Update: Tumor Incidence in Residents Adjacent to the Lookout Mountain Antenna Farm 1979-2002

Golden, Colorado

Prepared by:
Colorado Department of Public Health and Environment
In Collaboration with the Department of Environmental Health at Colorado State University, and the Department of Preventive Medicine and Biometrics at the University of Colorado Health Sciences Center

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I. INTRODUCTION

This study is an update of earlier reports released by the Colorado Department of Public Health and Environment (CDPHE) in June 1998 and February 1999, which evaluated cancer incidence in the Lookout Mountain area for the period 1979-1997.[1,4] The current study updates the incidence of a variety of cancers, including brain and central nervous system (CNS) tumors in census tract 98.10 (see Figure 1), by including cases diagnosed during 1998-2002.

In June 1998, the State Health Department completed an epidemiologic study that was initiated in response to concerns about the health status of people living in Jefferson County, Colorado adjacent to the Lookout Mountain antenna farm.[1] Prior to the initiation of the study, a scientific advisory panel consisting of researchers and epidemiologists from the Jefferson County Health and Environment Department, the Department of Environmental Health at Colorado State University, and the Colorado Department of Public Health and Environment was convened to develop a study protocol and provide peer review of the study results. The May 28, 1998 protocol was described in a document entitled *Protocol for a Study of Cancer Incidence in Residents Adjacent to the Lookout Mountain Antenna Farm*.[2]

At the time of the 1998 study, previously published epidemiologic studies had suggested a possible association between electromagnetic radiation (EMR) and increased rates of brain tumors, particularly in persons working in certain occupations.[5, 7-9,11,22-24,26-29] Some positive findings were also reported for populations with possible radiofrequency (RF) radiation exposure in residential settings, although the epidemiological evidence has not been consistent or conclusive, in part due to limitations of the designs of the research studies.[6,7,18-21] The panel concluded that, while no conclusive association between RF exposure and increased risk of cancer had been established in the published scientific literature, there also was not sufficient information to exclude the possibility of increased risk under some circumstances.

The objective of the June 1998 study was to examine the incidence of a number of different types of cancer in census tract 98.10, which includes communities near the Lookout Mountain antenna farm, and to compare the incidence to that of the Denver metropolitan area. Cancer incidence data were available for the Denver metropolitan area from the CDPHE

Colorado Central Cancer Registry (CCCR), a population-based registry of cancer diagnoses for the entire state of Colorado. The study looked at the incidence of several cancer types that had been hypothesized in other epidemiological studies to be potentially associated with radiofrequency (RF) field exposures. Overall, the number of cancers diagnosed in census tract 98.10 was not higher statistically than would be expected for the ages and numbers of males and females living there. An addendum to the June 1998 report was released in July 1998.[3] The addendum differed from the initial report in the comparison population selection. The July 1998 report relied on a comparison population that was restricted to 30 census tracts in the Denver metropolitan area with a median household income similar to census tract 98.10. The calculations presented in the addendum did not change the conclusions of the original study.

When the June 1998 report was released, analyses of areas smaller than the entire census tract had not been done. It was recommended in the June 1998 report that if additional radiofrequency exposure data become available, the CDPHE scientific advisory panel should convene "to determine if a relationship between exposure distribution and existing block groups can be identified, ...to guide the design of any further studies." In August 1998, a citizens group provided CDPHE with maps of radiofrequency measurements taken on Lookout Mountain and maps indicating the residence location of persons with suspected brain cancers, based on word-of-mouth information available to community members. The maps raised a concern among community members of possible spatial clustering of brain cancer cases in areas where the radiofrequency (RF) measurements were higher relative to other parts of Lookout Mountain. Based on the availability of the RF exposure measurements, the panel recommended additional study of cancer incidence for smaller geographic areas, called block groups (BG), within census tract 98.10. The advisory panel recommended that the block group analysis focus on brain and other central nervous system (CNS) tumor incidence, because these were the only consistently elevated ratios (although within expected statistical variation) reported in the 1998 study.

The 1999 block group analysis analyzed available brain/CNS tumor data for 1979-1997.[4] Observed/expected (O/E) ratios were calculated for malignant tumors, and for all malignant and benign tumors combined. The following results were presented for the seven block groups within census tract 98.10:

- For benign and malignant tumors combined, all O/E ratios were within expected statistical variation except for females living in block group 2 (O/E=5.02, 95 % CI= 1.04-14.68; results based on 3 cases). Histology was consistent for all 3 cases diagnosed in women in BG2- all had benign meningiomas.

- For malignant tumors only, all O/E ratios were within expected statistical variation except for males living in block group 3 (O/E=4.40, 95 % CI= 1.20-11.25; results based on 4 cases). Cell types listed for the 4 cases diagnosed in men in BG3 were malignant astrocytomas and glioblastomas.

The report concluded that some evidence from the study supported an association between RF exposure from the antennas and brain/CNS tumors, and some did not.

Study findings that were **consistent** with an association included:

- BG2 and BG3 (where statistically elevated O/E ratios occurred) were the block groups located closest to the towers.
- All cases (or surviving family members) reported that the residence had an unobstructed view to the towers (i.e., potential for exposure).
- For all cases from BG2, interviews indicated individuals had lived in the Lookout Mountain area for 10 years or longer.

Study findings that were **inconsistent** with an association included:

- Two of the five cases diagnosed from BG3 had lived near the Lookout Mountain antennas less than 5 years.[1]
- Four of the five cases from BG3 had also worked in an occupation associated with an increased risk of developing a brain tumor (electrical or telecommunications work, aircraft pilot, work with meteorological radar).[2]
- Cell types were not the same for BG2 and BG3 cases, and men and women were not similarly affected in each block group.

The 1999 study concluded that the inconsistencies noted above weaken the hypothesis of a common etiology of elevated brain/CNS tumors in the two block groups with statistically elevated O/E ratios. However, the study also acknowledged the prevailing uncertainty and inconsistencies in the state of the science regarding the plausibility of an association between RF exposure and cancer, as well as large uncertainty in using geographic area (residence by block group) to estimate RF exposure from the towers. The 1999 study recommended that O/E ratios be updated after the 2000 census data were available, and that CDPHE continue to monitor the evolving scientific evidence regarding health effects of non-occupational radiofrequency exposure.

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[1] - The current panel notes that while latency, or time between exposure and clinical recognition of a disease, is believed to be at least 5 years and usually more than 10 years for a genotoxic environmental exposure and cancer, tumor promoters may shorten latency periods for disease already initiated. Non-ionizing radiation has been suggested to act as a promoter, however uncertainty remains regarding a potential biological mechanism by which RF radiation might act. Therefore, it is not yet possible to assign a scientifically based estimate of cancer latency associated with RF exposure.

[2] - The current panel notes that these exposures could represent an alternative source of exposure to non-ionizing radiation or could be additive, with exposures to the towers as a contributory factor.

