CANCER OCCURRENCE IN GOODHUE COUNTY

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EXECUTIVE SUMMARY

The Minnesota Department of Health (MDH) receives over 100 calls or letters each year from around the state expressing concerns about cancer rates or cancer risks in a community, school, office, or other population. Goodhue County residents have voiced such concerns about many different issues, but most often about cancer rates in relation to the Prairie Island Nuclear Generating Plant near Red Wing. A specific population of concern is the Prairie Island Indian Community who reside within a half mile of the Prairie Island plant.

Cancer concerns were heightened in 1994 following claims of large increases in breast cancer death rates in ten Minnesota counties near the Prairie Island and Monticello nuclear power plants. Subsequent analyses by MDH of cancer occurrence in these counties found no excesses or unusual trends for breast cancer, thyroid cancer, or leukemia. More importantly, extensive environmental monitoring confirms that the public is not exposed to potentially harmful levels of radiation from the plant (levels are only rarely detected above background and are well below radiation standards). Despite these findings, concerns have remained.

The purpose of this report is to address ongoing cancer concerns by providing an extensive summary of cancer occurrence among Goodhue County residents. Cancer occurrence in the Prairie Island community or other specific populations within the county, however, could not be addressed with the available data.

Major Findings:

Rates of Newly-Occurring Cancers

- A total of 1,828 new cancers were diagnosed among Goodhue County residents during the nine-year period 1988-1996. The overall cancer incidence rate was the same as the statewide average for females and significantly below average for males.

- Childhood cancer incidence was the same as the state average for males (8 occurrences, 8 expected), but significantly below the average for females (1 occurrence, 6 expected).

- Among males, cancer incidence was significantly less than expected for colon cancer (63 occurrences, 88 expected) and non-Hodgkin's lymphoma (27 occurrences, 43 expected); incidence was significantly higher than expected for skin melanomas (42 occurrences, 27 expected) and Hodgkin's Disease (14 occurrences, 6 expected). Among females, no significant deficits or excesses of cancer incidence were found for any type of cancer.

Rates of Cancer Deaths

- A total of 849 cancer deaths occurred during the period 1988-1996. The overall cancer death rate was below average for males and the same as the state average for females. Childhood cancer mortality was also the same as or below the state average.

- Fewer than expected deaths were found for esophagus cancer among males (5 deaths, 12 expected). For females, fewer than expected deaths were found for lung cancer (55 deaths, 75 expected), and greater than expected deaths were found for breast cancer during the ten year period 1988-1997 (115 deaths, 84 expected).

Other Findings

- Three available years of data (1995-97) showed that a significantly higher proportion of breast cancers among Goodhue women were diagnosed at the most advanced stage (3.9% statewide vs. 10.1% Goodhue County).

- Extensive efforts were made to examine cancer incidence rates for regions *within* Goodhue County. These efforts confirmed the many limitations and pitfalls of such analyses. Most importantly, clear evidence of a systematic and potentially misleading difference was found between rural and urban regions. Additional analyses from 20 Minnesota counties confirmed that apparent urban/rural differences in cancer occur in many, if not most, counties in the state. Several factors are likely to contribute to these differences such as the location of nursing homes and other senior housing, as well as access to health care.

Conclusions

- Overall cancer incidence and cancer mortality rates in Goodhue County are the same as or below the statewide average. Childhood cancer rates are also at or below the average.

- The few differences that were found for rates of specific types of cancer are typical of the findings from virtually any county in the state. Of potentially greatest public concern is the excess of breast cancer deaths, although there is no excess of new cases of breast cancer. While this finding may well be the result of random variability, the excess of breast cancer deaths without an excess of newly-diagnosed breast cancers is consistent with limited data suggesting that a significantly higher proportion of breast cancers among Goodhue women were diagnosed at the most advanced stage.

- Analyses of cancer rates for small geographic regions within a county are likely to produce erroneous or misleading results due to a variety of factors.

- Engineering and radiation standards along with extensive environmental monitoring, not analyses of community cancer rates, provide assurance that populations residing near Prairie Island are not at increased health risks from the power plant.

Recommendations

- All women should follow national guidelines for breast cancer screening. Health care practitioners should recommend annual breast cancer screening for their patients age 40 and older according to national guidelines (Appendix E).

- Data on the stage of cancer at the time of diagnosis should continue to be monitored for Goodhue and all other counties in the state. These data may highlight areas where additional educational and screening activities are warranted.

- Additional analyses are already in progress to better identify and document the limitations in examining cancer rates in small geographic areas.

CANCER OCCURRENCE IN GOODHUE COUNTY

Background of This Report

Each year, the Minnesota Department of Health (MDH) receives over 100 calls or letters from citizens, elected officials, or health professionals expressing concern over cancer occurrence in a neighborhood, community, school, or workplace. These concerns have arisen from all areas of the state. These concerns often originate in one of two ways: (1) an unusual number of cancers are perceived to have occurred in some area or population and it is feared that some type of environmental exposure may be responsible; or (2) exposure to some environmental pollutant is known or suspected to have occurred and there is considerable concern about the risk of cancer from that exposure. Most of these concerns reflect misunderstandings about both the frequency and the causes of cancer.

