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Public domain small-area cancer incidence data for New York State, 2005-2009

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Abstract

There has long been a demand for cancer incidence data at a fine geographic resolution for use in etiologic hypothesis generation and testing, methodological evaluation, and teaching. In this paper we describe a public domain data set containing data for 23 anatomic sites of cancer diagnosed in New York State between 2005 and 2009 at the level of the census block group. The data set includes 524,503 tumors distributed across 13,823 block groups with an average population of about 1,400. In addition, the data have been linked with race and ethnicity and with socioeconomic indicators such as income, educational attainment, and language proficiency. We demonstrate the application of the data set by confirming two well-established relationships: that between breast cancer and median household income, and that between stomach cancer and Asian race. We foresee that this data set will serve as the basis for a wide range of spatial analyses and serve as a benchmark data set for evaluating spatial methods in the future.

Key Words

Introduction

There has long been a demand for a free high-quality publicly available data set of cancer incidence data at a fine geographic resolution. Such a data set provides a common reference that researchers can use for examining the potential relevance of etiologic risk factors, for evaluating and comparing spatial statistical methods, and for pedagogic purposes. Within the United States, researchers have made extensive use of a data set of 592 cases of leukemia diagnosed in central New York between 1978 and 1982 that was originally described by Waller et al. (1992, 1994). Despite its age, this data set continues to be cited frequently (Gangnon, 2012; Rogerson, 2012). Alternatively, some researchers make use of study-specific data sets that cannot be shared for reasons of patient confidentiality, while others rely on synthetic data (Guo and Wang, 2011).

The New York State Department of Health (NYSDOH) has published a public domain data set that goes a long way toward meeting this demand (New York State Department of Health, 2013a). It was the result of state legislation passed in 2010 mandating that NYSDOH make detailed cancer data available to the public (State of New York, 2013). The data set consists of observed and expected counts for 23 anatomic sites of cancer at the neighborhood scale, diagnosed between 2005 and 2009. An enhanced version of the data linked to United States census data is also available at http://tinyurl.com/onpd6zp.

In this paper we describe this data set, create some basic cancer surveillance maps, and conduct some basic ecologic analyses. For the latter, we examine the associations between female breast cancer and median household income and between stomach cancer incidence and the proportion of Asians in the population. These examples were selected because the relationships are well-established and should presumably be evident in the data. Additionally, the fine geographic

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resolution of these data should allow for additional insights beyond what can be obtained through conventional non-spatial analysis.

Regarding the ecologic analyses, stomach cancer rates among Asian-Americans are consistently high, with infection by *h. pylori* regarded as the primary etiologic factor (Fock and Ang, 2010). Stomach cancer rates among Asians are more than double those for non-Hispanic whites both in New York State (New York State Cancer Registry, 2014) and in the eighteen states and metropolitan areas included in the National Institutes of Health's SEER program (National Cancer Institute, 2012). Minor risks for stomach cancer not specific to Asians include a high intake of salt-preserved foods and dietary nitrite combined with low intake of fruit and vegetables, along with smoking (Brenner et al., 2009). Stomach cancer also exhibits large gender differences, with rates among men roughly double those of women.

Breast cancer incidence has consistently been found to relate to higher socioeconomic status (SES), as described in a recent review of 90 studies over the 1978-2009 period (Klassen and Smith, 2011). Most researchers have used SES as a marker for specific behaviors or exposures known or believed to have an etiologic relationship with cancer, including age at menarche and menopause, parity, nulliparity, age at first birth, and oral contraceptive use. However, since many of these behaviors tend to occur in combination as part of broader lifestyle patterns, the reviewers conclude that a compelling case can be made for considering SES as a direct risk factor for breast cancer (Klassen and Smith, 2011).