This update of cancer incidence in residents in the Lookout Mountain community recalculates O/E ratios using the 2000 census population estimates for the geographic area defined by census tract 98.10, and for the block groups within the tract, for cases reported to the state Cancer Registry from 1979-2002. Literature published since the 1999 study has not yet established a conclusive association between electromagnetic radiation and cancer nor has it identified a toxicological mechanism of action. A discussion of the developments in the scientific literature is presented in the discussion section of this report.

As with the prior investigation, a scientific advisory panel was convened with representatives from the Department of Environmental Health at Colorado State University, the Department of Preventive Medicine and Biometrics at the University of Colorado Health Sciences Center, and CDPHE.

II. METHODS

The June 1998 study considered all of census tract 98.10 as one geographical unit for statistical purposes, using 1985-95 Cancer Registry data and 1990 census data. The February 1999 study of brain and CNS tumors examined incidence in the seven block groups of census tract 98.10 from 1979 (the first year of complete metro Denver data from the Cancer Registry) through 1997. Calculations were performed separately for 1979-84 and 1985-97 because of changes in population between 1980 and 1990 and changes in the geographic boundaries for some of the block groups between the 1980 and 1990 U.S. censuses. At that time, 2000 census data were not yet available to aid in population estimation between 1990 and 1997.

The present study uses the previous census data and the more recently available 2000 census data to better estimate population changes over the 1979-2002 time period. It also updates cancer statistics for the area for the same time period.

A. Definition of study areas and time periods selected for study

The area of study adjacent to the Lookout Mountain antenna farm was defined by census tract 98.10 boundaries established for the 1990 Census. The boundaries of this census tract are Clear Creek, U.S. Highway 6, I-70, the Dakota Hogback, Bear Creek, State Highway 74, Cold Springs Gulch, I-70 and Beaver Brook. The total population of census tract 98.10 was 11,601 in 2000, 8,897 in 1990, and 5,971 in 1980. As of the 2000 Census, the area covered by census tract 98.10 is now defined as two census tracts 98.44 (with six block groups) and 98.45 (with four block groups). For purposes of historical consistency with the earlier reports, references to the smaller areas within the tract, called block groups, have been maintained with their 1990 Census boundary definitions. These are presented schematically in Figure 1 and are described below.

- Block group 1 (1990 definition), generally located in the northwest portion of the census tract, is bounded by Lookout Mountain Road, I-70, Beaver Brook and Clear Creek. 2000 population = 1392.

- Block group 2 (1990 definition) is a small area located mostly west of the corner of Highway 6 and Lookout Mountain Road. 2000 population = 500.

- Block group 3 (1990 definition) is generally bounded by Lookout Mountain Road, Highway 6, Heritage Road and I-70. 2000 population = 3066.

- Block group 4 (1990 definition) is an "island", i.e., completely contained, within block group 5 (1990 definition); therefore analyses for block group 4 were combined with block group 5. Block groups 4 and 5 make up a triangle shaped area bounded by Highway 6, I-70 and Heritage Road. 2000 population for block group 4 = 615 and for block group 5 = 1931.

- Block group 6 (1990 definition) in the southeast portion of the census tract is bounded by I-70, the Dakota Hogback, Bear Creek, and Grapevine Road. 2000 population = 287.

- Block group 7 (1990 definition) in the southwest portion of the census tract is bounded by Bear Creek, State Highway 74, Cold Springs Gulch, I-70 and Grapevine Road. 2000 population = 3810.

Boundaries for the entire census tract and for block groups 1, 4/5, 6, and 7 were the same in the 1980 and 1990 Census definitions. For the areas covered in 2000 by this census tract and these same block groups, 2000 populations could be used directly or apportioned (especially to maintain the 1990 definition of block group 1 and still use 2000 population data), so analyses for these areas were performed for the entire time period from 1979 to 2002. Block groups 2 and 3 were separate in the 1990 census, but, in 1980, the area covered by these two block groups was one block group for census purposes with no sub-block group boundaries matching the 1990 block group boundaries. Because of this situation and slight changes in the boundaries for block group 3 in 2000, analyses for these two block groups were restricted to the years 1985-2002. The 1990 definition of block group 3 was maintained even though 2000 population data were used.

B. Tumor types selected for study

This study presents an update of all tumor types and age groups evaluated in the two previous studies.[1, 4] Cancers included were leukemia, brain and central nervous system (CNS), non-Hodgkin lymphoma, female breast, eye melanoma, and all cancers combined. Benign brain and CNS tumors, in addition to malignant brain tumors, were investigated for all block groups to be consistent with previously published epidemiologic studies. For the 2004 update, tumors

included in the 2002 Central Brain Tumor Registry of the U.S. (CBTRUS) standardized definition of brain tumor were also considered.[30] This included tumors from the pineal and pituitary glands and certain olfactory tumors of the nasal cavity. For leukemia, brain and CNS, and all cancers combined, tables were prepared for children age 0-14, cases age 15+, and all ages combined. All other cancer sites were evaluated for all ages combined.

Primary brain and CNS tumors are categorized in the CCCR according to the International Classification of Diseases for Oncology (ICD-O) anatomic site and histology codes. Tumors metastatic to the brain or CNS from a distant primary site are not included. Likewise, tumors originating in other structures of the face, head, and neck are not included. The ICD-O codes include a classification for tumor behavior, i.e., benign, in-situ, malignant, or uncertain.

Additional tumors assessed based on the 2002 definition of brain tumors published by CBTRUS were pituitary and pineal glands (ICD-O site codes C75.1-C75.3) and olfactory tumors of the nasal cavity [ICD-O site C30.0 (histologies 9522-9523)]. There were no cases of olfactory tumors of the nasal cavity reported during 1979-2002 in the Lookout Mountain area. There were seven cases of pituitary gland tumors (all benign) and no pineal gland cases, compared to about seven cases of these two tumors combined expected over this time period. These seven cases were distributed evenly throughout the area with no more than two cases reported from any single block group. No statistical testing was done on these data because block group level case counts were all less than three.

C. Calculation of observed/expected ratios of cancer cases and tests of statistical significance

The expected number of individual types of cancer was calculated by multiplying the comparison area's age- and gender-specific incidence rates by the age- and gender-specific population estimates for census tract 98.10 (and its seven block groups for the brain and CNS tumors). Risk ratios termed Observed/Expected, or O/E, ratios were calculated by dividing the number of diagnosed cases by the expected number of cases for the geographic area for a particular time period. The ratio of the observed number of tumor cases to the expected number may be considered a standardized incidence ratio (SIR).

For brain and CNS tumors we performed two types of analyses: (1) an O/E ratio for all brain and CNS tumors (combining benign and malignant) and (2) an O/E ratio for malignant tumors alone. Previously published epidemiologic studies of general population exposure to RF sources have been inconsistent regarding the type of tumors included in the investigations, with some studies looking only at the occurrence of malignant tumors, while others have investigated both benign and malignant tumor outcomes.

