06)	---	---	---	--	--	0.65 (0.08-2.34)	--	--	0.64 (0.08-2.31)
Pancreas	10	6.8	1.47 (0.70-2.70)	10	6.5	1.54 (0.74-2.83)	8	5.9	1.36 (0.59-2.67)	--	--	0.71 (0.19-1.81)
Lung/bronchus	49	44	1.10 (0.82-1.46)	**62**	**42**	**1.49 (1.14-1.91)**	46	37	1.23 (0.90-1.64)	42	36	1.15 (0.83-1.56)
Prostate	75	84	0.90 (0.70-1.12)	76	77	0.98 (0.77-1.23)	64	69	0.93 (0.72-1.19)	78	68	1.14 (0.90-1.43)
Testis	--	--	1.53 (0.31-4.46)	**--**	--	1.01 (0.21-2.96)	--	--	1.08 (0.22-3.16)			0.77 (0.09-2.77)
Urinary bladder	23	21	1.08 (0.68-1.62)	**30**	**20**	**1.48 (1.00-2.11)**	25	18	1.35 (0.88-2.00)	18	17	1.05 (0.62-1.65)
Kidney/renal pelvis	13	9.0	1.45 (0.77-2.47)	8	8.7	0.92 (0.40-1.80)	8	7.9	1.01 (0.43-1.98)	8	8.1	0.98 (0.42-1.94)
Brain/nervous system	--	--	0.79 (0.16-2.31)	--	--	1.20 (0.39-2.81)	--	--	1.05 (0.29-2.70)	--	--	0.78 (0.16-2.28)
Thyroid	--	--	0.98 (0.12-3.53)	--	--	2.21 (0.72-5.17)	---	---	---	--	--	0.89 (0.11-3.23)
Hodgkin's lymphoma	--.	--	2.84 (0.77-7.27)	--	--	1.63 (0.34-4.77)	---	---	---	--	--	1.20 (0.15-4.35)
Non-Hodgkin's lymphoma	6	11	0.55 (0.20-1.21)	8	11	0.73 (0.31-1.43)	7	10	0.69 (0.28-1.43)	12	10.0	1.21 (0.62-2.11)
Leukemias	7	8.2	0.86 (0.34-1.77)	**--**	--	0.60 (0.19-1.39)	11	7.7	1.43 (0.72-1.65)	10	7.3	1.37 (0.66-2.53)
All other sites	27	26	1.03 (0.68-1.50)	**37**	**26**	**1.42 (1.00-1.96)**	27	24	1.13 (0.97-1.23)	18	23	0.79 (0.47-1.25)

[a] Obs = observed, Exp= expected.

[b] SIR = standardized incidence ratio, adjusted for age; CI = 95% confidence interval.

-- Observed and expected numbers smaller than six are not presented to protect individuals' confidentiality.

---- SIRs & 95% CIs are not shown when 0-1 cases are observed.

BOLD = statistically significant elevation compared to statewide (excluding NYC).

Table 4d. Cancer incidence among females: moderate impact sub-areas compared to NYS (excluding NYC): 1990-2008, Tonawanda health outcomes