Methods and Materials

Cancer incidence data

The data represent all invasive malignant tumors diagnosed among New York State residents between 2004 and 2009 and recorded in the New York State Cancer Registry (NYSCR) as of November 3, 2011. The NYSCR achieved the highest national certification levels for data timeliness, completeness, and quality over this entire time period (North American Association of Central Cancer Registries, 2014). The 23 anatomic sites included in the data set account for 86 percent of all reportable malignant tumors in New York State. This set of cancer sites encompasses the most common cancers plus certain less common cancers with well-hypothesized environmental or occupational etiologies. A listing of the 23 sites and the number of tumors diagnosed in the 2005-2009 period is given in Table 1. The data set additionally includes counts for all other sites combined (71,785), for a grand total of 524,503 tumors. Only 503 tumors (0.1%) had to be excluded because they lacked age, sex and/or any address information. The full data set can be freely downloaded from the New York State Department of Health web site: https://health.data.ny.gov/Health/Cancer-Mapping-Data-2005-2009/cw3n-fkji.The data are provided at the level of the census block group. Block groups are relatively homogeneous statistical units of about 600 to 3,000 people and are the smallest unit for which sample-based data are tabulated by the United States Census Bureau's American Community Survey (United States Census Bureau, 2014). In New York State in the 2010 census, there were 15,464 block groups, with an average population of 1,253, and 94% of these had a population of between 600 and 3,000. In order to protect patient confidentiality, a block group needed to have a minimum of 6 tumors diagnosed among males and 6 tumors diagnosed among females,

summed over all cancer sites, for it to be included in the data set. Block groups not meeting this threshold were merged with neighboring block groups from the same census tract using a downloadable geographic aggregation tool developed in SAS version 9.2 (SAS Institute, Inc., Cary, NC). (Babcock 2010; Talbot and LaSelva, 2010). This resulted in a reduction in the number of block groups by 11% to 13,823 and a corresponding increase in average population to 1,402. In the data set, merged block groups are identified with a custom code containing the letters 'DOH' so as not to be confused with census codes. The census block groups comprising each merged block group are provided in a separate crosswalk file.

For approximately 94% of the cancer cases, the block group was determined by automated matching of the address at diagnosis to a street reference file maintained by the New York State Office of Cyber Security. For about 5% of the cases, the block group was determined by clerical review of the address, where it failed to match the reference file for reasons such as misspellings, use of unofficial street names, post office box-only addresses, partial or ambiguous addresses, or addresses too new to have been included in the street reference file. The clerical review was performed by staff of the NYSCR using various online reference sources and the New York State Department of Motor Vehicles database. For the remaining 0.75% of the cases, the block group was imputed by randomly matching with a record sharing the same ZIP code.

Expected counts were calculated using the indirect standardization method, adjusted for sex and 5-year age groups up to 85+, using the 2010 census counts for New York State. As a consequence, for every cancer site, the sum of the expected counts equals the sum of the observed counts.

In exchange for such fine geographic detail, other aspects of the data had to be omitted to ensure patient confidentiality. Accordingly, there is no information on the age, sex, race, ethnicity, or any other demographic characteristics of the cases, except where the sex is implied by the cancer site. These data can be obtained elsewhere on the NYSDOH web site at the county or state level.

Cluster membership data

In addition to observed and expected counts, the public domain data set also includes an indicator variable used to highlight block groups with unusually high or low cancer incidence, as determined using the spatial scan statistic (Kulldorff et al., 1997). A block group was defined as a high incidence area if (i) it was included in the most likely high incident rate cluster detected by the spatial scan statistic, provided the cluster was statistically significant at the alpha=0.05 level, or (ii) it was included in a non-overlapping secondary cluster also statistically significant at the alpha=0.05 level, and (iii) the observed rate was at least 50% higher than the expected rate. A block group was defined as a low incident area in the same manner, except here the expected rate had to have been at least 50% higher than the observed rate. The third criterion was imposed to minimize the tendency to identify small absolute differences in risk between large portions of the state (most typically between New York City and upstate New York) and instead emphasize smaller areas with greater variations in risk (Boscoe et al., 2003). Each record in the data set thus contains the block group identifier, observed counts, expected counts, and cluster membership status (high, low, or neither) for each of the 23 cancer sites, plus all other sites combined.

Enhanced data

The enhanced data set adds the populations for each block group by sex, race, ethnicity, average household size, number of occupied and vacant housing units, number of persons above and below the poverty line, number of persons in each of 16 income categories, median household income, number of persons with and without at least a high school education, and number of persons with limited English proficiency. The population counts here are from the 2010 United States Census (2011a) and the socioeconomic data are from the 2006-2010 American Community Survey (United States Census Bureau, 2011b).