In this study, the O/E ratios are reported with 95% confidence intervals. Observed/Expected ratios that have a 95% confidence interval that includes the value of 1 are

not considered statistically high or low. For example, an O/E ratio of 1.50 with a 95% confidence interval of 0.2 to 3.6 includes the value 1 in the confidence interval, i.e., 1 is within the interval from 0.2 to 3.6. Therefore, the O/E ratio is considered to be within expected statistical variation and not a "statistically significant" outcome.

The statistical significance of the O/E ratio, or SIR, was tested by treating the observed number as a Poisson variate in respect to its expected frequency.[12] A two-tailed test was used to test the null hypothesis that there was no difference between observed and expected numbers of cancer cases. The probability level of 0.05 was used as a cutoff with the one-tail bound at the 0.025 level. We did not perform statistical testing on O/E ratios with less than three observed cases due to the high statistical variability that is inherent with such frequencies.

D. Adjusting for income

All observed/expected statistics for the present study were calculated using a standard area for comparison that included census tracts in the Denver metropolitan area with similar incomes as the Lookout Mountain study area, defined as census tract 98.10. There is a well-recognized association in the epidemiological literature between socioeconomic status (SES) and brain tumor occurrence, with risk increasing with higher SES.[10, 17] As in the past studies, an attempt was made in this update to control for potential bias from differences in SES by limiting the comparison population used to estimate expected case counts to only those census tracts in the Denver metropolitan area that were within $5,000 of the median household income of census tract 98.10.

For the 1979-84 time period, 35 census tracts with a 1980 median household income between $22,286 and $25,286 (within plus or minus $1500 of the median household income of $23,786 in census tract 98.10) were selected from the Adams, Arapahoe, Douglas, Denver and Jefferson counties to use as the standard. Median household incomes were obtained from the report, *1980 Census of Population and Housing, Census Tracts, Denver-Boulder, Colorado Standard Metropolitan Statistical Areas, PHC80-2-138,* published by the U.S. Dept. of Commerce, Bureau of the Census in June 1983.

For the 1985-95 time period, 30 census tracts with a 1990 median household income between $43,875 and $53,875 (within plus or minus $5000 of the 1990 median household income of $48,875 in census tract 98.10) were selected from Adams, Arapahoe, Douglas, Denver and Jefferson counties to use as the standard. Median household incomes were obtained from a December 1993, Denver Regional Council of Government's publication, *The New Audience: a demographic report about older adults in the region: Census Tracts by County.*

For the 1996-2002 time period, 17 census tracts with a 2000 median household income between $75,500 and $85,500 (within plus or minus $5000 of the 2000 median household income of $80,000 in the area covered by census tract 98.10, or census tracts 98.44 and 98.45 in

2000) were selected to use as the standard. Median household incomes were obtained from table P53, Census 2000 Summary File 3 (SF 3) on the U.S. Census Bureau website, http://factfinder.census.gov.

It had been determined previously, using 1990 census data, that there was variation in the median household income among the seven block groups of census tract 98.10. However, because the number of Denver metropolitan area comparison census tracts (and corresponding population size) would be small for several of the seven block group income categories, we selected comparison census tracts using the median household income for the entire 98.10 census tract and used the same tracts for comparisons with all seven block groups.

The 35 census tracts used for the 1979-84 portion of the analysis totaled nearly 154,000 persons in 1980, the 30 census tracts used for the 1985-95 calculations totaled nearly 121,000 persons in 1990, and the 17 census tracts used for the 1996-2002 calculations totaled about 75,000 persons in 2000. For all time periods combined, the race/ethnicity composition of census tract 98.10 (about 94% white, non-Hispanic) was similar to the comparison areas (about 90% white, non-Hispanic). Cancer cases diagnosed in the comparison population were about 95% white, non-Hispanic compared to 97% white, non-Hispanic in census tract 98.10.

E. Case interviews

As was done for the 1999 study, follow-up telephone interviews were conducted with individuals diagnosed with a brain/CNS tumor, or surviving family member, for cases reported as residing in block groups where statistical elevations were observed, i.e., block groups 2 and 3. No statistical testing was performed on the results of the interviews. The interviews were intended to provide descriptive epidemiologic information for the purpose of exploring whether it was plausible that disease was associated with radiofrequency radiation from the antennas.

Case interviews were conducted by telephone to gather data on length of residence near the antennas, approximate distance of the home from the antenna towers, the person's occupation (a potential confounder), whether there were close blood relatives who had a brain tumor, and whether there was an unobstructed view of the antenna towers from the residence. Radiofrequency radiation can be effectively blocked by hillsides, trees, or other structures. Therefore, an unobstructed view of the towers would indicate the potential for exposure from the antennas. RF intensity has also been shown to decrease rapidly with distance from the source, and questions about distance from the towers were intended as an estimate of the potential for significant radiofrequency exposure. Information was gathered on length of residence in the Lookout Mountain area prior to diagnosis. Cases or individuals responding to the interviews were asked whether past occupational exposure to EMR may have occurred prior to diagnosis, however there was no attempt to gather detailed information about the length of exposure or precise nature of job duties.

III. RESULTS

The purpose of this report is to update tumor incidence statistics reported in the previous 1998 and 1999 CDPHE reports.[1,4] Results displayed in Tables 1a-4b show updated O/E ratios calculated using Census 2000 population data, as well as additional cases of brain/CNS tumors reported to the state Cancer Registry for the 1998-2002 time period. Table 5 displays the number of brain and CNS cases diagnosed by year in the entire census tract and in individual block groups, for the period 1979-2002.

Tables 1a, 1b, and 1c display the number of cancer cases diagnosed compared to the expected number of cases in census tract 98.10 during 1979-2002 for each of the different cancer types evaluated. All of the comparisons were within expected statistical variation or statistically lower than expected, based on the age and sex of the residents and using the comparison areas of census tracts socioeconomically similar to census tract 98.10. A total of 882 cancers were diagnosed among males and females compared to about 968 cases expected for a ratio of 0.91, which was statistically lower than expected. The male ratio for all cancers of 0.96 (468 cancers compared to about 487 cases expected) was within expected statistical variation, while the female O/E ratio for all cancers combined of 0.86 (414 cancers compared to about 481 cases expected) was statistically lower than expected. Leukemia ratios for males and both genders combined were also statistically lower than expected.

The O/E ratio for all cancer types for cases aged 0-14 and 15 and over were also mostly within expected statistical variation. The exceptions were statistically lower than expected ratios for male leukemias aged 15 and over, female cancers combined aged 15 and over, male and female cancers combined aged 15 and over, and male and female leukemias aged 15 and over.

Tables 2a, 3a, and 4a, show the number of brain and CNS tumors (combining benign and malignant tumors) diagnosed in census tract 98.10 during 1979-2002, while Tables 2b, 3b, and 4b are restricted to persons with malignant brain tumors.

