Relationship Between Cancer and Ecological Integrity

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Abstract

Evidence suggests a link between cancer and environmental degradation. Further, recent research suggests stream water quality may perform as a predictor of cancer in polluted areas. In this study we used ecological integrity as a measure of water quality along with incidence of cancer in four zip codes in Central Virginia. Streams were sampled throughout a 10 year period. Within the same time period, cancer data from the Virginia Cancer Registry was collected and incidence calculated. To determine relationships among variables, regressions were performed between ecological integrity and all cancer types. Total Cancer and breast cancer were the only cancer incidences significantly correlated with ecological integrity. Further, breast cancer relationship had a much greater slope indicating a stronger relationship to declining ecological integrity. We propose a number of explanations, chief among them a correlation with land disturbances typified in a suburban area and the suburban lifestyle. Further research into unique aspects of suburban lifestyle is suggested.

Introduction

Despite yearly advances in biological understanding and technology, science has not yet been able to conquer cancer as it has conquered other diseases. Research has looked towards both genetics and the environment for simple causation, and has come to the conclusion that cancer is multi-factorial disease. In fact, evidence suggests that breast cancer is the result of environmental influences on genetically predisposed individuals (Brown et. al. 2006). As a result, much of our understanding of cancer causation is from well controlled genetics experiments or epidemiological studies focusing on specific risk factors.

Environmental factors as etiology for cancer is difficult to quantify. Cancer is a diverse and complex set of diseases with a multi-factorial etiology with environmental factors acting on this complexity (McGuinn et. al. 2012). Additionally, exposures and effects at low levels in the environment are constantly present and this makes it difficult to predict or implicate a specific substance or process (Wild, 2009). Cancer implications pertaining to environmental factors are often circumstantial therefore making them difficult to pinpoint for control.

The pursuit of this investigation was inspired by findings from Hitt and Hendryx (2010). They found the ecological integrity of streams measured through benthic invertebrate surveys was negatively related to incidence of respiratory, urinary, digestive and breast cancers. Smoking, poverty and urbanization did not explain the relationship between ecological integrity to cancer yet the authors found coal mining provided links to environmental degradation and elevated cancer incidence.

A multitude of pollutants along with xenoestrogens that disrupt endocrine function are distributed to rivers and streams annually (Kolpin et. al.2002). Sources are diverse including agriculture, wastewater treatment and other human activities. These compounds often act synergistically and have shown adverse affects in fish (Jeffries et. al. 2010). Because impacts from these chemicals are synergistic their presence in the environment should cause concern.

In this paper we looked to correlate the incidence of cancer in the greater metropolitan area of Lynchburg Virginia with the ecological integrity of an area. It was our belief that declining water quality of an area represented greater cancer risk due to increased exposure to various pollutants. We also believed that links to environmental degradation would be independent of genetic predisposition and suggest a real link to environmental integrity and cancer risk.

Methods

Cancer data from the Virginia Cancer Registry was obtained for every recorded cancer case in the Central Virginia area over the past 10 years. Data included type of cancer diagnosed and zip code of the patient. All data was divided into cancer categories—oral, blood, digestive, respiratory, breast, female genital, male genital, and urinary cancers. Since the purpose of this study was intimately concerned with cancer incidence in certain zip codes rather than the ultimate outcome of those cancers, we calculated a cancer incidence proportion by dividing the number of cancer cases to the total 2010 population of the zip code. Population data was obtained from the United States Census Bureau as recorded during the year 2000 census.

Environmental integrity was calculated from collected fish population samples over a similar 10 year period. We use only fish populations in this study as we believe they represent longer term changes in stream health. A reach of stream (defined as 30 times the width) was sampled using electrofishing equipment. All fish were collected and immediately identified to species. We used a modified Index of Biological Integrity (Kerr et. al. 1986; Kerr and Chu 1998) modified to reflect stream health in central Virginia (Table 1). One stream reach in each zip code was sampled and IBI calculated.

Table 1 – Descriptions of measures used to calculate IBI in evaluated streams throughout the region of study.

IBI Measures	Description
Measure 1 – Total Fish Species	This measurement decreases with increased overall degradation.
Measurement 2 – Total number of darter species/relative percent of darter species to the total.	This measure decreases with increasing sedimentation and decreased benthic oxygen supply. The many darter species found in our area are benthic insectivores living in riffles.
Measurement 3 – Total number/relative percent of water column insectivores	This number generally decreases with the loss of riparian vegetation.
Measurement 4 – Total number/relative percent of pool-benthic insectivores.	This is a measure of sedimentation and channelization as pool-benthic habitat increases.
Measurement 5 – Total number/relative percent of intolerant species.	This measure distinguishes high and moderate quality sites using species that are intolerant of various chemical and physical perturbations.
Measurement 6 – Relative abundance of tolerant species	This measurement increases with human influences. It is a general measure of degradation.
Measurement 7 – Relative abundance of omnivores or generalist feeders	The percent of omnivores in the community increases as the physical and chemical habitat deteriorates
Measurement 8 – Relative abundance of top carnivores	Systems with high integrity are able to support adequate (up to 10%) populations of sport fish piscivores
Measurement 9 – Deviation from ideal or number of individuals in sample	It is expressed as the deviation from an ideal community as measured throughout the region

Collected samples were compared to known and ideal stream samples in the region and give a score from 1-5. A score of 1 reflected a sample that did not have species composition or diversity reflective of streams in the area. A score of 5 reflected well established conditions for a stream community. By evaluating all 9 measures to our collected samples a score of 45 reflects ideal conditions and is the highest IBI score assigned. A score of 9 reflects the lowest possible score and no adherence to known stream conditions.