Interactive cancer incidence map

In addition to the downloadable data, an interactive map of the data can be viewed on the NYSDOH web site (New York State Department of Health, 2013b). This map also allows the viewing of locations of regulated environmental sites and facilities within the state, ranging from fuel tanks to commercial pesticide sellers to hazardous waste sites. Figure 1 shows a screen capture from this site, showing breast cancer and hazardous waste generators in a portion of Manhattan. The web site is designed for viewing on a typical computer screen with a horizontal format, so the map actually extends much further to the right.

Descriptive maps

For this paper, we constructed two maps of the data. The first shows standardized incidence ratios (SIRs, the ratio of the observed to expected cases) for female breast cancer in Manhattan; the second shows clusters for the same data using the cluster membership indicator variable described above. We chose Manhattan because of its international familiarity and because areas

much larger than this are difficult to depict on a standard page size. For the SIR map, we classified the SIRs into seven categories and used a diverging color scheme centered on the statewide rate (that is, centered on an SIR of 1). Note that the SIRs and clusters are relative to New York State and not to Manhattan or New York City.

Ecological analyses

We assessed the relationship between stomach cancer and Asian race by calculating the percentage of the population in each block group with a race of "Asian alone" as measured in the 2010 Census by cluster membership (high, low, or neither). Additionally, we tabulated the relative risk of stomach cancer for different concentrations of Asians, independent of the cluster locations. For breast cancer, we used median household income data for the 2006-2010 period from the American Community Survey. We calculated the median household income by cluster membership, and then the relative risk of breast cancer for each income decile, independent of the cluster locations. All calculations were performed using SAS version 9.2 (SAS Institute, Inc., Cary, NC).

Results

Descriptive Maps

Figure 2 shows the two views of the breast cancer data for Manhattan. The SIR map, containing values for 981 block groups, is noisy given that the mean number of breast cancer cases per block group is 6, with a range from 0 to 77. Even so, general patterns of high rates east and west of Central Park and low rates in Chinatown can be discerned. The cluster map identifies four areas of high rates and one area of low rates that are numbered on the map. Descriptive statistics

for these cluster areas are given in Table 2. Cluster 4 also includes data from two block groups

outside of Manhattan. Each of these five clusters meets the criteria described above: statistically

significant, non-overlapping, and with a relative risk greater than 1.5 or less than two-thirds.

Because interesting spatial patterns might not necessarily follow a circular shape, or because the

no-overlap rule may cause interesting patterns on Manhattan to be masked by more pronounced

patterns in nearby Brooklyn, Queens, or the Bronx, we attempted to use the SIR map to identify

additional areas of interest from among those not included in a cluster. These are labeled A and

B on the cluster map: a seeming low area centered in Washington Heights and a seeming high

area in Harlem, both elliptical in shape. However, neither met all of the inclusion criteria.

Although the Harlem cluster had more than a doubling of risk, the number of cases was

insufficient to reach statistical significance. Conversely, the Washington Heights cluster was

statistically significant but the relative risk was above the cutoff used to identify low-risk

clusters.

Ecological Analyses

The stratification of stomach cancer cases by cluster membership is shown in Table 3. Elevated

clusters comprise 27.7% of the state population and 51.8% of the Asian population, meaning that

Asians are 1.87 times more likely to reside in an elevated stomach cancer cluster than not. They

are similarly less likely to live in a non-cluster area and much less likely to live in a low cluster

area.

Stratification of stomach cancer cases by the percent Asian within each block group yields the

results shown in Table 4. Majority-Asian block groups have a stomach cancer incidence rate that

is more than double the average rate in the state. The rate is slightly elevated for block groups that are 10 to 50 percent Asian, and below the expected rate for block groups less than 10 percent Asian.

The stratification of breast cancer cases by cluster membership is given in Table 5. The difference in household median income between high and low cluster areas is a factor of 3. Stratifying the block groups by median income deciles shows a nearly monotonic increase in risk with increased income, with a 40 percent difference in risk between the highest and lowest deciles (Figure 3).

Discussion

We have described a highly granular public-domain cancer incidence data set and conducted some simple analyses using the data as published. Our intention was to demonstrate that this data set is a convenient resource for the detailed exploration of spatial patterns of disease and for the evaluation and comparison of different spatial statistical and epidemiological methods.

