

CAUSES OF CANCER IN WARREN COUNTY, NEW YORK

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Report to President Obama from the President's Cancer Panel 2008-2009

- **“The Panel was particularly concerned to find that the true burden of environmentally induced cancer has been grossly underestimated. With nearly 80,000 chemicals on the market in the United States, many of which are used by millions of Americans in their daily lives and are un- or understudied and largely unregulated, exposure to potential environmental carcinogens is widespread.”**

In August, 2019 the New York State Department of Health issued a report entitled “Governor’s Cancer Research Initiative: Cancer Incidence Report for the Warren County Study Area.” Using state cancer registry data this report documents statistically significant elevations of oral, colorectal, laryngeal, lung, brain and other nervous system and thyroid cancers in Warren County than the rest of New York State excluding New York City. In addition the report addressed esophageal cancer,

melanoma and leukemia because rates in Warren County were at least 40% higher than in the rest of upstate New York.

In an effort to understand the cause of these elevations in cancer rates the DOH compared demographic, behavioral, healthcare and occupational factors in Warren County as compared to the average of the same factors in all of the other upstate counties. They used the American Community Survey (ACS), the **B**ehavioral **R**isk **F**actor **S**urveillanc**e** **S**ystem (BFFSS), the **S**tatewide **P**lanning and **R**esearch **C**ooperativ**e** **S**ystem (SPARCS) and the County Health Rankings & Roadmaps Program. Overall they concluded that residents of Warren County smoke more, are more obese, and more white, but that they are more physically active and have better access to health care than the New York average. The report attributed the elevations in lung, laryngeal, esophageal and oral cancers to smoking, with a possible synergistic effect of alcohol consumption and HPV infection. They dismissed the elevations in thyroid cancer as being a consequence of high quality health care in the region with over-diagnosis as well as a consequence of high rates of obesity. For colorectal cancer they attributed the elevated risk to obesity and smoking, as well as higher rates of screening. They explain elevated rates of melanoma by the fact that the population in Warren County is primarily white, and whites are more vulnerable to melanoma. They dismissed the elevated rates of leukemia as being a time-limited anomaly, and found that they could not explain the elevated rates of brain cancer.

There is no question but that smoking and being obese are unhealthy factors. It is also clear that having light skin is a risk factor for the development of malignant melanoma. They then stated, “Results from the environmental investigation did not show any unusual environmental exposure that could explain the elevated cancer incidence rates in Warren County.”

There are two major problems with this report. In the first place, the comparison with all of upstate New York does not allow for analysis of rates of cancer in Warren County as compared with other individual counties, especially those of similar demographics. They report that as compared to all of NYS exclusive of NYC, there are statistically significant elevations in the number of current male and female smokers and individuals being overweight or obese. Our research shows that when country-level data is analyzed the incidence of smoking and overweight/obesity in Warren County is not elevated relative to other NYS countries. The elevations in rates of those cancers that NYSDOH attributes to smoking and obesity are cannot simply be due to smoking and obesity.

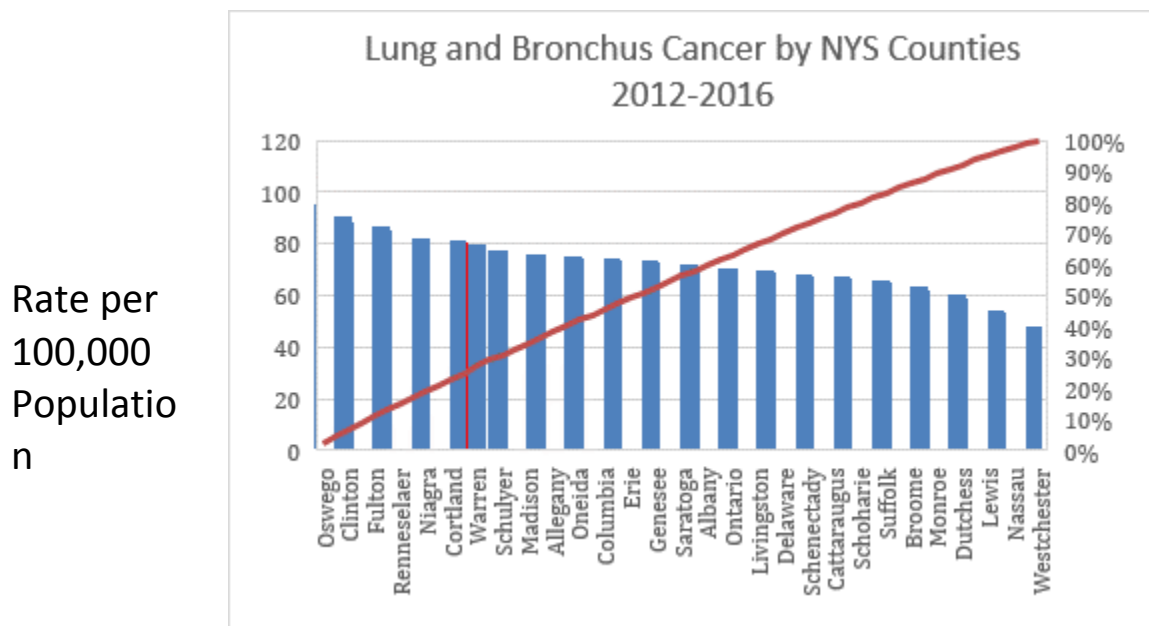
The other issue of concern is the failure of the NYSDOH to adequately address environmental causes of cancer.

Statements such as “..toxicological data do not indicate that these criteria air pollutants are environmental risk factors for cancer” are blatantly untrue, as the International Agency for Research on Cancer, part of the World Health Organization, has rated air pollution, especially particulate air pollution, as a

Group 1, known human carcinogen (IARC, 2013). Environmental causes of the specific cancers elevated in Warren County will be discussed below.

Figure 1 shows rates of lung and bronchus cancers in upstate counties. Warren County has higher rates of these cancers in all but twelve counties in spite of the fact that the rate of smoking is only average.

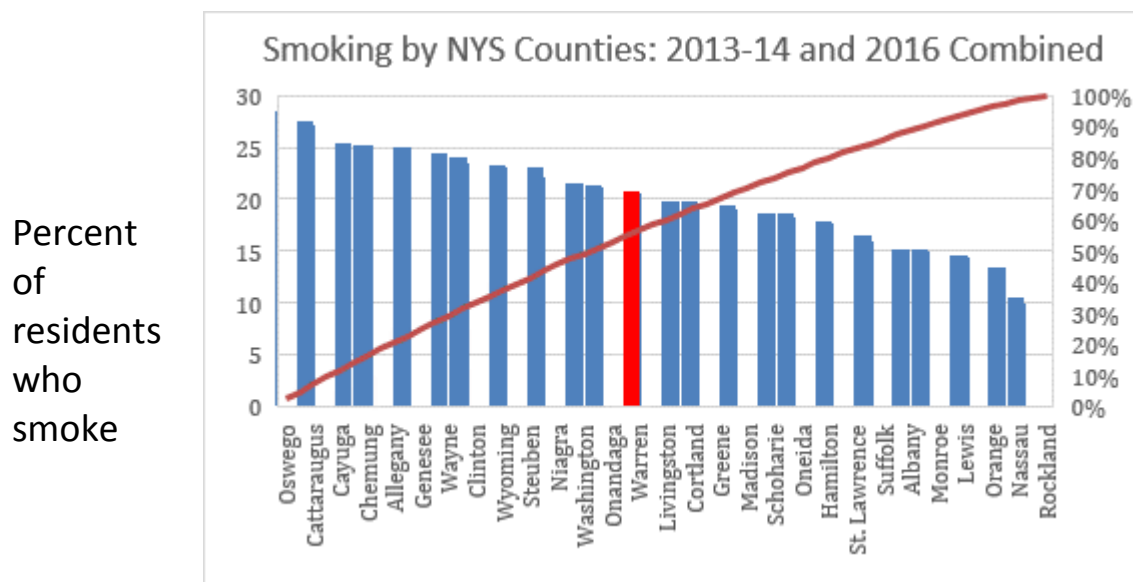
Figure 1: Rates of lung and bronchus cancers in upstate New York counties



Only 12 of 56 counties exceeded the lung cancer rate of Warren County (81.2). The Warren County rate was significantly above the 72.7 median rate per 100,000 for all NYS counties.