Many simple regressions were used to evaluate the relationship between the incidence of a specific cancer type and the IBI for every year available. We did not adjust for any confounding factors.

Study Area

We conducted the study in the Blackwater Creek watershed in central Virginia (Figure 1). This are encompasses the city of Lynchburg and the surrounding counties of Campbell and Bedford. Each of the zip codes represented an area where a stream was sampled and cancer data compiled and incidence calculated. Some socioeconomic information can be generalized from both the location of each zip code and also land use data collected during the water quality studies.

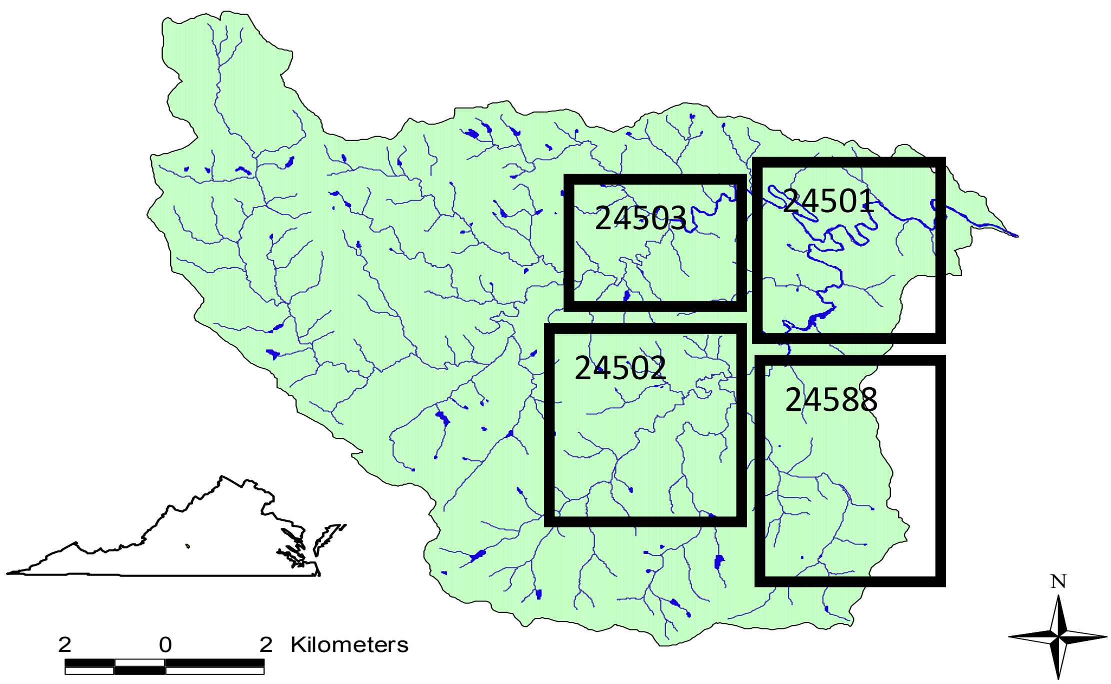

Figure 1 – Blackwater Creek Watershed with generalized zip code areas used in this study. The zip code boxes highlight the stream reaches studied. The city of Lynchburg is within the 24501 zip code.

Results

Both total cancer and breast cancer were correlated with ecological integrity (Figure 2). Higher incidence of cancer occurred in areas of poor ecological integrity. The breast cancer relationship was stronger as seen by the increased slope of the regression.