Goodhue County has a population of about 42,000 and is located just southeast of the Twin Cities Metropolitan Area, bordering the Mississippi River (Figure 1). As with other counties, the cancer concerns in Goodhue County have involved a variety of communities, geographic regions, types of cancer, and environmental issues. However, over half of these concerns have involved questions about cancer occurrence in relation to the Prairie Island Nuclear Generating Plant operated by the Northern States Power Company (NSP). This nuclear power plant is located on the west bank of the Mississippi River in Red Wing, approximately 30 miles southeast of the Twin Cities. Roughly 20,000 Minnesota residents in Goodhue and Dakota counties live within 10 miles of the Prairie Island Plant. An additional 5,000 residents of Pierce County, Wisconsin, also reside within 10 miles of the plant.

The most publicized cancer concerns occurred in 1994 when the MDH was asked by residents and the media to respond to allegations by Ernst Sternglass that breast cancer death rates were higher in ten Minnesota counties (and four Wisconsin counties) located near the Prairie Island and Monticello nuclear power plants. These allegations were made while the Minnesota Legislature was considering one of the most contentious issues in its history: whether to allow NSP to store its spent nuclear fuel in dry casks at the Prairie Island plant. These allegations appeared to contradict findings from a national study by the National Cancer Institute of cancer mortality rates in counties near all US nuclear facilities

(including those in Minnesota). That study found no pattern of excess cancers in counties with nuclear facilities.[1, 2]

To respond to the claims of excess cancer, the MDH conducted an analysis of cancer death rates (1950-1992) and cancer incidence rates (1988-1992) in these ten counties. This analysis provided clear evidence that rates and trends of breast and other cancers in these counties were comparable to rates elsewhere in the state.[3] An update with two additional years of cancer data further confirmed these findings.[4] Appendix A in this report provides yet another update with cancer data through 1996. This update again shows that the rates of breast cancer, thyroid cancer, and leukemia in the ten counties are the same as or significantly less than the state average.

It is important to emphasize that the analyses of cancer occurrence described above were undertaken to respond to claims of elevated cancer rates, and not to confirm or refute the safe operation of a nuclear power plant. The measurement of ionizing radiation, the sources of exposure (both man-made and natural), and the carcinogenic risks from radiation exposure are well understood–better understood than for any other environmental agent. This understanding has allowed for the careful utilization of radiation in many medical and commercial applications. Plant engineering, regulatory standards, and extensive radiation monitoring programs–not analyses of community cancer rates–provide assurance that populations residing near Prairie Island are not at increased health risks from the plant (see Appendix B for more information on the Radiation Monitoring Program).

Purpose and Limitations of this Report

Despite the findings from the previous analyses of cancer rates and the environmental monitoring conducted throughout the life of the Prairie Island Plant, some public concern remains that cancer rates may be higher among county residents or among those living near the Prairie Island plant. This report attempts to address these concerns by focusing on cancer occurrence specifically among Goodhue County residents and by including all major types of cancer. This report pulls together and summarizes existing data on the occurrences of newly-diagnosed cancers as well as cancer deaths.

While this report provides extensive data on county-wide cancer occurrence, it does not address cancer occurrence for particular populations or regions *within* the county. It does

not address cancer occurrence among various racial groups in Goodhue County. Racial data are frequently missing from medical records from which cancer information is obtained by MDH. Even when race is present, it is unlikely to have been ascertained in a way comparable to census data to which it must be matched.

This report also does not address cancer rates specifically among the Prairie Island Indian Community (Prairie Island Mdewakanton Dakota Community). The community has approximately 500 members, of which 176 live on the Prairie Island reservation,* less than half a mile from the boundary of the NSP nuclear plant. A study of cancer rates in such a small population would be problematic. It would require the identification of all tribal members, their ages and gender, residential history, and probably other personal data. Erroneous conclusions could be reached if identification of tribal members were incomplete or influenced by the member's health status. Even if this loss of privacy seemed warranted and cooperation could be obtained from the relevant populations to collect such information, the very small numbers of people would make interpretation difficult or impossible. For example, there would be very little chance of detecting even a two-fold or three-fold excess of a common cancer such as breast cancer. Such an effort would also require significant resources. Although the findings from such a study could serve to reinforce various public health activities (dietary practices, screening, etc.), the findings would neither prove nor disprove any relationship to the operation of the power plant. An extensive environmental monitoring program (Appendix B) has not shown any radiation levels exceeding standards and it is exceedingly rare to detect levels above natural background radiation.

This report also does not address cancer occurrence for geographic regions within Goodhue County such as cities, townships, or census tracts. Such "small-area" analyses of cancer data are subject to many types of errors and uncertainties, both random and systematic, and may pose a risk of violating patient privacy if published. [5-12] Since these limitations cannot usually be adequately taken into account, the data are often misleading and uninterpretable. Recognizing these issues and limitations, but also acknowledging the public interest in cancer data for specific regions, an extensive effort was made in this study to determine whether and how valid and interpretable cancer rates could be determined for defined regions (e.g., census tracts) for an entire county. These efforts, which included data from a variety of sources and other counties, re-affirmed that such "small-area"

*Source: Minnesota Indian Affairs Council.

analyses cannot be reliably conducted or interpreted despite considerable time and resources. This report contains only limited discussion of the geographic analyses (full data will be presented in a separate technical report).