Figure 2 shows rates of smoking in all of the upstate New York counties. What is apparent is that smoking rates in Warren County are at about the middle of the range for all counties. While there is no question but that smoking increases rates of cancer, it is certainly not the only cause.

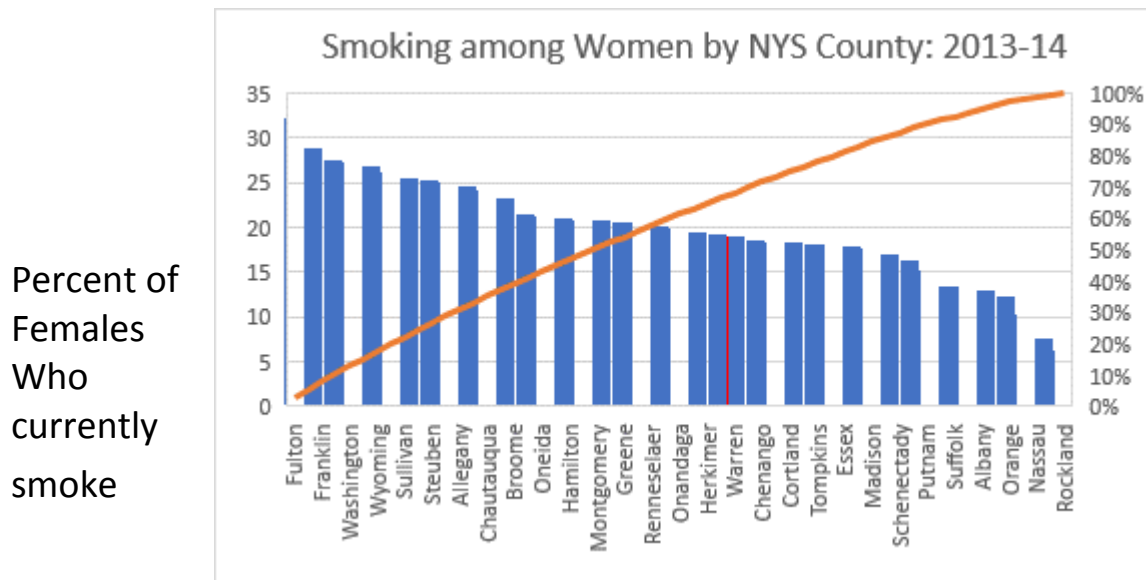
Figure 2: Smoking rates in New York counties exclusive of New York City



Warren County residents reported a 20.95 percent rate of cigarette smoking or just above the NYS median for all counties at 19.95 percent. Twenty-five NYS counties have higher rates of smoking than Warren County.

Figure 3 shows rates of smoking among women in the various NYS counties. Smoking is less common among women in Warren County than in most of NYS counties.

Figure 3: Smoking among women by NYS counties exclusive of NYC.



19.1 percent of women in Warren County reported being a current smoker. This rate fell below the median for the state at 19.9. Thirty two of 57 counties exceeded the female current smoking rate of Warren County.

These results are not consistent with the NYSDOH assertion that the elevated rates of lung and bronchial cancers are because of higher rates of smoking in residents of Warren County.

The report dismisses air pollution as being a major cause of lung cancer, as quoted above. The evidence that air pollution causes lung cancer is summarized in the IARC (2013) report.

Additional documentation can be found in the reports by Raaschou-Nielsen et al., 2013, Guo et al. (2016) and Gharibvand et al., (2017). Many particulates contain polycyclic aromatic hydrocarbons, which are major risk factors for lung cancer (Moorthy et al., 2015).

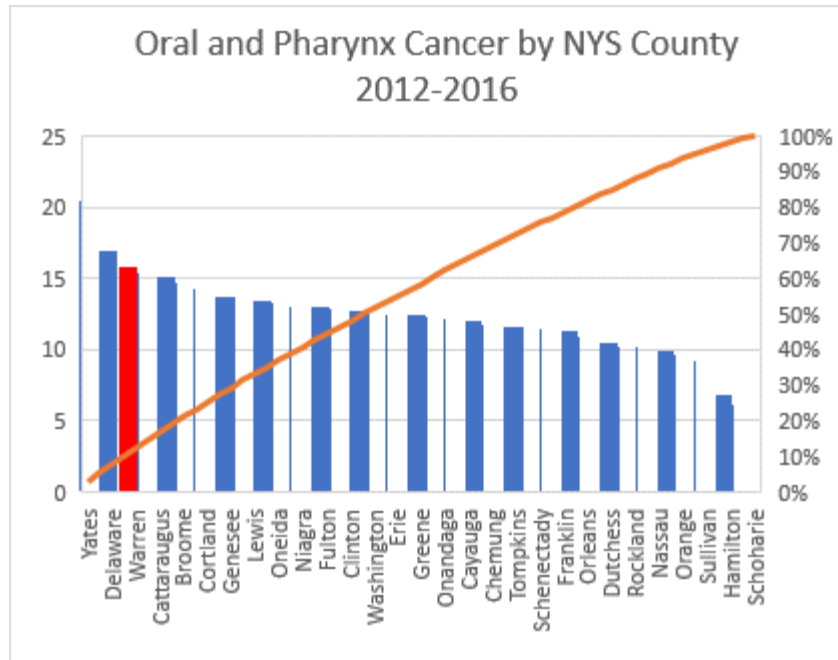
The DOH then suggests that wood smoke contributes 11% of Warren County's average inhalation cancer risk. But there is no evidence that wood stoves are more common in Warren than other New York counties. They also present data on 1,3-butadiene, acetaldehyde, benzene, carbon tetrachloride and formaldehyde, all known human carcinogens using the National Air Toxics Assessment data from 2011 and 2014. They show that with the exception of acetaldehyde in 2014 the comparison ratios for all of these chemicals are either lower than or equal to the average of the rest of upstate counties. However, they do not present county by county comparisons, and make no effort to document point source emissions within Warren County. Clearly there are several industries in the county that emit particulates and hazardous air pollutants, especially the Finch paper mill and Lehigh Cement. These industries may cause localized elevated concentrations of carcinogenic air pollutants, and their effects on county-wide cancer rates may be obscured in samples taken from a very limited number of sampling sites. According to the information in the National Emissions Inventory, Finch Paper LLC released 800,406.50 pounds of PM10 in 2017 while Lehigh Northeast Cement released 368, 865.32 pounds. No attempt was made to

determine whether residents living near to the site of emission were those who suffered from elevations in respiratory tract cancers.

Data on rates of cancers of the oral cavity and upper respiratory system are shown in Figures 4-6. Figure 4 shows data for oral and pharynx cancers, while Figure 5 shows data for larynx cancer for both sexes. Figure 6 shows rates of oral and pharynx cancers in only women. Rates for both are strikingly higher in Warren County than most other New York counties.

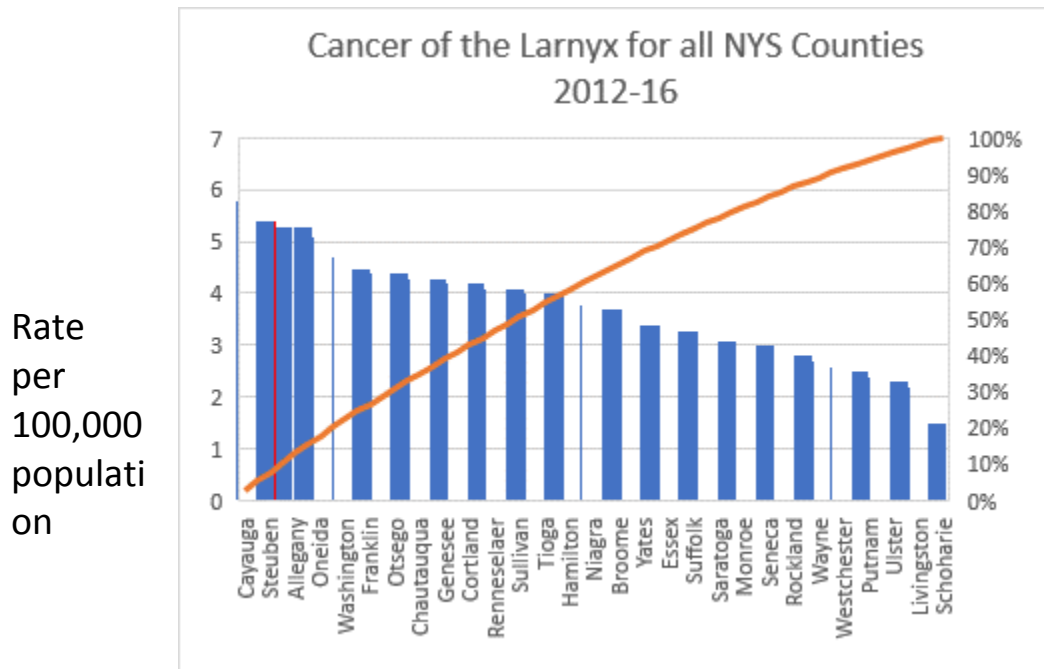
Figure 4: Oral and pharynx cancers in upstate counties in New York. The rate in Warren County is the fifth highest in New York.