We began by mapping SIRs and high and low clusters directly from the data set itself (Figure 2). An SIR map is an obvious way of viewing the data, but it has limited utility when the number of counts per geographic unit are small. Using the eye to identify some potentially interesting patterns on this map did not identify any that were missed by the spatial scan statistic, though there still could be some potential public health relevance to the 39 cases identified in a small section of Harlem where only 18 were expected. We do note that SaTScan, the software for calculating the spatial scan statistic, has the capability of identifying elliptical clusters, but this feature was not used in the data set described here and has been infrequently used by researchers

generally. Indeed, SaTScan has many customizable parameters (Amin et al., 2014) and users of these data are not bound by the cluster memberships included in the file. The spatial scan statistic is just one technique for boosting the signal-to-noise ratio in small-area disease data and many other techniques are available (Talbot et al., 2000; Johnson, 2004; Ozonoff et al., 2005).

Next, we conducted two simple ecological analyses using the data set. We identified a 2.5-fold increased risk between majority-Asian and non-Asian neighborhoods, which is greater than the roughly 2-fold risk between Asians and non-Asians in New York State and SEER. This suggests that stomach cancer risk could be more acute in ethnic enclaves than among Asians generally. This in turn could be related to the nationalities that tend to live in such enclaves (for example, Chinese and Korean) as opposed to those who are more assimilated and dispersed (such as Indian and Filipino), and their respective risks of *h. pylori* infection. Alternatively, it could simply be because of geographical variation in risk among the Asian population (McCracken et al., 2007). A natural follow-up question would be to investigate how stomach cancer rates among a particular group (say, Koreans) in Korean-majority neighborhoods compare with those among Koreans in Korean-minority neighborhoods. Such distinctions are seldom made in epidemiological studies but have implications for how doctors and public officials communicate risks to various racial and ethnic groups. Investigating this question is well beyond the scope of this paper and would require more detailed data than what is in the public data set, but we mention it here because it is a good example of the kinds of novel hypotheses that can emerge when data are available at a fine geographic resolution.

Our second application focused on the relationship between breast cancer and socioeconomic status. SES remains an understudied dimension of public health in part because these data are

rarely collected directly by population-based surveillance systems (Toprani and Hadler, 2013). Our finding of more than a 40 percent difference in risk between the highest and lowest income deciles is consistent with previous findings (Klassen and Smith, 2011). Much of what is known about the relationship between breast cancer and SES has come from case-control and cohort studies; our analysis had the advantage of being relatively simple and straightforward to execute. As such, it lends itself to use in classroom teaching. Two of the authors of this paper have taught a graduate-level class in Geographic Information Systems and Public Health for over a decade, and one of the greatest difficulties in the class has been locating geographically rich data sets that allow interesting findings to be generated within a period of about four to six weeks (the time between when basic competency in GIS is achieved and the end of the semester). While it is possible to obtain interesting results from coarse data sets at the level of states or counties, it is often the case that the relationships of interest are diluted by their highly heterogeneous nature. For example, New York has 62 counties but over half of the population lives in the seven which comprise New York City and Long Island. It makes no sense to assign identical socioeconomic characteristics to each person in Manhattan or Brooklyn. At the other extreme, a semester is too short to make use of data sets requiring outside permission or approval.

The data set also lends itself to methodological applications. For example, we know of one doctoral student who is using these data to study the effects of the modifiable areal unit problem on health outcomes at varying spatial resolutions (Nelson, 2014). Two master's students at another institution used these data as the basis for their capstone projects (William Scheider, University of Buffalo Department of Epidemiology and Environmental Health, personal correspondence). It has also been used in training workshops on spatial statistical methods given at several national conferences. More broadly, the data set has the potential to serve as a

benchmark data set for the evaluation and comparison of different spatial statistical methods involving spatial aggregation, clustering, smoothing, and regression (Kulldorff et al., 2004; Auchincloss et al., 2012). Here we limited ourselves to analyses drawn directly from the data as published – the observed and expected counts, cluster memberships, and linked census variables – but the applicability of these additional spatial statistical methods should be self-evident. Further, by including common as well as rare cancers, different aspects of the methods can be explored. The breadth of cancer sites also allows the findings to be interpreted in the context of known and hypothesized etiological relationships. In short, these data offer far more options than the 30-year old data set of 592 leukemia cases from central New York.