	Brookside Terrace			Sheridan Park			Riverside			Grand Island		
	# of cases		SIR (CI)[b]	# of cases		SIR (CI)	# of cases		SIR (CI)	# of Cases		SIR (CI)
	Obs[a]	Exp[a]		Obs	Exp		Obs	Exp		Obs	Exp	
Total Cancer	272	258	1.06	**332**	**271**	**1.22 (1.10-1.36)**	264	250	1.06 (0.93-1.19)	229	215	1.07 (0.93-1.21)
Oral cavity/pharynx	--	--	1.11 (0.30-2.84)	--	--	1.06 (0.29-2.71)	6	3.4	1.74 (0.64-3.79)	--	--	0.66 (0.08-2.39)
Esophagus	---	---	---	--	--	2.60 (0.71-6.67)	--	--	1.39 (0.17-5.01)	--	--	2.75 (0.57-8.05)
Stomach	---	---	---	--	--	1.15 (0.31-2.95)	--	--	0.61 (0.07-2.19)	6	2.4	2.48 (0.91-5.41)
Colorectal	27	31	0.88 (0.58-1.28)	30	32	0.94 (0.64-1.35)	39	30	1.30 (0.92-1.77)	19	22	0.85 (0.51-1.33)
Liver/intrahepatic bile duct	---	---	---	--	--	1.15 (0.14-4.16)	---	---	---	---	---	---
Pancreas	11	7.1	1.54 (0.77-2.76)	7	7.4	0.95 (0.38-1.96)	9	7.0	1.29 (0.59-2.45)	--	--	0.59 (0.12-1.73)
Lung/bronchus	36	37	0.97 (0.68-1.34)	**55**	**38**	**1.46 (1.10-1.89)**	**52**	**35**	**1.49 (1.12-1.96)**	35	28	1.24 (0.86-1.73)
Female breast	85	74	1.14 (0.91-1.41)	86	78	1.10 (0.88-1.36)	63	71	0.89 (0.68-1.14)	67	67	1.00 (0.78-1.28)
Cervix uteri	--	--	0.50 (0.06-1.82)	**--**	--	0.64 (0.13-1.88)	6	4.2	1.43 (0.52-3.11)		4.3	0.70 (0.14-2.04)
Uterus	23	16	1.42 (0.90-2.12)	19	17	1.14 (0.69-1.78)	13	15	0.87 (0.46-1.48)	**23**	**14**	**1.64 (1.04-2.46)**
Ovary	7	9.0	0.78 (0.31-1.61)	12	9.4	1.27 (0.66-2.22)	8	8.6	0.93 (0.40-1.83)	--	--	0.51 (0.14-1.31)
Urinary bladder	**18**	**7.7**	**2.34 (1.39-3.70)**	**19**	**7.9**	**2.40 (1.44-3.74)**	11	7.4	1.48 (0.74-2.65)	--	--	0.71 (0.19-1.81)
Kidney/renal pelvis	--	--	0.54 (0.11-1.57)	6	5.8	1.03 (0.38-2.24)	--	--	0.37 (0.05-1.35)	--	--	0.22 (0.01-1.22)
Brain/nervous system	**--**	--	0.93 (0.19-2.73)	6	3.7	1.64 (0.60-3.57)	--	--	1.20 (0.33-3.07)	--	--	0.67 (0.08-2.41)
Thyroid	--	--	0.87 (0.28-2.03)	--	--	0.57 (0.16-1.47)	--	--	0.48 (0.10-1.41)	6	6.6	0.91 (0.33-1.99)
Hodgkin's lymphoma	--	--	1.57 (0.19-5.69)	--	--	1.14 (0.14-4.13)	--	--	1.29 (0.16-4.67)	---	---	---
Non-Hodgkin's lymphoma	12	10	1.20 (0.62-2.09)	9	11	0.85 (0.39-1.61)	11	9.8	1.12 (0.56-2.00)	10	8.0	1.24 (0.60-2.28)
Leukemias	--	--	0.65 (0.18-1.67)	**13**	**6.7**	**1.93 (1.03-3.30)**	--	--	0.64 (0.17-1.63)	7	5.0	1.41 (0.57-2.90)
All other sites	23	24	0.95 (0.61-1.43)	**42**	**25**	**1.64 (1.19-2.22)**	22	24	0.92 (0.58-1.39)	21	19	1.12 (0.69-1.71)

[a] Obs= observed, Exp= expected.

[b] SIR = standardized incidence ratio, adjusted for age; CI = 95% confidence interval.

-- Observed and expected numbers smaller than six are not presented to protect individuals' confidentiality.

---- SIRs & 95% CI are not shown when 0-1 cases are observed. **BOLD** = statistically significant elevation (or deficit) compared to statewide (excluding NYC).

Appendix Table 1. Demographics of the Tonawanda study area and Erie and Niagara Counties: 1990, 2000, and 2010