Rate per
100,000
population



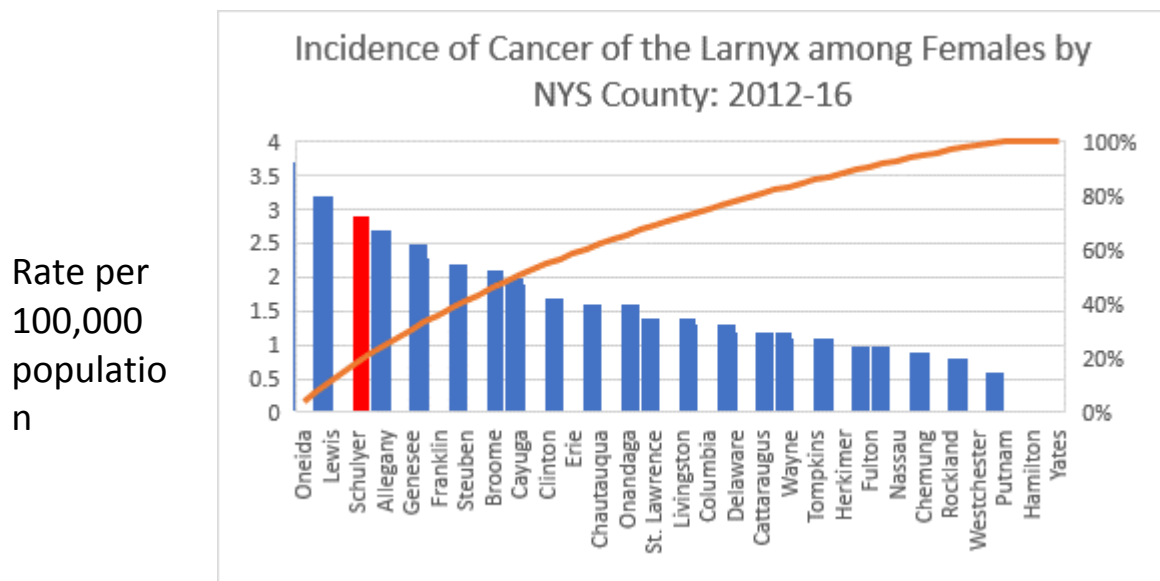
Only four counties exceeded the 15.8 incidence of oral cancer reported in Warren County in the 2012-16 study. The 15.8 incidence per 100,000 population was considerably elevated as compared to the median for all counties of 12.5 per 100,000 population.

Figure 5 shows rates of larynx cancers in upstate New York counties. Warren County has a rate higher than all but three other counties.



Only two of 56 counties exceeded the incidence of cancer of the larynx in Warren County. The 5.4 rate per 100,000 population was considerably above the 3.8 median for all New York State counties.

Figure 6 shows rates of larynx cancers in women for all counties other than NYC. The pattern is the same as seen for larynx cancers among both sexes.



The rate of cancer of the larynx among Females in Warren County was 2.9 per 100,000 population, well above the median for all counties of 1.4. Only five counties exceeded the rate of Warren County in this type of cancer.

The DOH report suggests that high oral cancers may result from **Human Papilloma Virus (HPV)** coming from oral sexual activity. There is certainly no evidence that oral sex is practiced more in Warren County than elsewhere in NYS. They also discount exposure to formaldehyde as being a factor, stating that “the

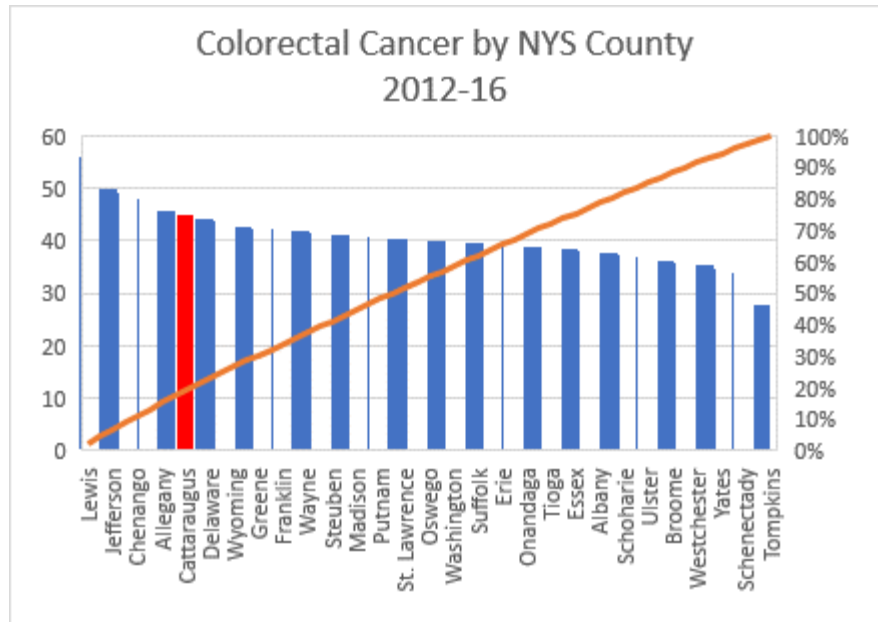
lifetime cancer risk associated with formaldehyde inhalation exposure is extremely small". This is incompatible with the conclusion of USEPA that formaldehyde exposure via inhalation and ingestion is responsible for 24% of all cancers, while the California EPA attributes 18% of cancers to formaldehyde exposure (summarized by Loh et al., 2007). While there is no clear evidence for excessive exposure to formaldehyde, the striking elevation in rates of these cancers is a clear indication that a study of sources of formaldehyde is warranted.

These results clearly show that the elevated rates of these respiratory tract and oral cancers cannot be explained by rates of smoking in Warren County.

Figure 7 shows the rates of colorectal cancers in Warren County as compared to that in other upstate counties. Warren County had more cases of colorectal cancer than all but eight other counties, especially among women. They suggest that the elevated rates of colorectal cancers in Warren County are due to excessive alcohol consumption, smoking and obesity, and that this risk may have been somewhat reduced due to the higher than average level of physical activity.

Figure 7: Rates of colorectal cancer in Warren and other counties in NYS.

Rate per
100,000
populatio
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Only eight of 56 counties exceeded the Warren County incidence of colorectal cancer of 45.1. Warren County's rate exceeded the median of 40.4 for all counties.

We have already shown above that there is no elevated rate of smoking in Warren County for both sexes (Figure 2) or specifically among women (Figure 3).

Figure 8 shows levels of overweight or obesity relative to those in other upstate counties.