This report focuses, therefore, on county-wide cancer data for Goodhue County. Specifically, this report (1) identifies the available sources of data on cancer occurrence among Minnesota residents, (2) describes the various measures of cancer occurrence in a population, and (3) examines and summarizes cancer incidence and mortality for Goodhue County.

Data Sources and Methods

Cancer Data

There are two types of data on statewide cancer occurrence in Minnesota: the occurrence of newly-diagnosed cancers and the occurrence of deaths due to cancer. Data on the occurrence of newly-diagnosed cancers (cancer incidence) among Minnesota residents are available from the Minnesota Cancer Surveillance System (MCSS). This cancer registry was established in 1988 and is an ongoing program of the Minnesota Department of Health. This system provides highly accurate and complete data on all pathology-confirmed cases of cancer among Minnesota residents. The most recent year for which complete data were available for this analysis was 1996.

Data on cancer deaths (cancer mortality) are available from death certificates. Death certificate data are coded and computerized by the Minnesota Center for Health Statistics. Although all causes of death are recorded, only the underlying cause of death is used in assessing mortality statistics. These data are published annually in the *Minnesota Health Statistics*. Cancer mortality data are also included in the biennial reports of the MCSS. This report includes mortality data through 1996 except when otherwise noted.

Cancer incidence (new occurrences) provides a much more complete and accurate picture of cancer occurrence than cancer mortality since it reflects all new occurrences of cancer, rather than just deaths from cancer. In 1996, for example, there were 19,976 new cancers diagnosed among Minnesota residents, while 8,848 deaths due to cancer were reported. Furthermore, cancer incidence is based on medical records which establish the diagnosis of a cancer (pathology-confirmed cases). Death certificate data, on the other hand, will not

include people who survived their cancer but died of other causes. Obviously much less medical information will be recorded on the death certificate than in the medical record. The main advantage of death certificate data is that they are available for all parts of the country and extend back for many decades, allowing a better historical perspective. This report focuses on cancer incidence data; cancer mortality data are presented for additional perspective.

Census Data

Census data (by gender and age) are required to calculate cancer rates and to estimate the number of cancers that would be "expected" to occur in a population. Statewide and county population estimates for the period 1988 through 1996 were obtained from the US Census Bureau.

Detailed census data for smaller geographic regions within Goodhue County (census tracts or zip codes) were only available for 1990. This was one of the several major limitations to the examination of cancer rates for specific regions within a county. The population estimates used in this report are presented in Appendix D.

Geographic and Residency Data

Residence data reported to the MCSS generally includes street address (or rural route or PO Box number), city, zip code, and county. Address data may be incomplete or missing and multiple addresses may occur from different record sources or for different time periods. Residence data are not subject to as many quality control measures as are applied to other data in the registry. Where no county has been reported, a county is manually assigned based upon the street address. Since half of all cancers are diagnosed in people over the age of 68, many addresses are not private residences but rather nursing homes, senior housing, or other institutional addresses.

As part of the effort to determine the accuracy of census tract assignment by computerized geocoding services, all addresses of cancer patients with a reported residence of Goodhue County or a zip code bordering Goodhue County were reviewed using a variety of maps, street directories, and other sources. (Additional details of the geocoding analyses will be included in a separate technical report.) Since this report focused on cancer incidence, residence information was not reviewed for death certificates.

In a corollary geographic analysis, breast cancer incidence was examined by zip code for 20 counties around the state (including Goodhue). This analysis was limited to the year 1990 since that is the only year for which the Census Bureau attempted to estimate the population of zip codes existing at that time. For each of the counties, breast cancer incidence in the county's largest city (county seat) was compared to the rest of the county.

Cancer Rates and Cancer Ratios

Cancer rates are usually expressed as the incidence rate or mortality rate per 100,000 people per year. Cancer incidence refers to the number of newly-diagnosed cancers, while cancer mortality refers to the number of cancer deaths. Cancer rates are usually given for males and females separately. The cancer rate can be given for specific age categories (such as age 60-64, 65-69) or as an overall rate over all ages. Because cancer rates are highly age-dependent, overall cancer rates must be "age-adjusted" (standardized) to account for differences in age in different populations. All rates provided in this report are annual rates, age-adjusted to the 1970 standard US population, consistent with current epidemiologic practice. If the rate is given for a period of years such as 1988-1996, the rate is the average annual rate during that time period.

Because specific types of cancers are relatively rare in a given year, cancer rates in small populations, including most Minnesota counties, show great variability and are statistically unreliable. The average county population outside the Twin Cities Metro area is roughly 27,000, while Goodhue County has a population of about 42,000. A few cancers more or less, or a slight shifting of the age distribution of cases can dramatically change the apparent rate. For the rare cancers, even statewide rates are subject to this variability. One way to reduce this variability is to average rates over several years. Except when examining annual trends, rates in this report have been averaged over a specified number of years.