For tables 2a, 3a, and 4a, the observed number of cases in the entire census tract was close to the expected number based on the age and sex of the residents and using comparison areas of census tracts socioeconomically similar to census tract 98.10. A total of 38 brain and CNS tumors were diagnosed during 1979-2002 in the entire census tract among males and females compared to about 35 tumors expected for an O/E ratio of 1.09. This is within expected statistical limits. The O/E ratio for males of 1.12 (19 tumors compared to about 17 expected) and the O/E ratio for females of 1.06 (19 tumors compared to about 18 expected) were also within expected statistical variation. Individual block group O/E ratios for benign and malignant brain tumors combined are displayed in Tables 2a, 3a, and 4a. Ratios were all within expected statistical variation except for females in block group 2 whose ratio of 4.39 (four tumors compared to about one expected) during 1985-2002 was statistically high. One male case was diagnosed in block group 2 in the 1985-2002 time period and one male from block group 2 was

diagnosed with a malignant brain tumor in 1980 (see Table 5). The O/E ratio for males and females combined in block group 2 was within expected statistical variation. The histology for the tumors of the four cases diagnosed in women in block group 2 during 1985-2002 was the same: benign meningioma. One male in block group 2 was diagnosed with a benign neurilemoma (schwannoma) during the 1985-2002 time period. The histology for the one male case diagnosed prior to 1985 was malignant astrocytoma.

Individual block group O/E ratios for malignant brain tumors only are displayed in Tables 2b, 3b, and 4b. Risk ratios were all within expected statistical variation except for males in block group 3. There were five malignancies diagnosed in males in block group 3 during the time period 1985-2002, compared to approximately one or two cases expected--an O/E ratio of 3.49 (95% CI: 1.13-8.15, $p<0.05$). The O/E ratio for males and females combined in block group 3 was within expected statistical variation. The histologic type for the five cancers diagnosed in males was listed as 1 astrocytoma, 1 medulloblastoma, and 3 glioblastomas.

Table 6 summarizes all data collected by telephone interview for 1985-2002 brain/CNS cases in block groups 2 and 3. Table 6 reflects interview responses gathered from both the 1999 study and the 2004 update. Interviews have indicated that all five cases in block group 2 had lived in residences that had direct line of sight to the antenna towers. One reported some obstruction of the line of sight by trees from inside the home but clear line of sight from outside the home in their yard. One had worked in an occupation associated with increased incidence of brain tumors. The length of time reported by interview that the five cases had lived in block group 2 prior to diagnosis was as follows: 18 years, 18 years, and 22 years, 11 years, and 33 years (average residence of approximately 20 years). In block group 3, five of six diagnosed individuals or a surviving family member have been successfully contacted since 1999. Interviews indicated that four of five individuals diagnosed with a brain or CNS tumor in block group 3 had worked in an occupation associated with an increased risk of developing a brain tumor. The fifth case occurred in a young child. The length of time persons with a brain tumor had lived in block group 3 prior to diagnosis was calculated based on information from the five interviews (4 male cases and 1 female case) and varied as follows: less than 1 year, 3 years, 5 years, 26 years, 26 years (average residence of approximately 10 years). All individuals interviewed from both block groups indicated there was direct line of sight to the antenna towers from the residence at the time of diagnosis. No one from either block group reported a history of serious head injury (resulting in concussion or requiring hospitalization) or radiation therapy for medical conditions prior to diagnosis.

The results of the current analysis confirm the findings of the 1999 study. Statistically significant SIRs persist in women in block group 2 and in men in block group 3. There has been one new case diagnosed in women in block group 2 and one additional case reported in men in block group 3. The histologic pattern of the new cases resembles that of the original cases diagnosed from 1985-1997 reported in the 1999 study. One new case of benign meningioma was diagnosed in a female in block group 2, and one new case of malignant medulloblastoma was

diagnosed in a male in block group 3. Consequently, SIRs for women in block group 2 and men in block group 3 remain statistically significant and the confidence intervals have become narrower (indicating greater precision of the risk estimate) with the larger study sample.

IV. DISCUSSION

The study design used in this update is essentially the same as the design used in the 1998 tract-level analysis and the 1999 block group-level analysis of cancer incidence.[1,4] As discussed in those previous reports, this type of health statistics review, designed to investigate an apparent excess number of people with a particular disease outcome, does not allow definitive conclusions to be made about a cause and effect relationship with any particular potential exposure, such as electromagnetic radiation from broadcast antennas.[25, 43] Studies of this type are frequently conducted around communities adjacent to suspected environmental exposures since they can readily and inexpensively use data routinely reported to cancer registries and allow citizens to compare cancer incidence in their community to the expected incidence based on rates in a similar comparison population not affected by the environmental exposure of concern.[13-15] Observed differences between communities, however, are not necessarily attributable to the hypothesized exposure. Lack of reliable data for critical exposure variables such as a measurement of individual exposure, in- and out-migration, other exposures inside or outside the home, or length of residence may result in misclassification bias in studies of this nature. Furthermore, inherent in this study design is that information on some potential confounders may be lacking and cannot be easily controlled for. This study was able to control for potential confounding due to population differences in age and sex, by calculating age- and sex-adjusted tumor rates. It also took into account socioeconomic status, since the comparison areas were roughly matched on income. SES has been shown to be an important risk factor for brain/CNS cancer.[10]

Data on individual-level exposures to electromagnetic radiation were not collected in this study, and geographic area (assigning cases to block group area) was used as a surrogate for exposure, similar to the 1998 and 1999 studies. Preliminary spot radiofrequency (RF) measurements from the Lookout Mountain area, taken by local scientists in the fall of 1998, indicated that the intensity of RF exposure is highly dependent on whether a residence has an unobstructed direct line of sight to the antennas. Because of the complex topography in the census tract, RF exposure within some block group boundaries is not uniform, and therefore, block group is at best a crude measure of exposure.

Telephone interviews of brain/CNS cases from block groups 2 and 3 indicated that all residences had direct line of sight to the antennas from their residence at the time of diagnosis, but this information does not confirm or quantify "exposure" or make meaningful comparisons to non-cases. Differences in residency time were reported, with all of the cases from block group 2 having lived at the residence listed at the time of their diagnosis for more than 10 years, while 3 of the 5 cases from block group 3 reported living at that residence for less than 5 years.

While latency, or the time between exposure and clinical recognition of a disease, is believed to be at least 5 years and usually more than 10 years for a genotoxic environmental exposure and cancer, tumor promoters may shorten latency periods for disease already initiated. As discussed below, non-ionizing radiation has been suggested to act as a promoter, however uncertainty remains regarding a potential biological mechanism by which RF radiation might act. Therefore, it is not yet possible to assign a scientifically based estimate of latency for exposure to RF radiation.