Percent of Adult Residents with BMI>25

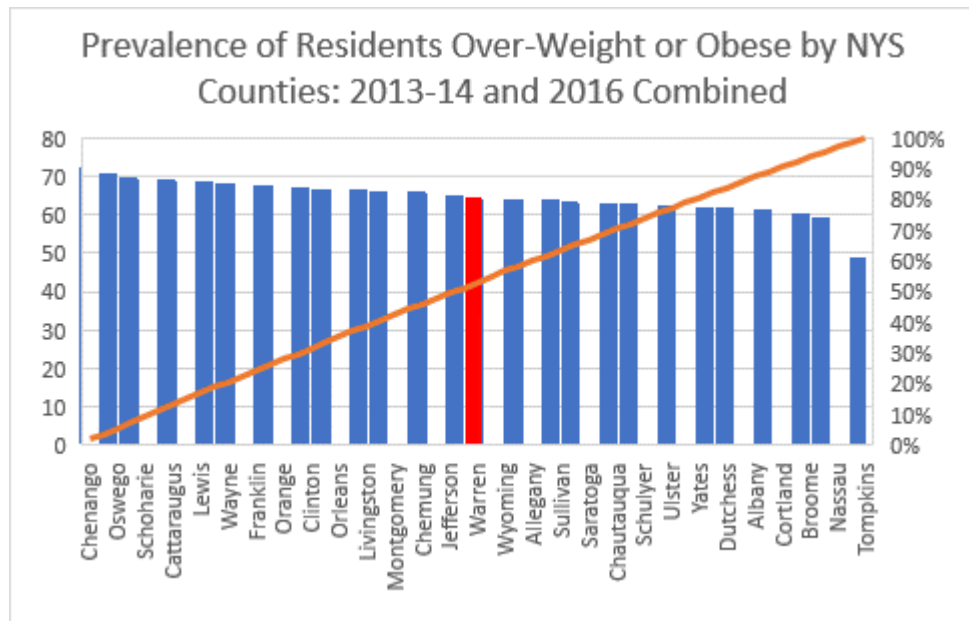
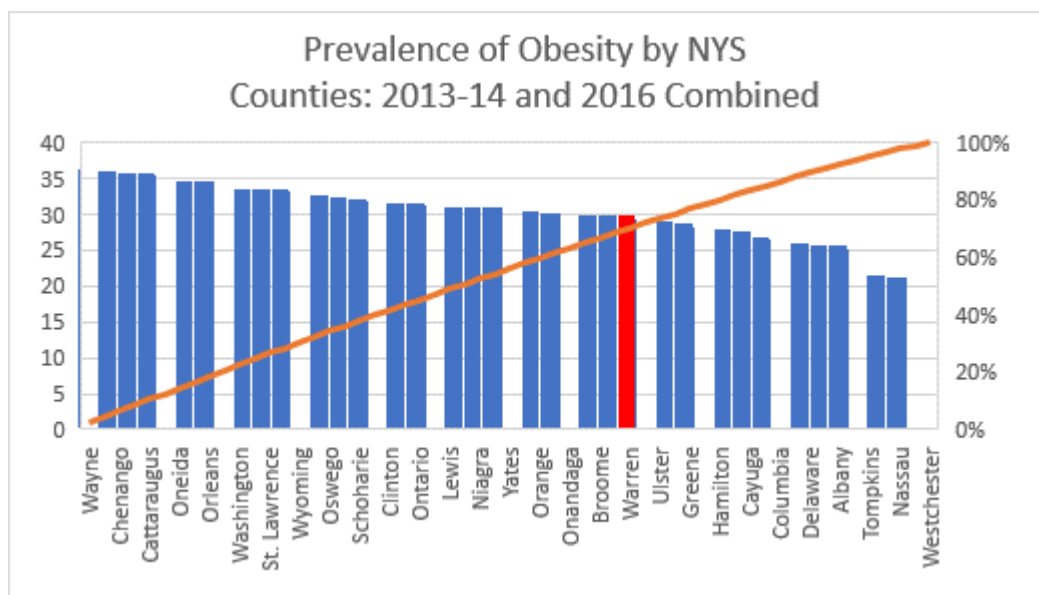


Figure 9 shows levels of obesity for both sexes relative to other upstate counties.

Percent of Adult Residents with BMI>30

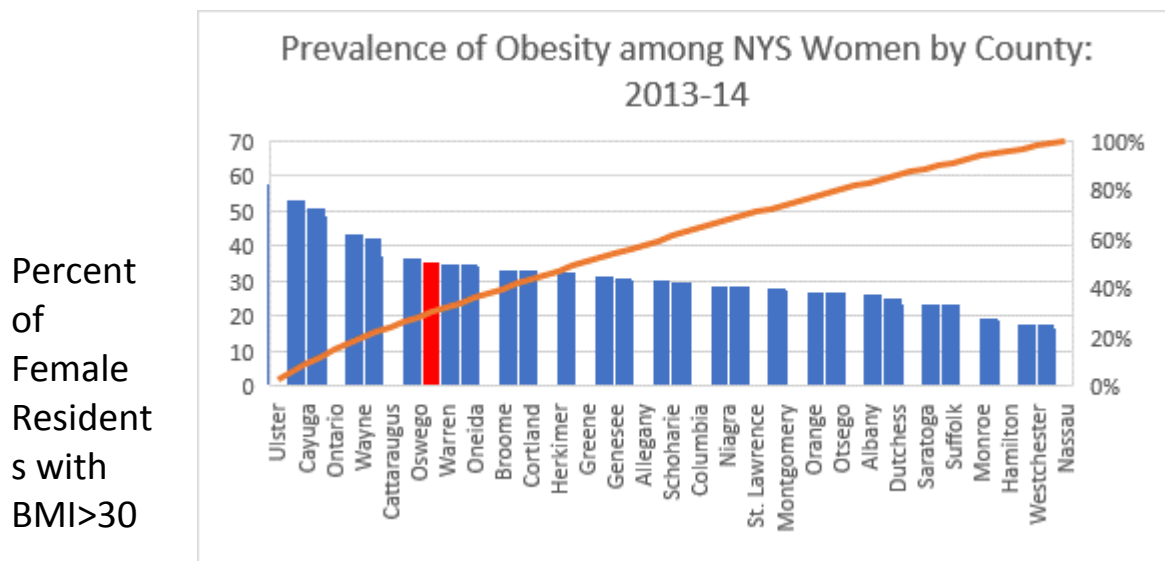


Warren County residents reported an obesity rate of 29.85% or more than

one percentage point below the median for all counties (30.95).

Thirty five of 57 counties had a higher rate of obesity than Warren County residents.

Figure 10 shows rates of obesity for women.



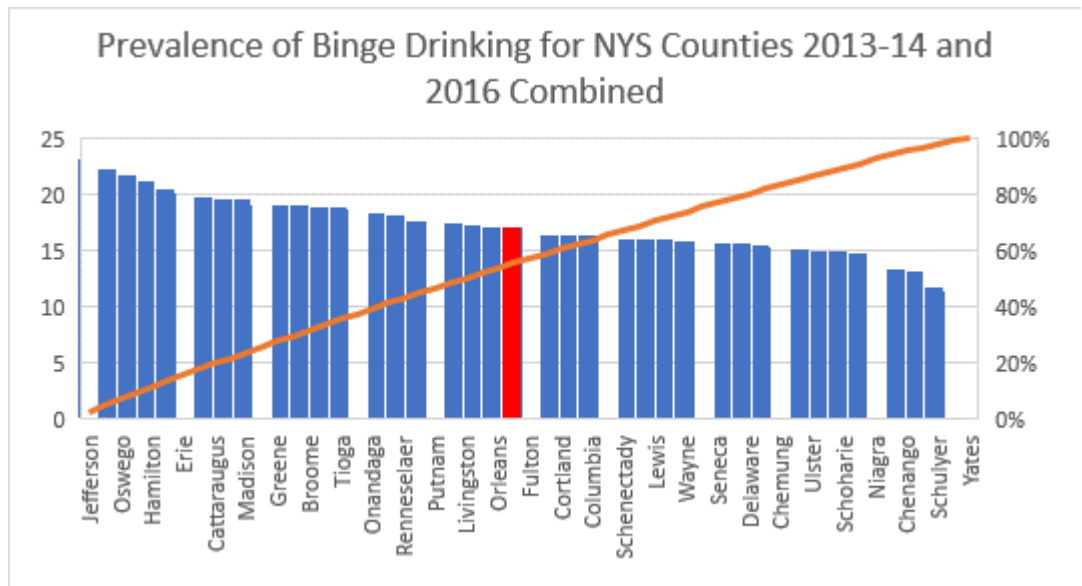
35.7 percent of women in Warren County were reported to have a BMI exceeding 30 in the 2013-14 survey. The median obesity rate for the state was 30.3. Twelve of 56 counties had higher female obesity rates than Warren County.

Clearly rates of overweight and obesity are not elevated in Warren County as compared to other NYS counties, though obesity among women is somewhat elevated. There must be other reasons for the elevated rate of colorectal cancer in Warren County.