	Tonawanda high impact area			Tonawanda moderate impact area			Erie County			Niagara County		
Demographics	**1990**[1,2]	**2000**[3,4]	**2010**[5,6]	**1990**[1,2]	**2000**[3,4]	**2010**[5,6]	**1990**[1,2]	**2000**[3,4]	**2010**[5,6]	**1990**[1,2]	**2000**[3,4]	**2010**[5,6]
Total Population	395	283	253	20,089	18,813	18,495	968,532	950,265	919,040	220,756	219,846	216,469
Males	50%	54%	50%	48%	48%	49%	48%	48%	48%	48%	48%	48%
Age (years)												
<6	8%	4%	6%	9%	8%	7%	8%	7%	6%	9%	7%	6%
6-19	14%	17%	16%	18%	20%	19%	18%	19%	18%	19%	20%	18%
20-64	60%	59%	55%	59%	57%	59%	59%	57%	60%	57%	57%	60%
>64	18%	20%	23%	13%	15%	15%	15%	16%	16%	15%	15%	16%
Race and ethnicity												
White	97%	94%	93%	98%	95%	88%	86%	82%	80%	93%	91%	88%
Black	3%	4%	1%	<1%	2%	4%	11%	13%	13%	5%	6%	7%
Native American	<1%	<1%	2%	<1%	<1%	1%	<1%	<1%	<1%	<1%	<1%	1%
Asian*	<1%	1%	<1%	<1%	<1%	1%	1%	1%	3%	<1%	<1%	<1%
Pacific Islander*	--	<1%	<1%	--	<1%	0%	--	0%	<1%	--	<1%	<1%
Other	<1%	<1%	<1%	<1%	<1%	2%	1%	1%	1%	<1%	<1%	<1%
Multi-Racial	--	<1%	3%	--	1%	2%	--	1%	2%	--	1%	2%
Percent Minority**	4%	7%	10%	3%	7%	15%	15%	19%	22%	8%	10%	13%
Percent Hispanic	1%	<1%	6%	1%	2%	7%	2%	3%	4%	1%	1%	2%
Income												
Median household income	$32,321	$35,511	$42,876	$28,075	$34,972	$42,303	$28,005	$38,567	$47,372	$28,408	$38,136	$45,964
% below poverty level	6%	13%	8%	11%	14%	19%	12%	12%	14%	11%	11%	13%

* Asian and Pacific Islander categories are combined for 1990 Census.

** Percent minority includes the non-white and white Hispanic categories.

1. U.S. Bureau of the Census. 1990 Census of population and housing summary tape file 1 (STF1). U.S. Department of Commerce. 1991.
2. U.S. Bureau of the Census. 1990 Census of population and housing summary tape file 3 (STF3). U.S. Department of Commerce. 1992
3. U.S. Bureau of the Census. 2000 Census of population and housing summary file 1(SF1). U.S. Department of Commerce. 2001.
4. U.S. Bureau of the Census. 2000 Census of population and housing summary file 3 (SF3). U.S. Department of Commerce. 2002.
5. U.S. Bureau of the Census. 2010 Census of population and housing summary file 1 (SF1). U.S. Department of Commerce. 2011.
6. 2005-2009 American Community Survey Data.

Appendix Table 2a. Low birth weight, prematurity & growth restriction (1990-2009), and total birth defects (1990-2008), high impact area compared to Erie & Niagara Counties: Tonawanda health outcomes review

Health Outcome	Number of Cases		RR[a]	95% CI[b]	
	Observed	Expected		Lower	Upper
Low birth weight (LBW)	4	2.7	1.19	0.38	3.70
Moderately LBW	2	2.2	0.94	0.23	3.75
Very LBW	2	0.5	2.58	0.36	18.3
Preterm birth	4	3.3	0.97	0.31	3.03
Moderately preterm	2	2.7	0.77	0.19	3.08
Very preterm	2	0.6	2.11	0.30	15.0
Term low birth weight	1	0.9	1.12	0.16	7.98
Small for gestational age	4	4.2	1.04	0.39	2.77
Total birth defects	3	2.8	1.16	0.37	3.60

Notes:
[a]RR = The adjusted rate ratio takes into account year of birth, mother's age (<19, 19-34, 35+ years), sex of baby, education (<high school, high school-some college, 4+ years college), race (white, other), total previous live births (0, 1, 2, 3+), and prenatal care (adequate, intermediate, inadequate). This adjustment can result in a rate ratio estimate that differs from the rate ratio estimate calculated as observed divided by expected, which adjusts only for mother's age (not shown)..
[b]95% CI = 95% confidence interval.

Appendix Table 2b. Low birth weight, prematurity & growth restriction, entire study area (high impact and moderate impact areas combined) compared to Erie & Niagara Counties: 1990-2009, Tonawanda health outcomes review

Health Outcome	Number of Cases		RR[b]	95% CI[c]	
	Observed	Expected[a]		Lower	Upper
Low birth weight (LBW)	245	264	1.00	0.88	1.13
Moderately LBW	201	212	1.00	0.87	1.16
Very LBW	44	52	0.95	0.69	1.30
Preterm birth	331	326	1.05	0.94	1.17
Moderately preterm	281	264	1.08	0.96	1.21
Very preterm	50	62	0.88	0.65	1.19
Term low birth weight	87	85	1.09	0.88	1.35
Small for gestational age	366	410	0.95	0.85	1.05

Notes:
[a] Expected values rounded to nearest whole number.
[b] RR = The adjusted rate ratio takes into account year of birth, mother's age (<19, 19-34, 35+ years), sex of baby, education (<high school, high school-some college, 4+ years college), race (white, other), total previous live births (0, 1, 2, 3+), and prenatal care (adequate, intermediate, inadequate). This adjustment can result in a rate ratio estimate that differs from the rate ratio estimate calculated as observed divided by expected, which adjusts only for mother's age (not shown).
[c] 95% CI = 95% confidence interval.