Variations in RF exposure to residents may have occurred over time for several reasons: more antennas were installed, changes occurred in broadcast frequency and intensity, and objects (e.g., buildings, trees) that could obstruct RF exposure were constructed, grew, or were removed. Lack of historical exposure data also results in uncertainty about what is the appropriate time period to examine. Radiofrequency exposures from Lookout Mountain antennas could have begun in the 1950s, but cancer registry data were not available until 1979. The latency period for brain tumors may be less than 10 years, but in the absence of complete information about incident cases occurring in the 1950s, 1960s, and 1970s, the scientific review panel could only examine incidence data on brain/CNS tumor occurrence reported to the state Cancer Registry since 1979, when complete cancer reporting began for the Denver metropolitan area.

There is still considerable debate about whether residents living near the Lookout Mountain towers are exposed to RF levels above current U.S. standards and exposure guidelines, and whether these safety guidelines are protective for chronic or low level RF exposure. The Federal Communications Commission (FCC), with input from other public health agencies, such as EPA, NIOSH, and FDA, is responsible for setting non-ionizing radiation exposure standards in the U.S. for telecommunications and broadcasting devices. Federal standards and guidelines on RF safety have not been revised since 1999 and are currently set at levels that will prevent biological effects caused by heating of tissue within the body.[38] Thermal effects (tissue heating) from exposure to high intensity RF are well established and data are adequate to set protective levels to prevent such short-term acute health effects in the general public and workers. Most national and international safety guidelines, such as those developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP),[36, 37] are based on similar dosimetry that establishes specific absorption rates (SAR) at levels that ensure harmful temperatures will not occur in various tissues in the body. A variety of safety factors are then applied to protect the general public and sensitive individuals.

Most western countries have now adopted ICNIRP guidelines or a similar approach. Some countries (Russia, China, Italy, Switzerland) have adopted standards based on prevention of thermal effects, with additional safety factors applied to protect against other possible non-thermal health outcomes. These exposure guidelines may differ by a factor of 100 or more from other western standards, however, many of these approaches have been criticized for basing a quantitative standard on studies of uncertain design, some of which rely on health endpoints not widely recognized in the U.S. medical community.[42]

According to recent reviews, most national and international organizations still consider the scientific evidence regarding RF exposure and chronic disease to be inconclusive and insufficient to establish quantitative exposure limits based on non-thermal effects associated with long-term chronic exposure or exposure to lower intensity RF fields.[32-35, 39-41,44] While some studies have demonstrated biological effects at RF exposure levels below those that produce tissue heating, conclusive evidence of harmful effects linking RF exposure to human health effects is not available and no causal mechanism attributable to RF exposure has been consistently demonstrated for these non-thermal effects.

Several large reviews of the available scientific literature on RF exposure and cancer have been released since 1999, with the majority of the work focusing on exposure to hand-held cell phones and base stations. [31-34,39-41] One of the most recent and comprehensive reviews of RF and cancer was completed in 2004 for the National Radiation Protection Board (NRPB), the United Kingdom's (U.K.) regulatory group.[41] As reported by the NRPB, some of the human epidemiologic data suggests an increased risk for some types of cancers from exposure to RF emissions, however the studies lack consistency in the types of cancers with positive outcomes and in the strength of association from one study to the next. An additional weakness in the epidemiologic literature is that most of the studies conducted to investigate RF exposure in populations living near communication towers have not had a reliable measure of chronic exposure. All of these factors, along with the absence of an identified biological mechanism, contribute to a weak causal relationship between RF exposure and increased risk of cancer.

As mentioned above, a specific mechanism of action has not been established for RF exposure and cancer outcome. Unlike ionizing radiation, energy from RF field exposure is not sufficient to break chemical bonds or directly damage DNA, but other mechanisms of harm have been proposed, such as heat stress proteins that may promote faster tumor growth.[40,41] Most *in vitro* studies have been negative for DNA damage, mutation frequency, and chromosome aberration frequency. Some animal studies report positive findings (strand breaks in DNA and increased malignancies) but generally only at exposure levels high enough to cause thermal heating.

The NRPB concludes that while the weight of evidence from the available studies does not suggest an increased risk of cancer from RF exposure from cell phones, the available studies also are not of sufficient length to rule out possible effects from long-term continuous exposure.[40,41] The agency currently recommends a precautionary approach until inconsistencies can be resolved and longer-term effects have been more thoroughly evaluated.

In this study, no individual-level information was available on personal exposure levels inside or outside of the home, such as use of electrical appliances or electronic equipment, frequency of cell phone use, or exposure to RF electromagnetic radiation from the towers. In

block group 3, the majority of those diagnosed with a brain or CNS cancer also reported having worked in a job category associated in the literature with an increased risk of developing a brain or CNS tumor. These exposures could represent an alternative source of exposure to non-ionizing radiation or could be additive with exposures to the towers as a contributory factor. In block group 2, where most cases occurred in women, no occupational exposure associated with an increased risk of brain tumor occurrence was reported. Although some occupational history was gathered during interviews for block group 2 and 3 cases, it is not possible to establish precise RF exposure levels over a meaningful period of time for any of these individuals from this study. The role of occupation as a potential confounder in this study is uncertain. Similarly, a positive family history of brain/CNS cancer could suggest an alternate etiology for disease outcome (other than exposure from the towers), or could suggest that an inherited cancer susceptibility gene made the case more likely to develop a tumor as a result of exposure to a carcinogen. It is not possible to clearly identify the role of family history and susceptibility in this study.

The gender of cases contributing to statistically significant O/E ratios was different between block groups 2 (female) and 3 (male)--although there are cases of both genders in both block groups. Findings are generally strengthened when both genders show a similar pattern of excess numbers of a particular type of cancer, because exposures found in or around the home would be expected to affect both genders. Therefore these findings tend to weaken the hypothesis of a common etiology of elevated brain/CNS tumors in block groups 2 and 3, although the importance of other factors in the development of brain/CNS tumors, and what, if any additive or synergistic effect with RF exposure they may have, is unknown.

There is a well-recognized association in the epidemiological literature between SES and brain tumor occurrence, with risk increasing with higher SES. [8,10, 17,26-29] As in the past CDPHE studies, an attempt was made in the 2004 update to control for potential bias from differences in SES by limiting the comparison population used to estimate expected case counts to only those census tracts in metro Denver that were within $5,000 of the median household income of census tract 98.10. Median income for each block group was also compared to median household income for the entire census tract. While there was considerable variation in the median household income of individual block groups within census tract 98.10, ranging in the 1990 census from $26,326 to $96,626, it was the judgment of the panel that selecting income-matched comparison populations for each block group would result in small comparison populations, thereby introducing increased statistical error into the calculations. Based on a comparison of the June and July 1998 analyses, it is unlikely that closer adjustment for income, block group by block group, would make any significant difference in the study results.