DOH suggests that alcohol consumption may also explain the elevated rates of colorectal cancer in Warren County without presenting any evidence to support the claim that there is excessive alcohol consumption. Figure 11 shows rates of binge drinking in NYS counties. Clearly rates in Warren County are not elevated in relation to those in other counties.

Figure 11: Binge drinking in NYS counties exclusive of NYC.

Percent of Residents Drinking > 5 drinks in one setting during last 30 days

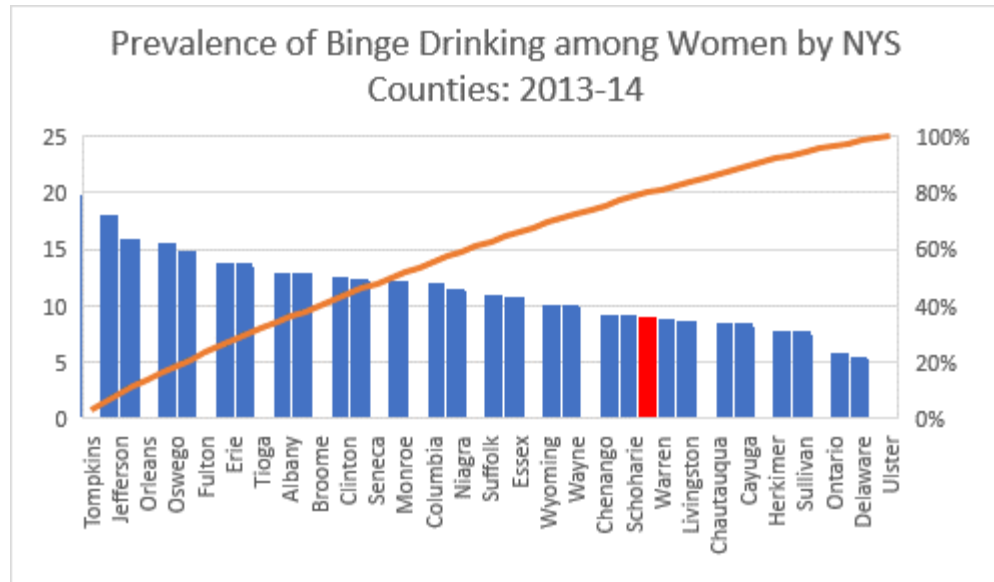


Warren County residents registered a binge drinking rate (17.1%) slightly above the median rate for all counties (17.05). Twenty-five counties had higher rates of binge drinking than Warren County.

Figure 12 shows binge drinking among Warren County women. This is certainly not elevated as compared to other NY residents.

Percent of female

resident
s
drinking
>5
drinks in
one
setting
during
last 30
days.



Nine percent of women in Warren County reportedly engaged in binge drinking in the 30 days prior to the survey. This is less than the median rate for counties of 11.3. Only 16 counties had a lower rate than Warren County.

Clearly none of the behavior factors for which the DOH attributes the excess risk of colorectal cancer (smoking, heavy alcohol use, obesity) can explain the excess rates.

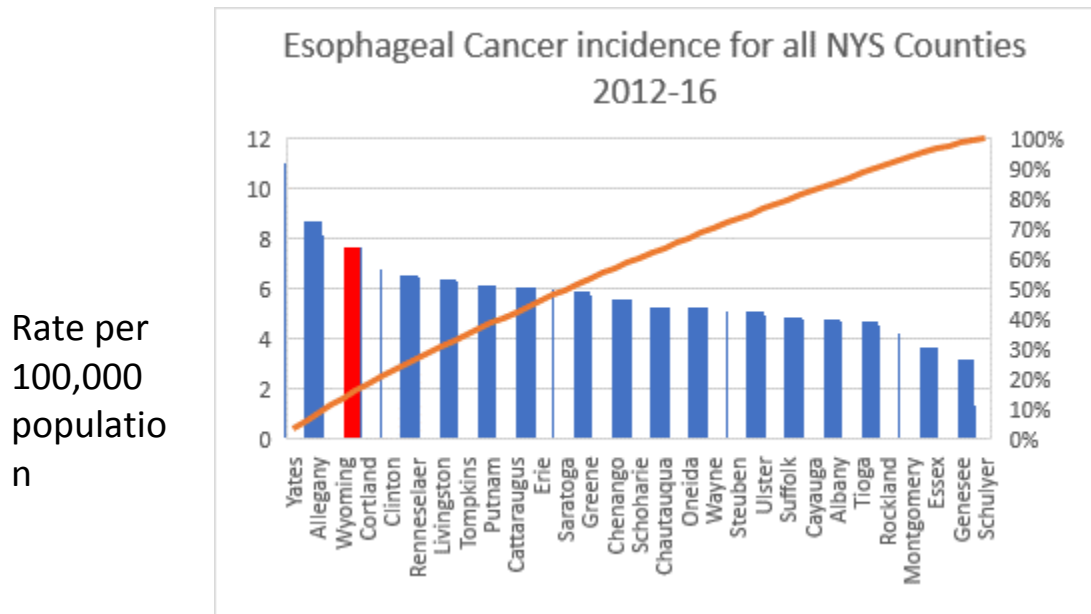
There are other environmental factors related to colorectal cancer that need attention. Disinfectant byproducts coming from drinking water treatment are an important risk factor. The report mentions two transient episodes of elevations at the Lagoon Manor Homeowners Association in 2009 and Glens Falls

City in 2003. But the EPA Enforcement and Compliance History online database reports for the years 2012-2017 the concentration of chloroform was 41.1 ppb, while the guideline was 0.4 ppb, a one-hundred-fold excess. The concentration of chloroform in the Queensbury water district was 42.4 ppb, even slightly higher. There were also significant elevations beyond guidelines for bromodichloromethane, hexavalent chromium, dichloroacetic acid, haloacetic acids, nitrate, radium, and total trihalomethanes in Glens Falls, and bromodichloromethane, dichloroacetic acid, haloacetic acids, total trihalomethanes, and trichloroacetic acid in Queensbury. Most of these are known human carcinogens. While it is not totally clear from the dataset, it appears that these are annual averages, not just one episode.

There are many carcinogens found in food that increase risk of colorectal cancer. While this is an ongoing area of research, this should be mentioned, especially in the situation where the behavioral risk factors cannot explain the elevation in rates.

Warren County also has an excessive risk of esophageal cancer, as shown in Figure 13. The DOH attributes this elevation to smoking and alcohol consumption. However the above information shows that smoking and excessive alcohol consumption cannot explain elevations in esophageal cancer rates. Other environmental causes of esophageal cancer are poorly understood, but passing off the elevated rates as being due to smoking and alcohol is not justified.

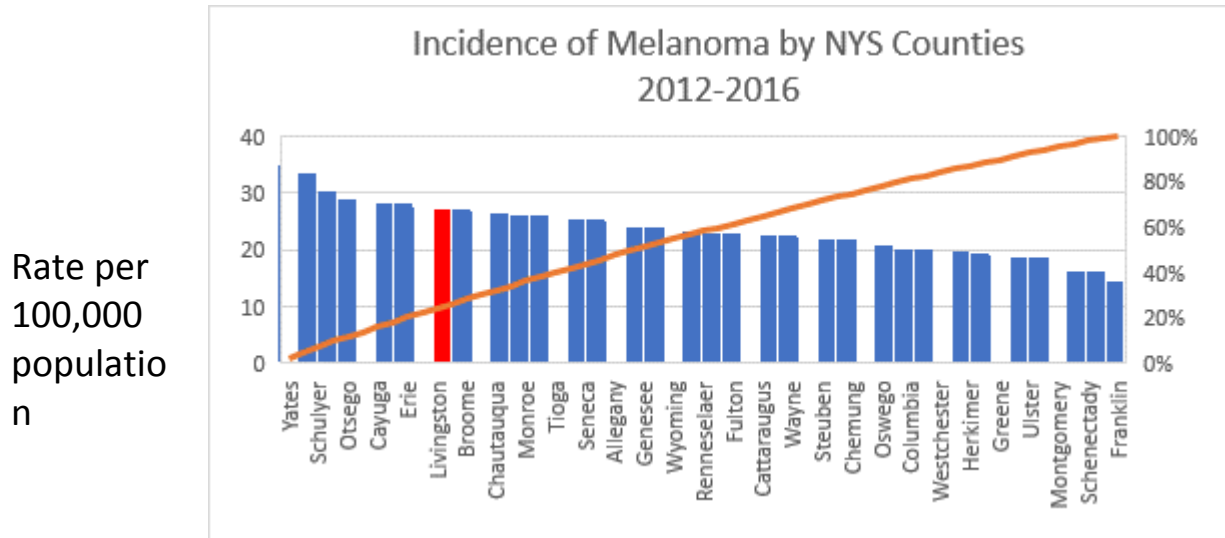
Figure 13: Esophageal cancer in NYS counties.