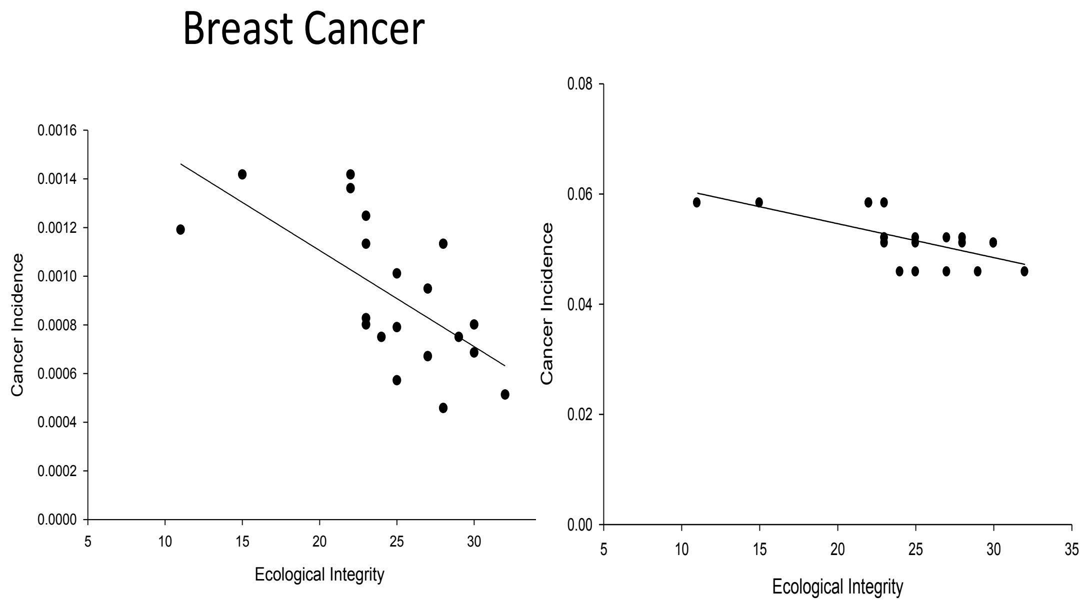

Figure 2 – Relationship between Breast Cancer, Total Cancer and Ecological Integrity. Cancer Incidence is per 1000 individuals and Ecological integrity is based upon 9 individual metrics measured from 9 (poor conditions) -45 (excellent conditions).

Ecological integrity was a measure of the overall condition of the stream based on fish species composition. Other forms of cancer were not correlated with ecological integrity (Table 2). Respiratory did show a similar trend to breast cancer but the relationship was not significant. And all other forms of cancer did not show any relationship.

Table 2 – Correlation Coefficients and Statistical Significance of all cancer types tested in our study. A simple ANOVA was used to test significance.

Cancer Type	Correlation Coefficient	Significance (p value)
Breast	0.43	0.002
Blood	0.002	0.84
Urinary	0.018	0.57
Genital Female	0.1	0.16
Genital Male	0.05	0.33
Respiratory	0.16	0.08
Digestive	0.03	0.48
Oral	0.008	0.7

Discussion

Our study suggests a significant association between total and breast cancer incidence and ecological integrity in central Virginia. This is in agreement to a similar study by

Brody et. al (2006) finding correlations between breast cancer incidence and decreased environmental integrity as measured by land disturbance or sewage pollution. Our data provides further demonstration of this link between land disturbance and cancer by looking at ecological integrity. Ecological integrity measured as IBI is the integration of land disturbance, sewage and other pollutants impact on aquatic organism health. The link found in this study suggests these human activities not only impact natural resources but also our own health.

Our study also provides further evidence supporting conclusions by Hitt and Hendryx (2010) suggesting direct relationships between ecological integrity and cancer mortality. Hitt and Hendryx (2010) suggested relationships to coal mining and toxins in West Virginia. Here we have no such obvious direct environmental risk factors to correlate our findings to. Brody et. al (2006) along with a much larger study on Long Island could not find direct epidemiological evidence linking specific pollutants to this elevated risk. While it is hypothesized that a suburban lifestyle could be harboring many risk factors that increase the risk of breast cancer no direct links can be suggested at this time. It is our belief that the same land disturbance that leads to degradation of water quality correlates with activities such as pesticide use, BPA in food and beverages, common household toxins or other behaviors that may create the elevated risk of breast and total cancer. While it is convenient to assume this behavior may cause the elevated risk it does not provide an explanation. We believe that it is the degradation itself that may be the link expressing itself in fish mortality and breast cancer incidence.

Considering confounding factors in our study we did not have access to many. Tobacco use and broad consideration of socioeconomic information from zip code was available. Whereas a low socioeconomic status is considered a risk factor for coronary artery disease, a higher socioeconomic status is associated with an increased risk of breast cancer. It is quite clear from this study that both the increase in total cancer as well as breast cancer was associated with the low values for ecological integrity. While the other forms of cancer show no correlation to our environmental data it is clear that higher socioeconomic status (as demonstrated through land disturbance producing low IBI scores) has a higher incidence of cancer in our area.

Specific links to endocrine disruptors and xenoestrogens are chemicals that interfere with the normal functioning of the endocrine system and reproduction in animals. These include chemicals found in vectors as diverse as pesticides and certain types of fish. Some of these chemicals can bio-accumulate in the environment, and may be present in stream water that has run-off the land. Currently there is dispute among the scientific community about what, if any, adverse health effects exposure to these established endocrine disruptors invites. Some believe that a low level exposure cannot be enough to cause harm (cite), while others believe that exposure could just be one of the aforementioned environmental hits that could result in breast cancer in a predisposed individual (cite). If risk factors are modifiable, then it would be prudent to limit exposure if possible as the evidence could come later.

Many other associations have been proposed and, although they have not yet been proven conclusive, have nevertheless acted as a springboard for future theories and experiments (cite articles about sunscreen, etc.). As of yet, there has been very little research combining breast cancer incidence and environmental integrity. Many diseases have been shown to have both a genetic and environmental component (cite). Therefore, it follows that an analysis of specific cancer incidence and ecological integrity could add to current understanding of not only cancer, but other diseases, and this study attempts to fulfill that role.

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