The histology or cell type of a cancer may offer clues to whether an elevated observed/expected cancer ratio is indicative of a possible association with a particular environmental exposure or possibly a chance occurrence. Differences were noted in the histologic type for cases residing in block group 2 compared to those in block group 3. All four

of the women diagnosed with tumors between 1985 and 2002 in block group 2 had benign meningiomas. One case was diagnosed in a male in block group 2. This individual was diagnosed with a benign neurilemoma (schwannoma). In block group 3, all cases were diagnosed with malignant astrocytomas, medulloblastomas, or glioblastomas. Five of six cases from block group 3 occurred in males. There is a previously demonstrated association of increased risk of meningioma from exposure to ionizing radiation, while the histologic cell types of brain tumors in studies of nonionizing EMR exposure have been mixed, the majority being astrocytoma and glioblastomas.[26-29] Because brain cancer is a relatively rare disease and case numbers are few in the Lookout Mountain area, it is difficult to interpret these differences in tumor subtype and whether or not they may have different etiologies.

The scientific literature generally points to an association between residential RF exposure and increased risk of developing leukemia and lymphoma.[16,31,40,41] One additional consideration noted by the panel, therefore, was the absence of a finding of an increased incidence of these types of cancers for the census tract as a whole. Additional evaluation likewise confirmed no excess incidence of leukemia or non-Hodgkin lymphoma in block groups 2 and 3, or in any of the other block groups within census tract 98.10.

There is an established association in the scientific literature between brain tumors and exposure to electromagnetic radiation in some occupational cohorts. This association was noted in a 1998 NIH Working Group Report on extremely low frequency EMR exposure (50-60 Hz field)[16], but it is not clear if health outcomes from exposure to this type of extremely low frequency radiation can be extrapolated to radiofrequency field exposures. Findings from epidemiological studies of residential exposures have generally been negative for brain/CNS cancer.

The World Health Organization (WHO) is currently taking a coordinating role, through its International EMF Project, to develop a research agenda to identify and address critical gaps in the scientific understanding of EMR exposure and health outcomes. The goal is to better coordinate studies being conducted internationally, improve study design, and encourage consistency in study methods, such as improved exposure dosimetry. Several large international epidemiological studies as well as laboratory studies in animals, designed to address some of the data gaps identified by the WHO, are currently underway and may be of value in assessing causality and biological plausibility. The WHO anticipates completion in 2005 of a comprehensive review of the existing RF literature and these large ongoing studies for publication of a revised Environmental Health Criteria (EHC) document. As part of this extensive review, WHO is coordinating with the International Agency for Research on Cancer (IARC), which conducts on-going evaluations of the carcinogenic potential of a number of chemical and physical agents. The IARC recently completed a review of extremely low frequency EMR and classified these fields as possibly carcinogenic to humans based on positive study findings for childhood leukemia. Evidence for all other cancer types was determined to be not classifiable. The IARC plans to complete a review of RF exposure and cancer in 2006.

The ultimate goal of the WHO International EMF Project is to harmonize EMR standards between countries by filling some of the critical data gaps that currently limit our ability to assess risk from EMR exposure. WHO has recognized that results of some of these better-designed cellular, animal, and epidemiological studies should be considered together before conclusions about possible health effects of RF radiation can be drawn. Consistent evidence from these different types of studies would strengthen the certainty of a true causal association. The WHO has indicated that their EHC document will include a review of the scientific evidence and also "well considered policy recommendations". In the interim, the WHO recommends consideration of a precautionary policy, such as minimizing exposure to RF radiation to a level that is as low as reasonably achievable, as well as strict adherence to existing safety standards.[44]

V. CONCLUSIONS AND RECOMMENDATIONS

Results of the 2004 update of cancer incidence for 1979-2002 for residents living in the vicinity of the Lookout Mountain towers are generally consistent with the findings reported in the previous studies, and confirm a persistent elevation of brain/CNS tumors in some of the geographic areas studied. The 1998 study covered the time period from 1985-1995. The 1999 study covered the time period from 1979-1997. This update analyzed Cancer Registry statistics for an additional 5 years of tumor data, and uses more precise population estimates made available with the release of the U. S. Census 2000 data.

Cancer incidence for all tumor types investigated for census tract 98.10 as a whole was within the expected statistical range. The only consistently elevated ratios reported in the 2004 update (although still within expected statistical variation) were for brain and other central nervous system (CNS) tumors, which is consistent with the findings in the 1999 study. Findings for brain/CNS tumor statistics by individual block groups can be summarized as follows:

1. The O/E ratios for benign brain/CNS tumors in women in block group 2 and malignant brain/CNS tumors in men in block group 3 remain statistically elevated.

2. O/E ratios were within expected statistical variation for brain/CNS tumors in all other block group areas for both men and women.

3. One additional new benign brain/CNS tumor was diagnosed in women in block group 2, during the extended years of observation of 1998-2002, and one additional malignant brain/CNS cancer was diagnosed in men in block group 3. These additional cases do not meaningfully alter the O/E ratio or confidence interval reported for these block groups in the 1999 study and do not alter the strength of association reported in 1999 for either block group.

4. Block groups 2 and 3 are the block groups in closest proximity to the towers.

5. 100% of cases diagnosed in block groups 2 and 3 during 1979-2002, or their survivors, indicated there was a direct line of sight or unobstructed view of the towers from the case's residence, indicating the potential for RF exposure at these residences.

6. In block group 2, for the period 1985-2002, the majority of the cases (4 of 5 cases) were diagnosed in females, all with similar histology -benign meningioma. One case reported a history of brain tumor in a close relative (maternal aunt) and one reported work in an occupation with an increased risk of developing a brain tumor. The importance of these factors in the development of brain/CNS tumors, and what if any additive or synergistic effect with RF exposure they may have, is unknown. The duration of residence in the case's home prior to diagnosis of disease was > 10 years in all block group 2 cases.

7. In block group 3, the majority of cases (5 of 6 cases) were diagnosed in males, all with malignant astrocytomas, medulloblastomas, or glioblastomas. The occupational history, i.e. an alternate exposure source, was positive in three of the five block group 3 cases for whom an interview was completed, although the precise length of occupational exposure to EMR is unknown, as is the potential for interactive effects with RF exposure in the home. The duration of residence in the case's home prior to diagnosis of disease was <5 years for 3 of the 5 cases. The latency, or time between exposure and clinical recognition of a disease, is believed to be at least 5 years and usually more than 10 years for a genotoxic environmental exposure and cancer. In light of the uncertainties related to potential biological mechanisms by which RF might act, however, it is not yet possible to assign a scientifically based estimate of latency for RF exposure and tumor growth.

8. Cell types were not the same for block group 2 and 3 cases, and men and women were not similarly affected in each block group. There is no indication in the scientific literature that residential exposure to RF would selectively affect one gender differently than another, therefore these findings tend to weaken the hypothesis of a common etiology of elevated brain/CNS tumors in block groups 2 and 3. However the scientific knowledge of RF exposure and the potential for interactive effects with other individual exposures is not adequate to draw firm conclusions about this disparity between genders.

9. There was no indication of an increase in risk in block group 2 or 3 for leukemia or lymphoma, the cancer types most frequently associated with exposure to RF from broadcast towers in previous epidemiologic studies.