Another common approach for examining cancer occurrence in smaller populations is to compare the number of cancers that actually occurred to the number of cancers statistically "expected" to occur.[13] In this report, the expected number of cancers represents the number of cancers that would have occurred in the county if the population in the county had experienced the same cancer rate as the statewide average. The expected number takes into account only the age and sex distribution of the population of interest. The actual

(observed) number of cancers divided by the expected number of cancers is called the Standardized Incidence Ratio (SIR) or the Standardized Mortality Ratio (SMR):

SIR = (observed no. of new cancers) / (expected no. of new cancers)
SMR = (observed no. of cancer deaths) / (expected no. of cancer deaths)

A ratio of 1.00 means that the observed and expected numbers of cancer are exactly the same. A ratio less than 1.00 means that there are fewer cancers than expected. For example a ratio of 0.75 means that the number of observed cancers was only 75% of the expected number (i.e., there was a 25% deficit of cancers). Correspondingly, a ratio greater than 1.00 means a greater than expected number of cancers. For example, a ratio of 1.50 means that there was 1.5 times as many or 50% more cancers than expected.

Because of random variability, especially in small populations, observed and expected values are rarely exactly the same. Statistical tests or confidence limits are often used to determine whether the difference is within normal random variation. However, when large numbers of comparisons are being made – such as in this report –"significant" differences are expected to occur by chance. Statistical tests, therefore, cannot be used as the sole means of interpreting apparent excesses or deficits of cancer. Indeed, thousands of "statistically significant" excesses or deficits of cancer can be found by comparing multiple types of cancer for each sex, year, and county throughout the state.[14, 15]

Although annual cancer incidence and mortality *rates* for Goodhue County are presented in this report for completeness, this report will primarily use the observed-to-expected ratio (SIR or SMR) as the main measure of cancer occurrence in Goodhue County.

Findings

County-wide Cancer Incidence (Newly-diagnosed cancers)

Cancer incidence rates were obtained from the MCSS for the years 1988-1996 (these were all of the years for which complete data were available at the time of analysis). These data–for various time periods– are published in the MCSS biennial reports on cancer rates

and trends in Minnesota.* Table 1 shows the average annual incidence rates (per 100,000) for the most common types of cancer and for all cancers combined for Goodhue County and for the state overall. These rates are shown for males, females, and both sexes combined. Table 2 also presents cancer incidence data for Goodhue County by providing the number of actual (observed) and expected cancers along with the Standardized Incidence Ratio (observed-to-expected ratio) for the most common types of cancer and for all cancers combined. Except for the category of childhood cancers (ages 0-14 years), the data in tables 1 and 2 are for all ages.

During the nine-year period 1988-1996, a total of 1,828 cancers were diagnosed among the residents of Goodhue County. Among males, there were 939 cancers compared to 1,015 expected, a small but statistically significant 8% deficit. Among females, 889 cancers were diagnosed which closely matched the 896 cancers that were expected. The number of childhood cancers was equal to the number expected for males (8 actual vs. 7.5 expected) and significantly less than expected for females (1 actual, 5.7 expected). The overall cancer incidence in Goodhue County is therefore comparable to or slightly lower than the statewide average.

For specific types of cancer, there was considerable variability as expected in small populations. This is seen in Figures 2 and 3 which show graphically the Standardized Incidence Ratios (actual/expected) from Table 2 along with their 95% Confidence Intervals for males and females, respectively. The vertical line down the center of the chart represents an SIR of 1.0, meaning the number of observed and expected cancers were the same. Points to the left of the line represent fewer than expected cancers, while points to the right of this line represent greater than expected cancers. A confidence interval that crosses the center line (i.e. the interval includes the value of 1.0) indicates that the difference between actual and expected values is within normal random variation and is not a statistically meaningful difference. The confidence limits shown do not account for the fact that many comparisons are being made and that the usual statistical criteria are of limited usefulness.

Except for the most common types of cancer, such as lung, colon, prostate, breast, and all cancers combined, the SIRs have wide confidence intervals, reflecting the small numbers

*The MCSS biennial report released in August 1999 includes cancer incidence data for the period 1988-1996.

and variability. If all cancer types were represented here, rather than just the two dozen most common, much more variability and uncertainty would be evident.

For males, Figure 2 shows that there are four types of cancer that do differ from their expectation based on conventional statistical criteria. Two were deficits and two were excesses. The two cancers that occurred less frequently than expected were colon cancer (63 occurrences, 88 expected; SIR=0.71) and non-Hodgkin's lymphoma (27 occurrences, 43 expected; SIR=0.63). The two cancers that occurred more frequently than expected were melanomas of the skin (42 occurrences, 27 expected; SIR=1.54) and Hodgkin's Disease (14 occurrences, 6 expected; SIR=2.19). No differences were found for any of the other less-common types of cancer that are not shown in Table 2 or Figure 2.

For Goodhue County females (Figure 3), none of the cancer types differed significantly from the expected numbers, except for the previously noted deficit of cancers among female children (SIR=0.18). No differences were found for any of the other less-common types of cancer for which data are not shown.

Comparing the male and female findings can sometimes be useful in identifying consistent patterns. There were deficits for two cancers among males: colon cancer (29% deficit) and non-Hodgkin's lymphoma (37% deficit). Among females, there was a non-significant 11% deficit (SIR=0.89) for colon cancer, but no deficit for non-Hodgkin's lymphoma (SIR=1.00). The 54% excess of melanomas among males was not found among females (SIR=1.05). The two-fold excess of Hodgkin's Disease among males was somewhat paralleled by the non-significant excess among females (8 occurrences, 5 expected; SIR=1.57). The 80% deficit of childhood cancers among females was not seen among males. Overall, there was little or no consistency between males and females.