Appendix Table 2C. Low birth weight, prematurity & growth restriction, moderate impact sub-areas compared to Erie & Niagara Counties, 1990-2009: Tonawanda health outcomes review

	Brookside Terrace			**Sheridan Park**			**Riverside**			**Grand Island**		
	Cases		Adjusted Rate	Cases		Adjusted Rate	Cases		Adjusted Rate	Cases		Adjusted Rate
	Obs[a]	Exp[a]	Ratio (CI)[b] **	Obs	Exp	Ratio (CI)	Obs	Exp	Ratio (CI)	Obs	Exp	Ratio (CI)
Low birth weight (LBW)	29	39	0.86 (0.60-1.25)	99	90	1.14 (0.93-1.39)	70	76	0.91 (0.72-1.16)	43	56	0.95 (0.70-1.28)
Moderately LBW	24	32	0.89 (0.60-1.34)	83	72	1.17 (0.94-1.45)	59	61	0.95 (0.74-1.24)	33	45	0.86 (0.61-1.23)
Very LBW	5	8	0.72 (0.27-1.93)	16	18	1.02 (0.61-1.69)	11	15	0.70 (0.36-1.34)	10	11	1.35 (0.72-2.51)
Preterm birth	45	49	1.02 (0.76-1.37)	127	111	1.14 (0.95-1.36)	92	93	0.97 (0.79-1.19)	63	70	1.02 (0.80-1.32)
Moderately preterm	39	39	1.07 (0.78-1.47)	109	90	1.18 (0.97-1.43)	81	75	1.05 (0.84-1.31)	50	56	0.97 (0.73-1.28)
Very preterm	6	9	0.74 (0.31-1.78)	18	21	0.95 (0.59-1.53)	11	18	0.57 (0.30-1.10)	13	13	1.33 (0.75-2.35)
Term low birth weight	14	13	1.33 (0.79-2.25)	33	29	1.14 (0.81-1.62)	26	24	1.04 (0.70-1.55)	13	18	0.87 (0.49-1.53)
Small for gestational age	55	61	1.03 (0.79-1.34)	126	141	0.91 (0.76-1.09)	114	118	0.95 (0.78-1.14)	67	86	0.96 (0.75-1.22)

[a] obs = observed cases; exp = expected cases; [b]CI = 95% confidence interval.

**Adjusted analysis - Poisson regression models were adjusted for sex, mother's age (<19, 19-34, 35+ years), education (<high school, high school +), race (white, other), total previous live births (0,1,2+), and adequate prenatal care (modified Kessner index: adequate, intermediate, inadequate). This adjustment can result in a rate ratio estimate that differs from the rate ratio estimate calculated as observed divided by expected, which adjusts only for mother's age (not shown).

Bold / shaded – indicates statistically significant elevation compared to statewide rates (excluding New York City).

Appendix Table 3a. Birth defects, <u>entire study area</u> (high impact and moderate impact areas combined) compared to Erie & Niagara Counties: 1990-2008, Tonawanda health outcomes review

Birth Defect Group	Observed Number	Expected Number	Adjusted Analysis**		
			Rate Ratio	95% Confidence Interval	
				Lower	Upper
Total Reportable Birth Defects	246	253	1.04	0.91	1.18
Surveillance Birth Defects	132	123	1.07	0.89	1.27
Total Cardiac Defects	70	69	1.07	0.84	1.36
Major Cardiac Defects	12	17	0.73	0.40	1.32
Cleft Lip/Cleft Palate	4	4.3	0.72	0.23	2.26
Choanal Atresia	2	0.7	3.09	0.74	12.8

**Adjusted analysis - Poisson regression models were adjusted for sex, mother's age (<19, 19-34, 35+ years), education (<high school, high school +), race (white, other), total previous live births (0,1,2+), and adequate prenatal care (modified Kessner index: adequate, intermediate, inadequate).). This adjustment can result in a rate ratio estimate that differs from the rate ratio estimate calculated as observed divided by expected, which adjusts only for mother's age (not shown).
Bold – indicates statistically significant elevation (or deficit) compared to statewide rates (excluding New York City).