Of course, no single data set can serve all needs. Perhaps the largest limitation of these data is the lack of block group information on the ages or age ranges of the cancer patients. While the age structure of the population is captured by the expected case counts, it is not possible to use these data to do age-specific analysis (for example, clusters of cancer patients under age 65) or to apply a different population reference standard. Similarly, the lack of individual sex, race, or ethnicity information constrains the kinds of analyses that can be performed, as does the absence of information on cancer stage, subsite, histology, treatment or survival. While this is a drawback for some epidemiological investigations, it is typically not an issue when evaluating and comparing spatial statistical methods. In summary, we anticipate that this data set can serve as a foundation for many methodological and epidemiological spatial analyses in the years ahead.

Acknowledgements

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Figure 3. Relationship between median household income (from 2010 census) and breast cancer incidence (2005-2009 diagnoses), New York State, at the block group level.

Cancer Site and ICD-O-3 classification (Fritz et al., 2000)	Number of tumors, 2005-2009
Prostate (C61)	78,162
Female breast (C50)	72,296
Lung and bronchus (C34)	67,217
Colon and rectum (C18-C20, C26.0)	49,801
Bladder, including in situ (C67)	25,134
Non-Hodgkin lymphoma (morphologies 9590-9596, 9670-9671, 9673, 9675, 9678-9680, 9684, 9687, 9689-9691, 9695, 9698-9702, 9705, 9708-9709, 9714-9719, 9727-9729; 9823, 9827 except where site is C42.0, C42.1 or C42.4)	22,279
Uterus (C54-C55)	17,194
Kidney and renal pelvis (C64-C65)	16,371
Thyroid (C73)	15,109
Leukemia (morphologies 9733, 9742, 9800-9949, 9963-9964)	14,091
Pancreas (C25)	13,927
Oral cavity and pharynx, excluding nasopharynx (C00-C10, C12-C14)	10,799
Stomach (C16)	9,285
Liver and intrahepatic bile duct (C22)	8,342
Ovary (C56)	7,582
Brain and other nervous system (C70-C72)	6,714
Esophagus (C15)	5,467
Larynx (C32)	4,179
Soft tissue (C38.0, C47, C49)	3,385
Testis (C62)	2,690
Bone and joint (C40-C41)	1,026
Mesothelioma (morphologies 9050-9055)	979
Nasal cavity and nasopharynx (C11, C30-C31)	689

Table 1. Cancer sites, ICD-O-3 classifications, and numbers of tumors included in the data set.

Cluster	Number of block groups	Observed	Expected	Relative Risk	Log-likelihood	p-value
1	36	330	206.1	1.60	31.5	<0.001
2	34	292	192.6	1.52	22.2	<0.001
3	23	150	88.6	1.69	17.6	<0.001
4	21*	211	139.7	1.51	15.7	0.003
5	38	167	265.4	0.63	21.1	<0.001
A	81	384	518.4	0.74	19.3	<0.001
B	4	39	18.0	2.17	9.2	0.120

*Also includes one block group on Roosevelt Island and one block group in Queens, both to the east of Manhattan and not shown in the figure.

Table 2. Statistics for breast cancer clusters on Manhattan.

Geographic location	Percentage of New York State population	Percentage of New York State Asian population	Index of concentration
High cluster	27.7	51.8	1.87
Not in a cluster	52.7	41.0	0.78
Low cluster	19.6	7.2	0.37

Table 3. Asian population by stomach cancer cluster type.

Asian % in block group	Observed stomach cancers	Expected stomach cancers	Relative risk (RR)
50% +	435	192	2.27
10 - < 50%	1,877	1,586	1.18
5 - < 10%	1,347	1,356	0.99
< 5%	5,626	6,150	0.91

Table 4. Stomach cancer risk by Asian population proportion.