Only five counties exceeded the incidence of esophageal cancer reported in Warren County. The median rate for all counties for this type of cancer was 5.6 per 100,000 while Warren County's rate was 7.7.

Figure 14 shows rates of malignant melanoma in Warren County as compared to other NYS counties. The NYSDOH report attributes this elevation to the fact that the majority of residents of Warren County are Caucasian and that people with white skin are more vulnerable to developing melanoma. While this is true, the percentage of white people in Warren County is not higher than that for most of the other counties in the state that do not have large cities and are primarily rural.

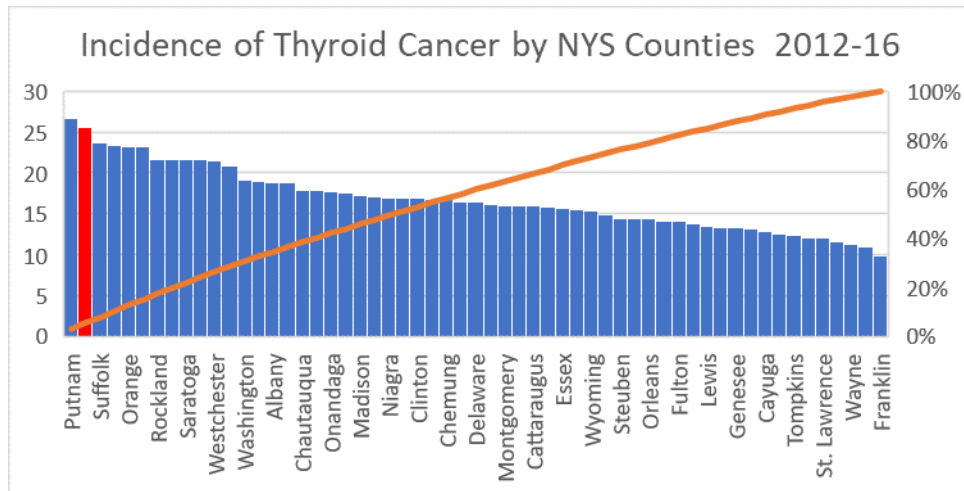
Figure 14: Rates of malignant melanoma for both sexes by NYS County.



Eleven counties exceeded Warren County in the incidence of melanoma during the period of the study. Warren County's rate of 27.4 exceeded the statewide median of 23.5 per 100,000 population.

Figure 15: Thyroid cancer in NYS Counties.

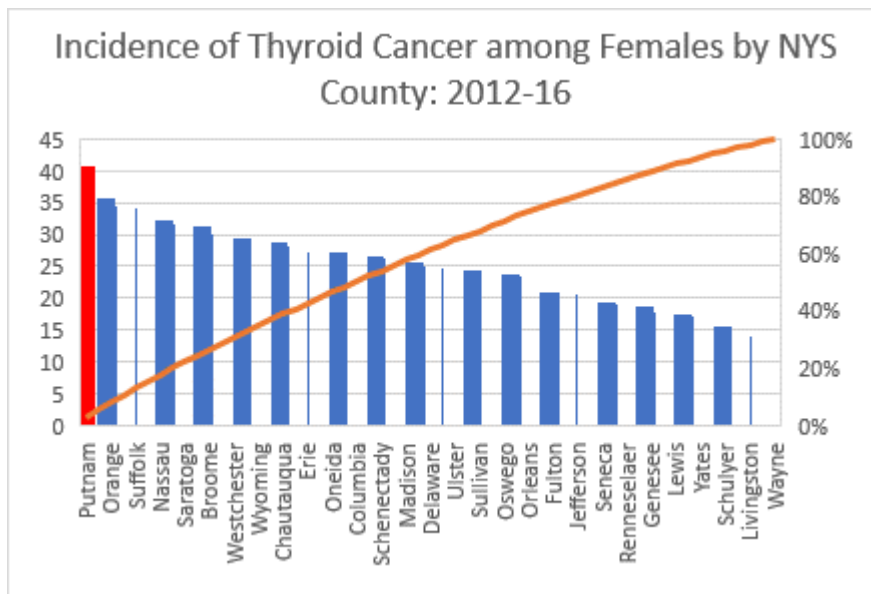
Rate per
100,000
populatio
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Only one county exceeded the rate of thyroid cancer in Warren County. The 25.5 rate per 100,000 population significantly exceeded the median of 16.4 for all counties.

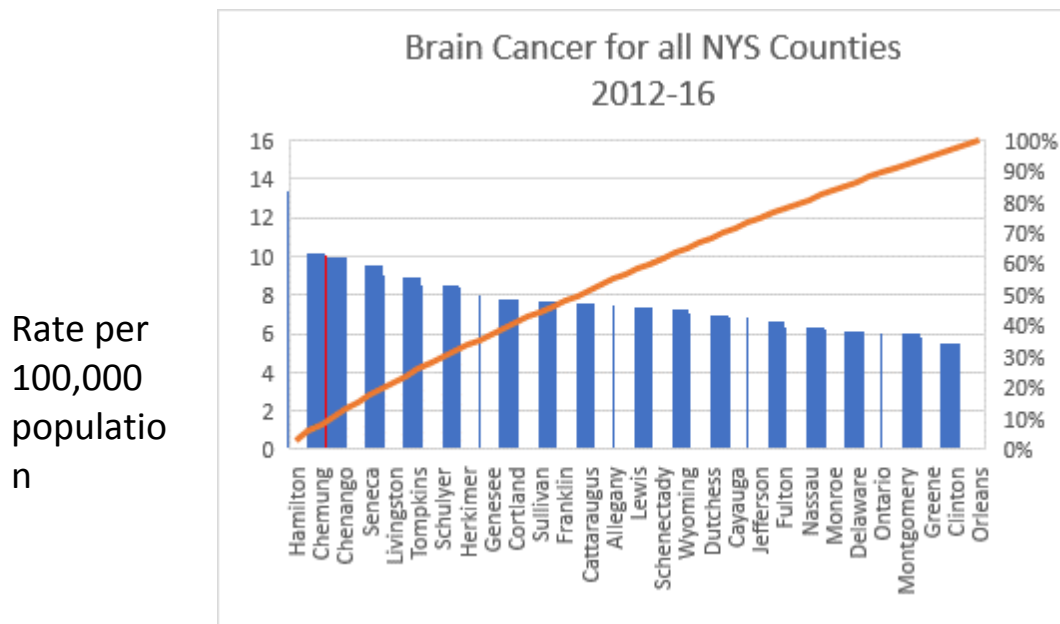
Figure 16: Thyroid cancer in women in NYS Counties.

Rate per 100,000 population



The rate of thyroid cancer among women in Warren County was 40.9 per 100,000, well above the median for all counties at 25.2. Warren and Putnam counties tied for the highest rate of all NYS counties.