The pattern of cancer incidence in Goodhue County is quite typical of that found in most of the counties outside the Metro area when multiple cancer rates are compared to the statewide average. "Statistically significant" excesses and deficits can be found in every county. Because of the variability in cancer occurrences in small populations and the large number of comparisons that are made for the various types of cancer (over 150 comparisons were made for cancer incidence alone), such "significant" differences in rates are in fact expected to be found from chance alone. Statewide, thousands of such differences are expected to occur and do occur at the county level. The small number of

differences in the rates of specific types of cancer in Goodhue County is consistent with random variation.

County-wide Cancer Mortality (Deaths)

Because of the smaller numbers, county cancer death rates have even a greater degree of statistical error (uncertainty) than cancer incidence rates. On average, the number of cancer deaths is less than half the number of new occurrences.

Table 3 shows the number of actual and expected cancer deaths for residents of Goodhue County during the period 1988-1996. During that nine-year period, there were 849 cancer deaths reported for Goodhue County. Among males, there were 403 deaths which is significantly less than the 455 expected (SMR=0.89). Among females, there were 446 cancer deaths, close to the 423 expected (SMR=1.06). Overall cancer deaths in Goodhue County are comparable to or below the statewide average.

For specific types of cancer, few significant differences were found. Figures 4 and 5 show the mortality data graphically. The wider confidence intervals compared to the incidence graphs reflects the much smaller numbers of deaths, leading to greater uncertainty or imprecision in the rates.

The only difference observed among males is the lower than expected number of deaths for cancer of the esophagus (5 deaths, 12 expected; SMR=0.41). In general, the pattern for cancer deaths was comparable to cancer incidence. Although the numbers were very small and not statistically significant, there were twice as many Hodgkin's Disease deaths as expected for males and females combined (6 deaths, 3 expected; SMR=2.0).

Among females, two significant differences were observed. The number of lung cancer deaths was 27% lower than expected (55 deaths, 75 expected; SMR=0.73), while the number of breast cancer deaths* was 37% higher than expected (115 deaths, 84 expected; SMR=1.37).

Because of the previous and ongoing concerns about breast cancer, additional mortality and incidence data for breast cancer were analyzed. Figure 6 shows the breast cancer death rates according to age for the period 1988-1996. This figure shows that the excess was not

limited to a particular age category. Figure 7 shows annual rates between 1988-1996 for breast cancer incidence and mortality for Goodhue County and statewide. County incidence rates vary greatly from year to year, varying above and below the statewide average. County mortality rates, on the other hand, are consistently above the statewide average during most of these years.

Figure 8 shows a longer-term perspective (1950-1997) on breast cancer mortality rates for Goodhue County and for the entire state. The volatility in annual rates from year to year at the county level is clearly seen, with the number of annual deaths varying from 1 to 15. Although two out of the last three years (1995-1997) were near the statewide average, rates were higher in Goodhue for all years between 1986 and 1993.

Figure 9 shows breast cancer incidence and mortality rates for 1988-1996 for all 87 Minnesota counties. This figure illustrates several points. It shows the wide range of incidence rates and mortality rates that can be observed at the county level. It also shows that at the county level, there is little relationship between breast cancer mortality and incidence over the same time period. The poor correlation between breast cancer incidence and mortality rates can also be seen nationally when comparing statewide incidence and mortality rates.[16]

One possible explanation (other than statistical chance) for an excess of mortality without an excess of incidence is that breast cancers were being diagnosed at a later stage with a poorer prognosis. MCSS began collecting data on the stage of the cancer at the time of diagnosis in 1995. At the time of this analysis, these data were available only for the years 1995 through 1997. Table 4 shows the available stage data for breast tumors for Goodhue County and for the whole state. Several classification systems are used for categorizing stage data; the data presented here are for the system that has changed the least over the past 20 years (Generalized Summary Stage). In this system, the earliest stages are referred to as "localized" while the latest or most advanced stages are referred to as "distant" (tumors that have spread to parts of the body remote from the primary tumor or metastasized). These data suggest that Goodhue County had a lower proportion of early stage tumors, and a higher proportion of the late stage tumors, compared to the state. The statewide proportion of distant (most advanced) stage breast tumors was 3.9%, while for Goodhue County it was 10.1%. While this difference is statistically significant, the small numbers of

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*Female breast cancer deaths were ascertained through 1997; all other deaths were through 1996.

occurrences (99 cases in Goodhue) over the three-year period for which stage data are available limit the conclusions that can be drawn.

Cancer Incidence for Geographic Regions within Goodhue County

As previous noted, an extensive effort was made to categorize ("geocode") all patient addresses in Goodhue County (and adjacent regions of surrounding counties) according to census tract (Figure 10). While a complete description of the methods and findings of this analysis will be presented in a separate technical report, some major findings are noted here.