As discussed in the two previous CDPHE studies,[1,4] the results of this type of study cannot produce conclusive information about cancer causation. Rather, the goal of the scientific advisory panel was to determine if there are data that support an association between the observed elevated risk ratios for brain and CNS tumors and radiofrequency exposure from the broadcast towers.

The panel concluded that this study does not allow us to draw any conclusions about risk from the towers and does not provide an adequate basis to make additional public health recommendations to the community at this time. The relatively few additional cases diagnosed since the 1999 study do not add significant new information when considered independently and do not change the outcome reported previously for block groups 2 and 3, although the findings of the update do support the presence of a persistent elevation of brain/CNS tumors in block groups 2 and 3. The panel members noted that it is not likely that a conclusive answer will emerge for this community with additional similar health statistics reviews, in the absence of more precise individual-level exposure data.

The panel members strongly recommended further review of any well-designed RF exposure surveys for the Lookout Mountain area, should such data become available, and consideration of linkage of RF exposure data with available Cancer Registry statistics. Individual level exposure data would allow further testing of the hypothesis of an association between RF exposure and increased risk of developing a brain/CNS tumor, which is suggested in this block group level analysis.

There remain public health questions as to whether brain and CNS tumors in residents of block groups 2 and 3 could be associated with radiofrequency exposure from the Lookout Mountain antenna towers. The biological plausibility of an association between RF exposure and long-term chronic health effects, such as cancer, is still uncertain. Epidemiological studies in populations living near communication and broadcast towers emitting RF radiation have not been consistent in terms of the specific types of cancers reported or the strength of association found, and suffer from imprecise exposure assessment. The disparity in the results of the broader epidemiological evidence limits the ability to draw an inference from this update of tumor incidence in geographic areas near the Lookout Mountain towers.

The WHO and many other national and international health agencies have identified the need for a better scientific understanding of possible health effects associated with RF exposure and are currently recommending consideration of a precautionary approach until this uncertainty can be addressed by further scientific study.

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Table 1a - Number of **Males** with Cancer Compared to the Expected Number in Census Tract 98.10 by Cancer Site, 1979-2002

Cancer Site	Observed	Expected	O/E Ratio	P value	95% C.I.
All Cancers	468	487.12	0.96	NS	0.88-1.05
- Age 0-14	6	3.645	1.65	NS	0.61-3.60
- Age 15+	462	483.48	0.96	NS	0.87-1.04
Brain and CNS	14	10.30	1.36	NS	0.74-2.28
- Age 0-14	2	0.72	2.80	NC	NC
- Age 15+	12	9.58	1.25	NS	0.65-2.19
Leukemias	6	14.34	0.42	<0.05	0.15-0.91
- Age 0-14	2	1.29	1.56	NC	NC
- Age 15+	4	13.06	0.31	<0.01	0.08-0.78
Non-Hodgkin Lymphoma	17	19.66	0.87	NS	0.50-1.38
Male Breast	0	NC	NC	NC	NC
Eye Melanoma	0	NC	NC	NC	NC

NC = not calculated; statistical test not calculated if the observed number was <3.
NS = not statistically high or low, i.e. p>0.05

Table 1b - Number of **Females** with Cancer Compared to the Expected Number in Census Tract 98.10 by Cancer Site, 1979-2002

Cancer Site	Observed	Expected	O/E Ratio	P value	95% C.I.
All Cancers	414	480.47	0.86	<0.01	0.78-0.95
- Age 0-14	3	3.23	0.93	NS	0.19-2.72
- Age 15+	411	477.24	0.86	<0.01	0.78-0.95
Brain and CNS	9	7.13	1.26	NS	0.58-2.40
- Age 0-14	1	0.93	1.07	NC	NC
- Age 15+	8	6.20	1.29	NS	0.56-2.54
Leukemias	9	10.63	0.85	NS	0.39-1.61
- Age 0-14	1	1.05	0.95	NC	NC
- Age 15+	8	9.58	0.84	NS	0.36-1.65
Non-Hodgkin Lymphoma	11	15.83	0.70	NS	0.35-1.24
Female Breast	163	184.20	0.89	NS	0.75-1.03
Eye Melanoma	0	NC	NC	NC	NC

NC = not calculated; statistical test not calculated if the observed number was <3.
NS = not statistically high or low, i.e. p>0.05

Table 1c - Number of **Males and Females** with Cancer Compared to the Expected Number in Census Tract 98.10 by Cancer Site, 1979-2002

Cancer Site	Observed	Expected	O/E Ratio	P value	95% C.I.
All Cancers	882	967.59	0.91	<0.01	0.85-0.98
- Age 0-14	9	6.87	1.31	NS	0.60-2.49
- Age 15+	873	960.72	0.91	<0.01	0.85-0.97
Brain and CNS	23	17.43	1.32	NS	0.84-1.98
- Age 0-14	3	1.65	1.82	NS	0.38-5.33
- Age 15+	20	15.78	1.27	NS	0.77-1.96
Leukemias	15	24.97	0.60	<0.05	0.34-0.99
- Age 0-14	3	2.34	1.28	NS	0.27-3.75
- Age 15+	12	22.63	0.53	<0.05	0.27-0.92
Non-Hodgkin Lymphoma	28	35.49	0.79	NS	0.53-1.14
Female Breast	163	184.20	0.89	NS	0.75-1.03
Eye Melanoma	0	NC	NC	NC	NC

NC = not calculated; statistical test not calculated if the observed number was <3.
NS = not statistically high or low, i.e. p>0.05

Table 2a - Number of **Males** with Brain and CNS Tumors **(Benign + Malignant)**[1] Compared to the Expected Number in Census Tract 98.10 by Block Group

Place	Time Period	Observed	Expected	O/E Ratio	P value	95% C.I.
Entire Tract	1979-02	19	16.92	1.12	NS	0.68-1.76
Block Group 1	1979-02	2	2.77	0.72	NC	NC
Block Group 2	1985-02	1	0.75	1.33	NC	NC
Block Group 3	1985-02	5	2.48	2.02	NS	0.65-4.72
Block Group 4&5	1979-02	4	3.94	1.02	NS	0.28-2.60
Block Group 6	1979-02	0	0.54	0.00	NC	NC
Block Group 7	1979-02	6	5.10	1.18	NS	0.43-2.56

[1]--"Benign + malignant" includes all tumors, i.e., benign, in-situ, malignant, and uncertain.
NC = not calculated; statistical test not calculated if the observed number was <3.
NS = not statistically high or low, i.e. p>0.05

Table 2b - Number of **Males** with Brain and CNS Tumors **(Malignant only)** Compared to the Expected Number in Census Tract 98.10 by Block Group