Appendix Table 3b. Birth defects, moderate impact sub-areas compared to Erie & Niagara Counties, 1990-2008: Tonawanda health outcomes review

	Brookside Terrace			Sheridan Park			Riverside			Grand Island		
	Cases		Adjusted Rate	Cases		Adjusted Rate	Cases		Adjusted Rate	Cases		Adjusted Rate
Birth Defects	Obs[a]	Exp[a]	Ratio (CI)[b] **	Obs	Exp	Ratio (CI)	Obs	Exp	Ratio (CI)	Obs	Exp	Ratio (CI)
Total Reportable	27	40	0.77 (0.52-1.12)	100	84	**1.23 (1.01-1.51)**	72	71	1.05 (0.83-1.33)	44	55	0.90 (0.67-1.21)
Surveillance	12	19	0.65 (0.37-1.14)	57	41	**1.38 (1.06-1.80)**	40	35	1.10 (0.80-1.53)	20	27	0.78 (0.50-1.20)
Total Cardiac	6	11	0.61 (0.27-1.37)	33	23	**1.46 (1.02-2.08)**	23	19	1.27 (0.84-1.91)	7	15	0.52 (0.25-1.09)
Major Cardiac	4	2.6	1.77 (0.66-4.74)	2	5.7	0.19 (0.03-1.38)	5	4.8	1.15 (0.48-2.77)	1	3.7	0.32 (0.04-2.27)
Cleft Lip/Palate	0	0.7	--	2	1.4	0.74 (0.10-5.29)	0	1.2	--	2	0.9	2.20 (0.55-8.86)
Choanal Atresia	0	0.1	--	0	0.2	--	1	0.2	5.52 (0.76-40.3)	1	0.1	6.38 (0.88-46.4)

[a] obs = observed cases; exp = expected cases; [b]CI = 95% confidence interval.

**Adjusted analysis - Poisson regression models were adjusted for sex, mother's age (<19, 19-34, 35+ years), education (<high school, high school +), race (white, other), total previous live births (0,1,2+), and adequate prenatal care (modified Kessner index: adequate, intermediate, inadequate).). This adjustment can result in a rate ratio estimate that differs from the rate ratio estimate calculated as observed divided by expected, which adjusts only for mother's age (not shown).

--- When the observed number is 0-1, no adjusted rate ratio or confidence interval is shown.

Bold / shaded– indicates statistically significant elevation compared to statewide rates (excluding New York City).

Appendix Table 4a. Cancer incidence, high impact area compared to Erie & Niagara Counties, males and females combined: 1990-2008, Tonawanda health outcomes review

	# Cases		SIR[b]	LCI	UCI
	Obs[a]	Exp[a]			
TOTAL CANCERS	35	42.33	0.83	0.58	1.15
Oral cavity/pharynx	3	0.90	3.33	0.69	9.74
Esophagus	0	0.54	---	---	---
Stomach	2	0.72	2.78	0.34	10.06
Colorectal	8	4.66	1.72	0.74	3.39
Liver/intrahepatic bile duct	0	0.38	---	---	---
Pancreas	2	1.07	1.87	0.23	6.75
Lung/bronchus	3	6.88	0.44	0.09	1.27
Female breast	1	5.08	---	---	---
Cervix uteri	0	0.23	---	---	---
Uterus	2	1.11	1.80	0.22	6.51
Ovary	0	0.61	---	---	---
Prostate	2	7.24	0.28	0.03	1.00
Testis	0	0.17	---	---	---
Urinary bladder	2	2.44	0.82	0.10	2.96
Kidney/renal pelvis	0	1.12	---	---	---
Brain/other nervous system	1	0.56	---	---	---
Thyroid	0	0.56	---	---	---
Hodgkin's lymphoma	0	0.20	---	---	---
Non-Hodgkin's lymphoma	1	1.53	---	---	---
Leukemias	2	1.16	1.73	0.21	6.24
All other sites	6	4.12	1.46	0.53	3.17

Notes:
[a] Obs= observed, Exp= expected.
[b] SIR = standardized incidence ratio, adjusted for age.
[c] For 95% confidence intervals, LCI= lower confidence interval, UCI= upper confidence interval.
--- SIRs & 95% CI are not shown when 0-1 cases are observed.
BOLD = statistically significant elevation or deficit.