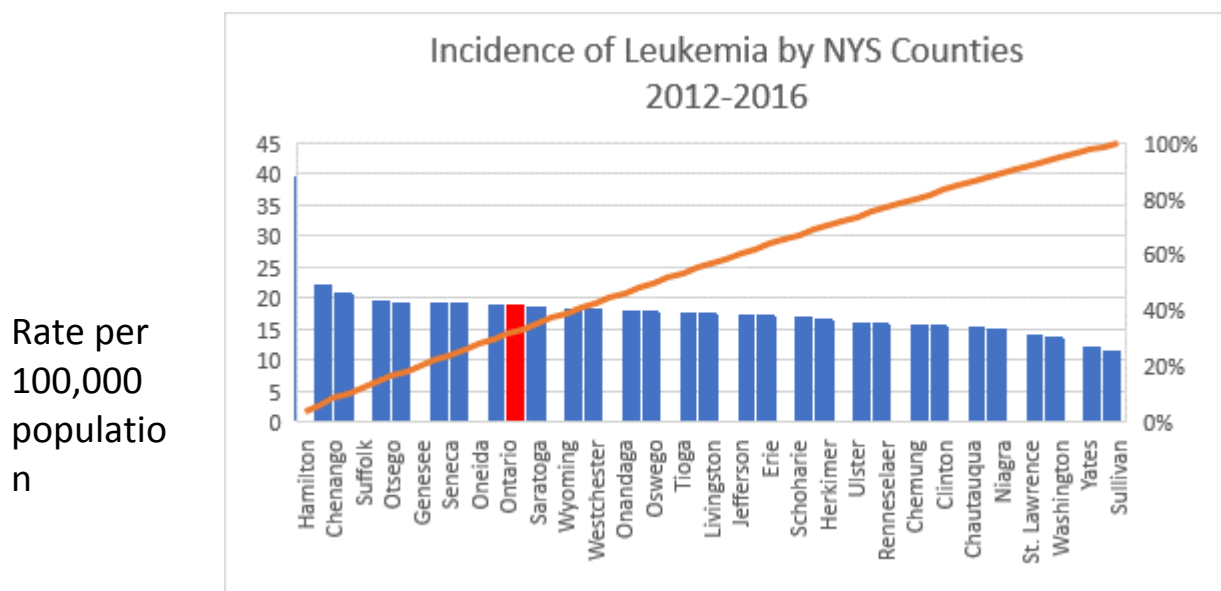
Figure 17 shows rates of brain cancer by county in NYS. Warren County has the fourth highest rate in the state outside of NYC.



Only three of 56 counties exceeded the rate of brain cancer reported for Warren County in the 2012-16 study. The Warren County rate of 10.1 was significantly above the median for all counties of 7.5 per 100,000 population.

Warren County also has elevated rates of leukemia. The elevation was almost entirely due to elevations in chronic lymphocytic leukemia in women, ages 20-49. One of the major risk factors for leukemia is exposure to benzene (Boberg et al. 2011). Benzene exposure comes from transport vehicles and emissions from major industries.

Figure 18: Rates of leukemia in NYS counties exclusive of NYC.



Warren County residents' rate of leukemia was 19.1 per 100,000 population during the period of the study. Fifteen counties exceeded that rate. The median for all counties was 17.9

Discussion and Conclusions:

Given that there are many causes of cancer, it is not easy to identify causes of higher rates in one region than another. Certainly personal behaviors such as smoking, excessive alcohol consumption, lack of adequate exercise and being overweight

or obese are risk factors for many diseases, including some cancers. But if one is going to place the blame for elevated rates of cancer on these personal life choices, one should be sure that they are indeed elevated. In this case the evidence that each of these is elevated among residents of Warren County to a degree sufficient to explain the higher rates of cancer is lacking. A more honest approach would be to simply state that the cause is not known with any certainty.

The other major problem with this DOH report is the failure to seriously consider environmental carcinogens as being responsible for the elevation in rates of these specific cancers. While the evidence for excessive exposure to air pollution, especially hazardous air pollutants and particulates, in Warren County is not strong, the DOH report dismisses air pollution other than coming from wood stoves as being a cause of cancer, while the World Health Organization has concluded that air pollution is a Group 1, known human carcinogen (IARC, 2013).

Diet is mentioned as a contributing factor, especially for colorectal cancer, but only in relation to inadequate consumption of fruits and vegetables. No mention is made of the host of carcinogenic substances found in many different foods, ranging from lipophilic carcinogenic chemicals such as dioxin and furans that come from emissions from industrial facilities and backyard burn barrels, and then bioconcentrate in all animal fats, to pesticides applied to vegetables and fruits.

There are many pesticides that are possible or probable human carcinogen present in both animal and plant products. Disinfectant byproducts in drinking water are mentioned but dismissed on the basis of old data.

The most blatant example of ignoring an environmental exposure known to cause cancer is the lack of any serious discussion of the possible role of polychlorinated biphenyl (PCB) exposure, given the long history of exposure in this region. PCBs are rated as known human carcinogens by the International Agency for Research on Cancer (IARC, 2016), a part of the World Health Organization.

There is strong evidence that PCB-contaminated sludge was widely distributed in wide regions of the county. Warren County is immediately adjacent to the Washington County towns of Hudson Falls and Fort Edward, where General Electric for years used PCBs to fill capacitors and transformers, leading to very significant contamination not only of the Hudson River but also of the surrounding area. Figure 19 shows geographic proximity of Glen Falls to Hudson Falls and Fort Edward.

Figure 19: Map of the Glens Falls, Hudson Falls and Fort Edward area with indications of the residents studied by Fitzgerald et al. From Fitzgerald et al. (2007). The triangles indicate the residences of the subjects of the study.

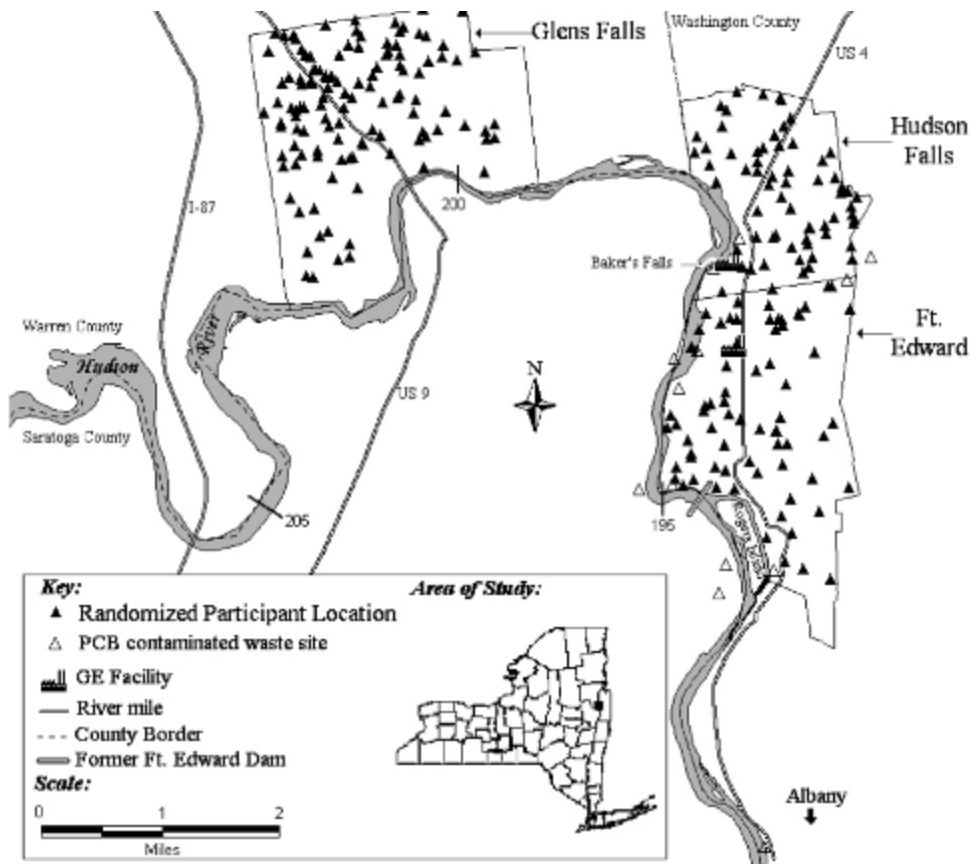


Fig. 1. Map of the Upper Hudson River: Fort Edward, Hudson Falls, and Glens Falls.

In an article in the New York Times on April 17, 2001, Robert Worth reported that more than six times as many PCBs were dumped on land as in the River. Much of this was in Warren County. There are many anecdotal reports of GE giving away and providing “clean” fill for yards, when in fact this was highly PCB-contaminated soils that were distributed around Warren County and other local communities without any warning of the dangers resulting. There are also many personal reports of GE providing PCB-contaminated oil to be sprayed on roads for dust control in the summer.

Thom Randall reported in the Post Star that 900,000 cubic yards of PCB-polluted sludge was dredged out of the River in the 1970s and either pushed up onto the shore or dumped at other sites in the region. The major dredging project occurred in 1974-1975 and there was a follow-up in 1977. There is a report on the NYS Department of Environmental Conservation website describing PCB contamination at the Bay Road Duck Pond. A local resident had obtained drums of PCB oil from the GE plant where he was employed and he used it as a weed killer in the pond. The contamination had spread downstream and had been remediated by the GE Corporation.