Geographic location	Percentage of New York State households	Median household income, 2010 ($)
High cluster	5.9	102,556
Not in a cluster	92.1	56,622
Low cluster	1.9	35,658

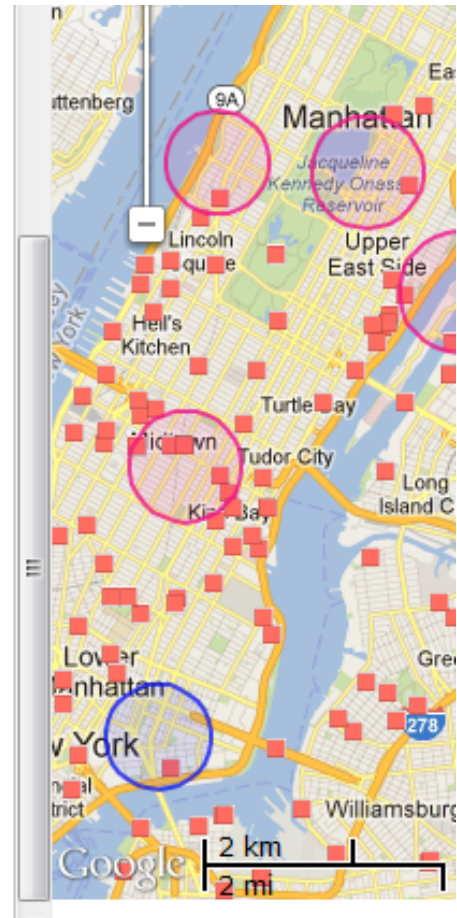Table 5. Median household income by breast cancer cluster type.

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Figure 2. Breast cancer incidence, Manhattan, 2005-2009. (a) Standardized incidence ratios, by block group (b) Clusters as defined by the spatial scan statistic (red and blue) and other areas of interest suggested by the SIR map (magenta and green).
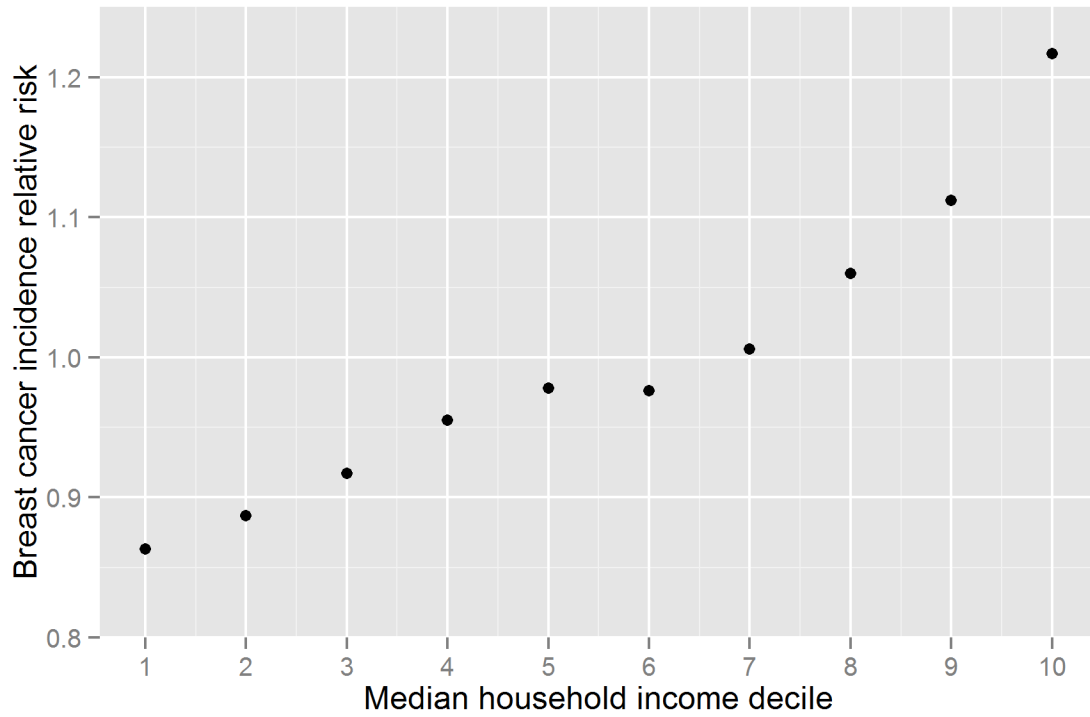
Figure 3. Relationship between median household income (from 2010 census) and breast cancer incidence (2005-2009 diagnoses), New York State, at the block group level.