Appendix Table 4b. Cancer incidence, moderate impact area compared to Erie & Niagara Counties: 1990-2008

	Males					Females				
	# Cases		SIR[b]	LCI[c]	UCI[c]	# Cases		SIR[b]	LCI[c]	UCI[c]
	Obs[a]	Exp[a]				Obs[a]	Exp[a]			
TOTAL CANCERS	**1,138**	**1056.9**	**1.08**	**1.02**	**1.14**	**1,097**	**982.8**	**1.12**	**1.05**	**1.18**
Oral cavity/pharynx	37	28.8	1.28	0.90	1.77	16	14.3	1.12	0.64	1.82
Esophagus	**30**	**18.1**	**1.66**	**1.12**	**2.37**	9	6.0	1.49	0.68	2.83
Stomach	22	21.1	1.04	0.65	1.58	13	12.6	1.03	0.55	1.76
Colorectal	117	114.6	1.02	0.84	1.22	115	107.3	1.07	0.88	1.29
Liver/intrahepatic bile duct	7	12.2	0.57	0.23	1.18	--	5.77	0.52	0.11	1.52
Pancreas	32	25.6	1.25	0.85	1.76	30	25.9	1.16	0.78	1.66
Lung/bronchus	199	175.5	1.13	0.98	1.30	**178**	**143.4**	**1.24**	**1.07**	**1.44**
Female breast						301	286.1	1.05	0.94	1.18
Cervix uteri						14	14.5	0.96	0.53	1.61
Uterus						**78**	**60.8**	**1.28**	**1.01**	**1.60**
Ovary						31	34.9	0.89	0.60	1.26
Prostate	293	298.7	0.98	0.87	1.10					
Testis	11	9.6	1.15	0.57	2.05					
Urinary bladder	96	79.6	1.21	0.98	1.47	**52**	**29.9**	**1.74**	**1.30**	**2.28**
Kidney/renal pelvis	37	32.8	1.13	0.79	1.56	12	20.5	0.59	0.30	1.02
Brain/other nervous system	15	16.2	0.93	0.52	1.53	15	13.1	1.15	0.64	1.89
Thyroid	10	7.7	1.30	0.62	2.39	18	25.7	0.70	0.42	1.11
Hodgkin's lymphoma	10	6.3	1.58	0.76	2.91	6	5.46	1.10	0.40	2.39
Non-Hodgkin's lymphoma	33	39.6	0.83	0.57	1.17	42	36.4	1.15	0.83	1.56
Leukemias	33	32.5	1.02	0.70	1.43	28	25.1	1.12	0.74	1.61
All other sites	109	107.0	1.02	0.84	1.23	108	94.6	1.14	0.94	1.38

Notes:

[a] Obs= observed, Exp= expected.

[b] SIR = standardized incidence ratio, adjusted for age.

[c] For 95% confidence intervals, LCI= lower confidence interval, UCI= upper confidence interval.

-- Observed and expected numbers smaller than six (when males and females are shown separately) are not presented to protect individuals' confidentiality.

---- SIRs & 95% CI are not shown when 0-1 cases are observed.

BOLD = statistically significant elevation (or deficit) compared to statewide (excluding NYC).

Appendix Table 4c. Cancer incidence among males, moderate impact sub-areas compared to Erie & Niagara Counties: 1990-2008, Tonawanda Health Outcomes Review

[a] Obs = observed, Exp= expected.

[b] SIR = standardized incidence ratio, adjusted for age; CI = 95% confidence interval.