In the end this effort highlighted the substantial time and resources required to manually geocode addresses in a rural county and it also demonstrated a variable and often poor performance of computerized geocoding. Most importantly, this effort clearly demonstrated the presence of systematic differences in rates between the Red Wing census tracts and the "rural" tracts (the rest of the county). For example, for both sexes combined, the overall cancer incidence for Red Wing was identical to the statewide average (728 occurrences, 731 expected; SIR=1.00). The overall cancer incidence for the "rural" tracts for both sexes combined showed a statistically significant 10% deficit of cancers (1042 observed, 1155 expected; SIR=0.90).

The general pattern of higher rates in the Red Wing ("urban") region and correspondingly lower rates in the rural region held for most individual types of cancer. The urban-rural differences were sharpest for females over 65 years of age.

Because it was believed that these findings were not unique to Goodhue County, an analysis was conducted of 20 non-Metro Minnesota counties including Goodhue County. Counties were randomly selected, primarily from southern Minnesota, without prior knowledge of cancer rates. Breast cancer incidence rates were determined for two regions within each county: the "urban" region was defined as the zip code of the largest city in the county, while the "rural" region was defined as the remainder of the county. The results of this analysis are shown in Figure 11. Although all combinations of rates were found, the overall trend was for higher rates in the "urban" areas compared to the "rural" areas. Thus the urban/rural difference found in Goodhue County is likely to occur in many, if not most, counties throughout the state.

While this analysis did not determine the cause of this systematic difference, several factors are likely to contribute to this pattern. Half of all cancers occur in people over the age of 68 and the patient addresses in MCSS are those *at the time of diagnosis*, whether it's a life-long residence, residence of a family member, senior or assisted housing unit, or nursing home. Red Wing is the largest community in Goodhue County and provides the greatest opportunities for senior housing, nursing care facilities, and access to health care. Elderly residents in the county are thus more likely to move into rather than out of Red Wing. A review of patient addresses shows that 16% of the Red Wing addresses but only 5% of the rural addresses represent a known nursing home, assisted living facility, or other senior housing.

An extreme example of how the presence of health care opportunities can impact apparent cancer incidence rates can be seen even at the county level. To the south of Goodhue County is Olmsted County with a population of approximately 114,000. The largest city is Rochester, which is home to the Mayo Clinic. When cancer incidence in Olmsted County is compared to the statewide average, significant excesses can be see for many types of cancer and for all cancers combined for both males and females. There is little, if any, likelihood that Olmsted County residents are at significantly greater risk of developing cancer than other state residents. A much more likely explanation is a combination of increased surveillance and detection of cancers among residents as well as migration of non-county residents into the community for diagnosis and/or treatment. Access to health care thus represents yet another factor that must be considered when attempting to examine and interpret area cancer rates.

Discussion

This report was undertaken to respond to numerous public inquiries over the years about cancer rates and risks in Goodhue County. While this report could not address cancer occurrence in specific racial or geographic regions within the county, this report provides more data on cancer occurrence in a single county than any previous MDH analysis.

These data should provide significant reassurance to the residents of Goodhue County that their risk of developing or dying from cancer is the same as or lower than the state overall. This finding applies to both adult cancers and childhood cancers. Even for specific types of cancer, there were relatively few differences to distinguish the county.

The finding that will most likely be of concern to community residents is the 37% excess of breast cancer deaths over the ten-year period 1988-1997 (115 deaths vs. 84 expected deaths; SMR=1.37). As noted in the Background to this report, cancer concerns in Goodhue were heightened by the 1994 claims that breast cancer deaths were higher in ten counties located near the Monticello and Prairie Island nuclear power plants. The ten Minnesota counties included in these allegations were found by MDH to have no differences in the incidence or mortality for breast cancers, leukemias, or thyroid cancers. An update of that analysis is included in Appendix A and reaches the same conclusions.

What then to make of the breast cancer mortality in Goodhue? Figure 9 shows the variability of breast cancer rates for all 87 Minnesota counties. Graphs for other types of cancer show the same type of variability. Such variability is expected from random chance alone. Furthermore, virtually every county in the state, when examined for 100 types of cancer for each gender, will have several deviations from the state average. For Goodhue females, there were no differences in the rate of newly-diagnosed cancers for any type of adult cancer (that includes breast cancer); for cancer deaths among females, there was one deficit (lung cancer) and one excess (breast cancer). These findings would certainly be consistent with random variation.

Random variation is not the only possible explanation of the data. Differences in breast cancer mortality rates, without corresponding differences in incidence, have been noted for large geographic regions within the US. For example, breast cancer mortality is 25%-30% higher in the Northeastern US compared to the South, although there is little difference in breast cancer incidence.[16-18] While some of the differences in mortality appear to be correlated with the prevalence of known risk factors in these regions, differences in survival and cancer control practices such as screening have also been implicated.

National data[19] indicate that the 5-year survival rate among women diagnosed with distant (most advanced) stage breast cancers is about 22% in contrast to the 97% survival rate for women diagnosed with localized (earliest stage) breast cancers. The proportion of breast cancers diagnosed at the most advanced stage was over twice as high in Goodhue County (10.1%) compared to the state average (3.9%). Although a statistically significant difference, this finding is based on data for only 99 breast cancers in Goodhue during 1995-1997 and should be cautiously interpreted. If this pattern existed for many years prior to 1995, it could account for an elevated breast cancer mortality in the absence of an elevated cancer incidence.