The question is whether residents of Warren County have been excessively exposed to PCBs as a result of the activities of General Electric at Fort Edward and Hudson Falls. The only mention of PCBs in the whole report is reference to one study done by DOH personnel monitoring air levels. But the Department of Health did not comment on the other research from this same research team, headed by Prof. Edward Fitzgerald. Dr. Fitzgerald was previously an environmental epidemiologist for the Department of Health, who then retired from the DOH and moved to be a professor in the Department of Epidemiology and Biostatistics at the School of Public Health at the University at Albany School of Public Health. All of these relevant publications were done as a collaboration with staff at the DOH.

These studies were designed to compare PCBs levels in people and measure indoor and outdoor air near residents' homes at Fort Edward and Hudson Falls with their control group – residents of Glens Falls. The study was based on the false assumption that people in Glens Falls were not exposed to PCBs, since they were upriver from the GE plants. Fitzgerald et al. (2007) report serum PCB concentrations of 67 men and 66 women from Fort Edward or Hudson Falls, and 60 men and 60 women ages 55 to 74 randomly selected from Glens Falls (see Figure 19). To their surprise they found higher PCB concentrations in Glens Falls residents (3.23 ppb) than folks from Fort Edward and Hudson Falls (3.07 ppb), and therefore concluded that it was not dangerous to live in Fort Edward! For comparison in the general US population the average PCB concentration reported in 2009 was 0.820 ppb (Patterson et al., 2009). Furthermore the 95th percentile was 3.53 ppb, which is to say that the average resident of Glens Falls has higher blood PCB concentrations than all but about 5% of the general US population.

Of the cancers elevated in Warren County, melanoma is the cancer that led the International Agency for Research on Cancer to declare PCBs to be a known human carcinogen (IARC, 2016). The Veterans Administration (VA Handbook, 2006) provides compensation for Vietnam Veterans who were exposed to Agent Orange containing dioxin for cancers of lung, larynx, trachea, and bronchus and chronic lymphocytic leukemia. PCBs have dioxin-like activity and diseases known to result from

dioxin exposure are also elevated upon PCB exposure (Carpenter, 2006). There is other evidence for PCBs and thyroid cancer, especially in the GE animal studies (Mayes et al., 1998). Thyroid cancer occurred in two individuals occupationally required to “smell” PCB-contaminated transformer oils (Carpenter, 2015). Howson et al. (2004) reported that some PCBs in blood were associated with a 2.94-fold increase in colorectal cancer. Hopf et al. (2009) have reported elevated rates of brain cancers among individuals occupationally exposed to PCBs. The elevated rates of leukemia in Warren County were almost only for chronic lymphocytic leukemia, the only form of leukemia that the VA Administration has concluded to results from Agent Orange exposure.

In conclusion, we have strong evidence from studies done by the DOH that a random sample of Glens Falls residents shows that they have very high levels of PCBs in their body. Furthermore the great majority of the cancers that are elevated in Warren County are those that are known to result from PCB exposure. The high rates of cancer in Warren County are not due to elevated rates of smoking or alcohol consumption nor elevated rates of obesity. They are due to PCB exposure resulting from contamination of the county by PCB-containing oils and soils.

References:

Boberg E, Lessner L and Carpenter DO. (2011) The role of residence near hazardous waste sites containing benzene in the development of hematologic cancers in upstate New York. *Int J Occup Med Environ Health*. 24: 1-12.

Bonner MR, Beane Freeman LE, Hoppin JA, Koutros S, Sandler DP, Lynch CF, Hines CJ, Thomas K, Blair A and Alavanja MCR (2017) Occupational exposure to pesticides and the incidence of lung cancer in the Agricultural Health Study. *Environ Health Perspect* 125: 544-551.

Carpenter, D.O. (2006) Polychlorinated biphenyls (PCBs): Routes of exposure and effects on human health. Rev. Environ. Health, 21: 1-23.

Carpenter DO (2015) Exposure to and health effects of volatile PCBs. *Rev Environ Health* 30: 81-92.

Fitzgerald EF, Belanger EE, Gomez MI, Huwang SA, Jansing RL and Hick HE (2007). Environmental exposures to polychlorinated biphenyls among older resident of upper Hudson River communities. *Environ Res* 104: 352-360.

Gharibvand L, Shavilik D, Ghamsary M, Beeson WL, Soret S, Knutsen R and Knutsen SF (2017) The association between ambient fine particulate air pollution and lung cancer incidence: Results from the AHSMOG-2 study. *Environ Health Perspect* 125: 378-384.

Hamra GB, Laden F, Cohen AJ, Raaschou-Nielsen O, Brauer M and Loomis D (2015) Lung cancer and exposure to nitrogen

dioxide and traffic: A systematic review and meta-analysis. *Environ Health Perspect* 123: 1107-1112.

Hopf NB, Waters MA and Ruder AM (2009) Cumulative exposure estimates for polychlorinated biphenyls using a job exposure matrix. *Chemosphere* 76: 185-193.

Howson M, Grimalt JO, Gjino E, Navarro M, Marti-Rague J, Peinad AM et al. (2004) Organochlorine exposure and colorectal cancer risk. *Environ Health Perspect* 112: 1460-1466.

IARC (International Agency for Research on Cancer) (2013) Outdoor air pollution. Monograph 109. In *IARC Monographs on the evaluation of carcinogenic risks to humans*, edited by International Agency for Research on Cancer.(IARC). Lyon, France: International Agency for Research on Cancer (IARC).

IARC (International Agency for Research on Cancer) (2016) Polychlorinated biphenyls and polybrominated biphenyl: evaluation of carcinogenic risks to humans. Monograph 107. In *IARC Monographs on the evaluation of carcinogenic risks to humans*, edited by International Agency for Research on Cancer.(IARC). Lyon, France: International Agency for Research on Cancer (IARC).

Lerro CC, Jones RR, Langseth H, Grimsrud TK, Engel LS et al. (2018) A nested case-control study of polychlorinated biphenyls, organochlorine pesticides and thyroid cancer in the Jans Serum Bank cohort. *Environ Res* 165: 125-132.

Loh MM, Levy JI, Spengler JD, Housemann EA and Bennett DH (2007) Ranking cancer risk of organic hazardous air pollutants in the United States. *Environ Health Perspect* 115: 1160-1168.

Loomis D, Browning SR, Schenck AP, Gregory E and Savitz DA (1997) Cancer mortality among electric utility workers exposed to polychlorinated biphenyls. *Occup Environ Med* 54:720-728.

Mallin K, McCann K, D'Aloisio S, Freels L, Piorkowski J, et al. Cohort mortality study of capacitor manufacturing workers, 1944-2000. *J Occup Environ Med* 46: 565-576.

Mayes BA, McConnell EE, Neal BH, Brunner MJ, Hamilton SB, Sullivan TM, Peters AC et al. (1998) Comparative carcinogenicity in Sprague-Dawley rats of the polychlorinated biphenyl mixtures Aroclors, 106, 1242, 1254, and 1260. *Toxicol Sci* 41: 62-76.

Moorthy B, Chu C and Carlin DJ (2015) Polycyclic aromatic hydrocarbons: From metabolism to lung cancer. *Toxicol Sci* 145: 5-15.

Patterson DG, Wong LY, Turner WE, DiPietro ES, McClure PG, Cash TP, Osterloh JD, Pirkele JL, Sampson EJ and Needham LL (2009) Levels in the U.S. population of those persistent organic pollutants (2003-2004) included in the Stockholm Convention or in other long-range transboundary air pollution agreements. *Environ Sci Technol* 43: 1211-1218.

Raaschou-Nielsen O, Anderson ZJ, Beelen R, Samoli E, Stafoggia M, Weinmayr G, Hoffman B et al. (2013) Air pollution and lung

cancer incidence in 17 European cohorts: prospective analyses from the European Study of Cohorts for Air Pollution Effects (ESCAPE). *Lancet* 14: 813-822.

Recio-Vega R, Mendez-Hernandez, Padua y Gabriel A, Jacobo-Avila A, Portales-Castanedo A et al. (2012) Potentially estrogenic polychlorinated biphenyls conveners serum levels and its relation with lung cancer. *J App Toicol* 33: 906-914.

VA Handbook (Veterans Administration Handbook) (2006) 1302: 10.