	Brookside Terrace			**Sheridan Park**			**Riverside**			**Grand Island**		
	# of cases		SIR (CI)[b]	# of cases		SIR (CI)	# of cases		SIR (CI)	# of Cases		SIR (CI)
	Obs[a]	Exp[a]		obs	exp		Obs	exp		Obs	exp	
Total Cancer	293	287	1.02 (0.91-1.14)	**316**	**276**	**1.14 (1.02-1.28)**	**267**	250	1.07 (0.94-1.20)	262	244	1.07 (0.95-1.21)
Oral cavity/pharynx	7	7.5	0.94 (0.38-1.93)	11	7.3	1.50 (0.75-2.68)	9	6.7	1.34 (0.61-2.54)	10	7.3	1.37 (0.66-2.52)
Esophagus	7	4.9	1.41 (0.57-2.91)	**7**	4.7	1.50 (0.60-3.08)	6	4.2	1.43 (0.52-3.11)	**10**	**4.3**	**2.35 (1.13-4.32)**
Stomach	8	5.8	1.39 (0.60-2.73)	6	5.5	1.09 (0.40-2.37)	--	--	0.80 (0.22-2.05)	--	--	0.84 (0.23-2.14)
Colorectal	32	31.4	1.02 (0.70-1.44)	31	30.0	1.03 (0.70-1.47)	28	27.3	1.03 (0.68-1.48)	26	25.9	1.00 (0.66-1.47)
Liver/intrahepatic bile duct	--	--	0.61 (0.07-2.21)	--	--	0.32 (0.01-1.76)	--	--	0.69 (0.08-2.51)	--	--	0.69 (0.08-2.50)
Pancreas	10	7.0	1.43 (0.68-2.63)	10	6.7	1.50 (0.72-2.75)	8	6.1	1.32 (0.57-2.60)	--	--	0.68 (0.19-1.74)
Lung/bronchus	49	48.6	1.01 (0.75-1.33)	**62**	**45.7**	**1.36 (1.04-1.74)**	46	41.1	1.12 (0.82-1.49)	42	40.2	1.05 (0.75-1.41)
Prostate	75	83.8	0.89 (0.70-1.12)	76	77.7	0.98 (0.77-1.22)	64	69.3	0.92 (0.71-1.18)	78	67.9	1.15 (0.91-1.43)
Testis	--	--	1.65 (0.34-4.82)	**--**	--	1.08 (0.22-3.15)	--	-	1.16 (0.24-3.38)	--	--	0.83 (0.10-3.01)
Urinary bladder	23	22.0	1.05 (0.66-1.57)	30	20.9	1.44 (0.97-2.05)	25	19.0	1.32 (0.85-1.94)	18	17.8	1.01 (0.60-1.60)
Kidney/renal pelvis	13	8.7	1.49 (0.79-2.55)	8	8.5	0.95 (0.41-1.86)	8	7.7	1.04 (0.45-2.04)	8	7.9	1.02 (0.44-2.00)
Brain/nervous system	--	--	0.76 (0.16-2.23)	--	--	1.16 (0.38-2.70)	--	--	1.02 (0.28-2.61)	--	--	0.75 (0.16-2.20)
Thyroid	--	--	1.09 (0.13-3.95)	--	2.0	2.49 (0.81-5.81)	---	--	0.53 (0.01-2.98)	--	--	1.01 (0.12-3.64)
Hodgkin's lymphoma	--	--	2.98 (0.81-7.64)	--	---	1.72 (0.35-5.02)	---	--	0.62 (0.02-3.44)	--	--	1.24 (0.15-4.49)
Non-Hodgkin's lymphoma	6	10.3	0.58 (0.21-1.27)	8	10.4	0.77 (0.33-1.51)	7	9.5	0.73 (0.30-1.51)	12	9.4	1.28 (0.66-2.23)
Leukemias	7	8.4	0.83 (0.33-1.71)	--	---	0.58 (0.19-1.35)	11	7.9	1.39 (0.69-2.48)	10	7.5	1.33 (0.64-2.46)
All other sites	27	28.5	0.95 (0.63-1.38)	37	28.1	1.32 (0.93-1.81)	27	25.7	1.05 (0.69-1.53)	18	24.7	0.73 (0.43-1.15)

-- Observed and expected numbers smaller than six (when males and females are shown separately) are not presented to protect individuals' confidentiality.

---- SIRs & 95% CIs are not shown when 0-1 cases are observed.

BOLD = statistically significant elevation compared to statewide (excluding NYC).

Appendix Table 4d. Cancer incidence among females: moderate impact sub-areas compared to Erie & Niagara Counties: 1990-2008, Tonawanda health outcomes review