It is not surprising that many of the cancer concerns in Goodhue County are related to the Prairie Island nuclear power plant near the city of Red Wing. Nuclear power plants and cancers are both high on the list of public fears and concerns. Radiation in sufficient doses is a known cancer risk and nuclear plants contain radioactive materials. Contrary to public perceptions, however, there is virtually no possibility that community cancer rates could be affected by normal operation of the plant. There are several reasons for this counter-intuitive statement. The measurement, sources of exposure, and health risks of ionizing radiation have been extensively studied for many decades and are better understood than they are for any other biological hazard. This has allowed for the establishment of environmental, occupational, and medical standards that protect the public from cancer-causing exposures to various forms of ionizing radiation.

Environmental radiation monitoring around the Prairie Island facility began in 1970, well before the plant went into commercial operation in 1973 (Appendix B). The environmental monitoring included samples of air, vegetation, food crops, dairy milk, and water (surface and wells). This established the background levels used for these samples. To date, extensive and ongoing environmental radiation monitoring data demonstrate that it is exceedingly rare to detect radiation above background levels and none of the levels have exceeded a fraction of radiation standards. Community cancer rates, therefore, will not be influenced by radiation from the plant.

Furthermore, national and international studies of populations around nuclear facilities have not found cancer excesses linked to radiation exposures.[20] Finally, the major determinants of cancer include a large variety of factors such as smoking, diet, alcohol use, sexual and reproductive history, certain viruses, UV and other radiation, certain medications, occupation, and genetics.[21] Smoking alone accounts for one-third of cancer deaths, while dietary factors are estimated to account for another third (Appendix C). Clearly, dietary and smoking habits will have a major impact on population cancer rates.

Conclusions

Several conclusions can be drawn from the volume of data presented and in light of the many similar county-level analyses conducted over many years. These are listed below.

- Overall cancer incidence and cancer mortality rates in Goodhue County are the same as or below the statewide average. Childhood cancer rates are also at or below the average.

- The few differences that were found for rates of specific types of cancer are typical of the findings from virtually any county in the state. Of potentially greatest public concern is the excess of breast cancer deaths, although there is no excess of new cases of breast cancer. Limited data suggest that a higher proportion of the breast cancers among Goodhue women were diagnosed at the most advanced stage. If this pattern has persisted for many years (prior to 1995), this finding would be consistent with an excess of mortality without an excess of incidence.

- Analyses of cancer rates in small geographic regions are likely to produce uninterpretable or misleading results. The errors and limitations of such analyses have public health implications for any similar future activities in Minnesota as well as other states.

- Plant engineering, radiation regulatory standards and environmental monitoring, not analyses of community cancer rates, provide evidence that populations residing near Prairie Island are not at increased health risks from the nuclear power plant (Appendix B).

Recommendations

- All women should follow national guidelines for breast cancer screening. Health care practitioners should recommend annual breast cancer screening for their patients age 40 and older according to national guidelines (Appendix E).

- Data on the stage of cancer at the time of diagnosis should continue to be monitored for Goodhue and all other counties in the state. These data may highlight areas where additional educational and screening activities are warranted.

- Additional analyses are already in progress to better identify and evaluate the likely errors and potentially misleading findings when examining cancer rates in small geographic areas.

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Table 1. Average Annual Cancer Incidence Rates[1] per 100,000 for Goodhue County and All Minnesota, 1988-1996.

	Goodhue County			*All Minnesota*		
Cancer	Males	Females	Both Sexes	Males	Females	Both Sexes
Oral Cavity	15.5	7.3	11.1	15.7	6.1	10.4
Esophagus	2.1	1.6	1.7	5.4	1.3	3.1
Stomach	9.0	5.4	6.9	8.8	3.4	5.7
Colon	27.0	27.7	27.3	38.1	29.1	33.0
Rectum	19.2	9.7	14.2	16.5	9.2	12.4
Liver	2.0	2.7	2.4	3.2	1.4	2.2
Pancreas	7.9	4.6	6.1	8.1	5.5	6.7
Larynx	6.1	1.0	3.3	6.4	1.2	3.6
Lung & Bronchus	54.7	29.3	40.1	64.4	34.7	47.5
Melanomas of Skin	19.1	9.5	13.6	12.9	9.6	11.0
Breast	0.6	120.3	66.0	0.8	110.3	60.6
Cervix Uteri	-	6.5	3.4	-	7.4	3.9
Corpus Uteri	-	22.9	12.4	-	22.5	12.3
Ovary	-	15.5	8.4	-	15.1	8.2
Prostate	143.5	-	61.3	147.8	-	63.6
Testis	6.3	-	3.0	5.1	-	2.5
Urinary Bladder	29.4	9.1	17.5	29.6	7.8	17.2
Kidney & Renal Pelvis	12.5	5.4	8.6	13.8	6.2	9.6
Brain & Other NS	7.2	5.0	6.0	7.4	5.1	6.2
Thyroid Gland	1.9	5.9	4.0	2.7	6.4	4.6
Hodgkin's Disease	7.8	5.6	6.6	3.3	2.7	3.0
Non-Hodgkin's Lymphomas	12.7	14.4	13.6	19.6	13.4	16.2
Multiple Myelomas	4.5	3.3	3.8	5.3	3.2	4.1
Acute Myelocytic Leuk.	3.5	1.7	2.6	3.1	2.0	2.5
Total Leukemias	16.0	9.5	12.6	14.8	8.6	11.3
Childhood Cancers (ages 0-14 yrs)	17.8	2.3	10.2	16.7	13.4	15.1
All Cancers	424.1	339.6	372.3	457.9	332.1	383.4

[1] Rates are age-adjusted to the 1970 standard population; includes all races.