Place	Time Period	Observed	Expected	O/E Ratio	P value	95% C.I.
Entire Tract	1979-02	14	10.30	1.36	NS	0.74-2.28
Block Group 1	1979-02	2	1.66	1.20	NC	NC
Block Group 2	1985-02	0	0.44	0.00	NC	NC
Block Group 3	1985-02	5	1.43	3.49	<0.05	1.13-8.15
Block Group 4&5	1979-02	1	2.44	0.41	NC	NC
Block Group 6	1979-02	0	0.33	0.00	NC	NC
Block Group 7	1979-02	5	3.08	1.63	NS	0.53-3.80

NC = not calculated; statistical test not calculated if the observed number was <3.
NS = not statistically high or low, i.e. p>0.05

Table 3a - Number of **Females** with Brain and CNS Tumors **(Benign + Malignant)**[1] Compared to the Expected Number in Census Tract 98.10 by Block Group

Place	Time Period	Observed	Expected	O/E Ratio	P value	95% C.I.
Entire Tract	1979-02	19	18.00	1.06	NS	0.66-1.65
Block Group 1	1979-02	3	2.76	1.09	NS	0.22-3.17
Block Group 2	1985-02	4	0.91	4.39	<0.05	1.20-11.23
Block Group 3	1985-02	1	2.91	0.34	NC	NC
Block Group 4&5	1979-02	8	5.29	1.51	NS	0.65-2.98
Block Group 6	1979-02	0	0.54	0.00	NC	NC
Block Group 7	1979-02	3	4.75	0.63	NS	0.13-1.85

[1]--"Benign + malignant" includes all tumors, i.e., benign, in-situ, malignant, and uncertain.
NC = not calculated; statistical test not calculated if the observed number was <3.
NS = not statistically high or low, i.e. p>0.05

Table 3b - Number of **Females** with Brain and CNS Tumors **(Malignant only)** Compared to the Expected Number in Census Tract 98.10 by Block Group

Place	Time Period	Observed	Expected	O/E Ratio	P value	95% C.I.
Entire Tract	1979-02	9	7.13	1.26	NS	0.58-2.40
Block Group 1	1979-02	2	1.08	1.86	NC	NC
Block Group 2	1985-02	0	0.35	0.00	NC	NC
Block Group 3	1985-02	1	1.23	0.81	NC	NC
Block Group 4&5	1979-02	3	1.98	1.52	NS	0.31-4.44
Block Group 6	1979-02	0	0.21	0.00	NC	NC
Block Group 7	1979-02	3	1.97	1.52	NS	0.31-4.45

NC = not calculated; statistical test not calculated if the observed number was <3.
NS = not statistically high or low, i.e. p>0.05

Table 4a - Number of **Males and Females Combined** with Brain and CNS Tumors **(Benign + Malignant)**[1] Compared to the Expected Number in Census Tract 98.10 by Block Group

Place	Time Period	Observed	Expected	O/E Ratio	P value	95% C.I.
Entire Tract	1979-02	38	34.92	1.09	NS	0.77-1.50
Block Group 1	1979-02	5	5.53	0.90	NS	0.29-2.11
Block Group 2	1985-02	5	1.66	3.01	NS	0.97-7.03
Block Group 3	1985-02	6	5.39	1.11	NS	0.41-2.43
Block Group 4&5	1979-02	12	9.23	1.30	NS	0.67-2.27
Block Group 6	1979-02	0	1.08	0.00	NC	NC
Block Group 7	1979-02	9	9.85	0.91	NS	0.42-1.73

[1]--"Benign + malignant" includes all tumors, i.e., benign, in-situ, malignant, and uncertain.
NC = not calculated; statistical test not calculated if the observed number was <3.
NS = not statistically high or low, i.e. p>0.05

Table 4b - Number of **Males and Females Combined** with Brain and CNS Tumors **(Malignant only)** Compared to the Expected Number in Census Tract 98.10, by Block Group

Place	Time Period	Observed	Expected	O/E Ratio	P value	95% C.I.
Entire Tract	1979-02	23	17.43	1.32	NS	0.84-1.98
Block Group 1	1979-02	4	2.74	1.46	NS	0.40-3.73
Block Group 2	1985-02	0	0.78	0.00	NC	NC
Block Group 3	1985-02	6	2.67	2.25	NS	0.83-4.90
Block Group 4&5	1979-02	4	4.41	0.91	NS	0.25-2.32
Block Group 6	1979-02	0	0.54	0.00	NC	NC
Block Group 7	1979-02	8	5.05	1.59	NS	0.68-3.12

NC = not calculated; statistical test not calculated if the observed number was <3.
NS = not statistically high or low, i.e. p>0.0

Table 5. Number of malignant or benign brain and central nervous system tumor cases in census tract 98.10, by year and block group at diagnosis.

Year	**Malignant**					
	Block Group					Total
	1	2	3	4/5	7	
1979					1	1
1980		1			1	2
1981						
1982	1					1
1983						
1984				2	1	3
1985			1			1
1986						
1987						
1988						
1989						
1990			1			1
1991						
1992					1	1
1993						
1994	1		1			2
1995	1		1	2	1	5
1996					1	1
1997			1		1	2
1998						
1999			1			1
2000						
2001	1				1	2
2002						
Total	4	1	6	4	8	23

Year	**Benign**					
	Block Group					Total
	1	2	3	4/5	7	
1979						
1980						
1981						
1982						
1983						
1984						
1985		1				1
1986				1		1
1987						
1988						
1989						
1990						
1991						
1992						
1993		1				1
1994				1		1
1995		1				1
1996					1	1
1997				1		1
1998	1			3		4
1999				1		1
2000		1		1		2
2001						
2002		1				1
Total	1	5		8	1	15

Empty cells indicate no diagnoses reported for the year in the block group.
Block group 6 is not included in Table 5 because no cases were reported from 1979-2002.

Table 6 - Summary of telephone interviews for brain/CNS tumor patients living in block group 2 or block group 3, diagnosed between 1985-2002.

Interview Question		Block Group 2 (n=5)	Block Group 3 (n=5)
Lived in area less than 5 years	[% answering *yes*]	0	60
Lived in area 5 years or more	[% answering *yes*]	100	40
Lived in area 10 years or more	[% answering *yes*]	100	40
Close blood relative with brain tumor	[% answering *yes*]	0	20
Can see antenna from home	[% answering *yes*]	100	100
Worked in occupation associated with increased risk of brain tumor[1]	[% answering *yes*]	20	80
Lived 1 mile or less from antennas	[% answering *yes*]	100	40
Lived 1 to 2 miles from antennas	[% answering yes]	0	40

[1] - Occupations associated in the scientific literature with an increased risk of brain tumor include electronics and electrical workers (i.e., lineman, electrical engineer, technician/assembler), work in telecommunications industry, radio/TV repairman, pilot/aircraft worker, farm/agricultural worker, work with solvents or paints, work in rubber or petrochemical industry. Occupations of persons in Block Groups 2 and 3 included pilot/aircraft worker (commercial or military), electrical work (computer software testing and geophysics), and work with radar (meteorological research).

Figure 1. Map of Block Group Areas within Census Tract 98.10