	Brookside Terrace			Sheridan Park			Riverside			Grand Island		
	# of cases		SIR (CI)[b]	# of cases		SIR (CI)	# of cases		SIR (CI)	# of Cases		SIR (CI)
	Obs[a]	Exp[a]		Obs	Exp		Obs	Exp		Obs	Exp	
Total Cancer	272	255	1.07 (0.94-1.20)	**332**	**268**	**1.24 (1.11-1.38)**	264	247	1.07 (0.95-1.21)	229	213	1.08 (0.94-1.23)
Oral cavity/pharynx	--	--	1.07 (0.29-2.75)	--	--	1.03 (0.28-2.64)	6	3.5	1.70 (0.62-3.69)	--	3.2	0.63 (0.08-2.28)
Esophagus	0	1.6	--	--	--	2.40 (0.65-6.14)	--	--	1.28 (0.16-4.64)	--	1.2	2.51 (0.52-7.33)
Stomach	--	--	0.30 (0.01-1.66)	--	--	1.14 (0.31-2.91)	--	--	0.60 (0.07-2.16)	6	2.4	2.52 (0.92-5.47)
Colorectal	27	28.7	0.94 (0.62-1.37)	30	29.7	1.01 (0.68-1.44)	39	27.9	1.40 (0.99-1.91)	19	21.0	0.90 (0.54-1.41)
Liver/intrahepatic bile duct	0	1.5	--	--	--	1.26 (0.15-4.55)	---	--	0.67 (0.02-3.71)	0	1.2	--
Pancreas	11	6.9	1.59 (0.79-2.84)	7	7.2	0.98 (0.39-2.01)	9	6.8	1.32 (0.61-2.51)	--	5.0	0.60 (0.12-1.77)
Lung/bronchus	36	38.6	0.93 (0.65-1.29)	**55**	**39.2**	**1.40 (1.06-1.82)**	**52**	**36.1**	**1.44 (1.08-1.89)**	35	29.4	1.19 (0.83-1.65)
Female breast	85	73.6	1.16 (0.92-2.17)	86	77.1	1.12 (0.89-1.38)	63	69.8	0.90 (0.69-1.15)	67	65.6	1.02 (0.79-1.30)
Cervix uteri	--	--	0.59 (0.07-2.15)	--	--	0.76 (0.16-2.21)	6	3.6	1.67 (0.61-3.63)	--	--	0.83 (0.17-2.42)
Uterus	23	15.9	1.45 (0.92-2.17)	19	16.3	1.16 (0.70-1.81)	13	14.7	0.88 (0.47-1.51)	**23**	**13.9**	**1.66 (1.05-2.49)**
Ovary	7	8.9	0.79 (0.32-1.62)	12	9.4	1.27 (0.66-2.22)	8	8.6	0.93 (0.40-1.84)	--	7.9	0.50 (0.14-1.29)
Urinary bladder	**18**	**8.0**	**2.26 (1.34-3.57)**	**19**	**8.3**	**2.30 (1.39-3.60)**	11	7.7	1.42 (0.71-2.55)	--	5.9	0.68 (0.18-1.73)
Kidney/renal pelvis	--	--	0.56 (0.12-1.64)	6	5.6	1.07 (0.39-2.32)	--	--	0.39 (0.05-1.40)	--	4.3	0.23 (0.01-1.28)
Brain/nervous system	--	--	0.95 (0.20-2.77)	6	3.6	1.65 (0.61-3.60)	--	--	1.21 (0.33-3.10)	--	3.0	0.67 (0.08-2.42)
Thyroid	--	--	0.87 (0.28-2.02)	--	--	0.57 (0.16-1.46)	--	--	0.48 (0.10-1.41)	6	6.7	0.90 (0.33-1.95)
Hodgkin's lymphoma	--	--	1.75 (0.21-6.32)	--	--	1.26 (0.15-4.54)	--	--	1.43 (0.17-5.15)	0	1.3	--
Non-Hodgkin's lymphoma	12	9.5	1.27 (0.66-2.22)	9	10.0	0.90 (0.41-1.71)	11	9.3	1.19 (0.59-2.12)	10	7.7	1.30 (0.62-2.38)
Leukemias	--	--	0.62 (0.17-1.59)	13	7.0	1.85 (0.99-3.17)	--	--	0.61 (0.17-1.56)	7	5.1	1.37 (0.55-2.83)
All other sites	23	24.7	0.93 (0.59-1.40)	**42**	**26.1**	**1.61 (1.16-2.17)**	22	24.5	0.90 (0.56-1.36)	21	19.3	1.09 (0.67-1.66)

[a] Obs= observed, Exp= expected.

[b] SIR = standardized incidence ratio, adjusted for age; CI = 95% confidence interval.

-- Observed and expected numbers smaller than six (when males and females are shown separately) are not presented to protect individuals' confidentiality.

---- SIRs & 95% CI are not shown when 0-1 cases are observed.

BOLD = statistically significant elevation (or deficit) compared to statewide (excluding NYC)