Table 2. Actual and Expected[1] New Cancers and Standardized Incidence Ratios for Residents of Goodhue County, 1988-1996.

	Males			*Females*		
Cancer	Actual Cases	Expected Cases	Ratio of Actual to Expected	Actual Cases	Expected Cases	Ratio of Actual to Expected
Oral Cavity	33	33.5	0.98	23	16.5	1.39
Esophagus	5	11.6	0.43	3	4.2	0.71
Stomach	21	20.5	1.03	16	11.8	1.36
Colon	63	88.3	0.71*	89	99.7	0.89
Rectum	38	36.0	1.06	27	27.5	0.98
Liver	4	6.9	0.58	6	3.8	1.58
Pancreas	17	17.4	0.98	13	15.9	0.82
Larynx	12	13.2	0.91	2	2.8	0.71
Lung & Bronchus	118	137.5	0.86	70	87.7	0.80
Melanomas of Skin	42	27.2	1.54*	24	22.8	1.05
Breast	1	1.7	0.59	306	285.2	1.07
Cervix Uteri	-	-	-	14	16.7	0.84
Corpus Uteri	-	-	-	55	56.0	0.98
Ovary	-	-	-	37	36.7	1.01
Prostate	335	338.2	0.99	-	-	-
Testis	12	10.4	1.15	-	-	-
Urinary Bladder	72	68.0	1.06	26	25.1	1.04
Kidney & Renal Pelvis	25	28.9	0.86	14	16.4	0.85
Brain & Other NS	15	14.6	1.03	11	10.9	1.01
Thyroid Gland	5	5.6	0.90	12	13.8	0.87
Hodgkin's Disease	14	6.4	2.19*	8	5.1	1.58
Non-Hodgkin's Lymphomas	27	42.7	0.63*	39	39.1	1.00
Multiple Myelomas	9	12.1	0.74	10	9.7	1.03
Acute Myelocytic Leuk.	7	7.0	1.00	7	5.8	1.20
Total Leukemias	31	32.2	0.96	31	24.2	1.28
Childhood Cancers (age 0-14 yrs)	8	7.5	1.06	1	5.7	0.18*
All Cancers	939	1015.3	0.92*	889	896.1	0.99

[1]The "expected" number of cancers represents the number of cancers that would have occurred in the region assuming its rates were identical to the statewide average.

*Ratio is significantly different from 1.00 ($p<0.05$); does not account for multiple comparisons.

Table 3. Actual and Expected[1] Cancer Deaths and Standardized Mortality Ratios For Residents of Goodhue County, 1988-1996[2].

	Males			*Females*		
Cancer	Actual Deaths	Expected Deaths	Ratio of Actual to Expected	Actual Deaths	Expected Deaths	Ratio of Actual to Expected
Oral Cavity	8	6.7	1.19	6	4.4	1.35
Esophagus	5	12.1	0.41*	3	4.2	0.71
Stomach	15	13.0	1.16	14	9.8	1.44
Colon	35	42.4	0.83	54	48.0	1.12
Rectum	11	7.4	1.48	9	6.0	1.51
Liver	7	7.9	0.88	5	5.1	0.97
Pancreas	22	22.0	1.00	22	24.7	0.89
Lung & Bronchus	111	123.6	0.90	55	75.1	0.73*
Soft Tissues	4	2.9	1.40	5	3.1	1.60
Melanomas of Skin	5	5.8	0.86	3	4.0	0.74
Breast[2]	0	0.5	0.00	115	83.7	1.37*
Cervix Uteri	-	-	-	3	4.4	0.68
Corpus Uteri	-	-	-	5	6.3	0.79
Ovary	-	-	-	28	23.4	1.20
Prostate	67	72.7	0.92	-	-	-
Urinary Bladder	18	13.9	1.30	7	6.8	1.02
Kidney & Renal Pelvis	12	12.2	0.98	9	8.3	1.08
Brain	6	10.8	0.56	13	9.2	1.41
Thyroid Gland	1	0.7	1.34	2	1.4	1.41
Hodgkin's Disease	3	1.5	2.07	3	1.3	2.31
Non-Hodgkin's Lymphomas	15	20.4	0.73	24	21.9	1.09
Multiple Myelomas	6	10.0	0.60	13	9.0	1.45
Leukemias	21	22.0	0.95	17	17.9	0.95
Childhood Cancers (ages 0-14 yrs)	1	1.3	0.77	0	0.9	0.0
All Cancers	403	454.6	0.89*	446	422.6	1.06

[1]The "expected" number of cancers represents the number of cancers that would have occurred in the region assuming its rates were identical to the statewide average.

[2]Female breast cancer deaths are through 1997.

*Ratio is significantly different from 1.00 ($p<0.05$); does not account for multiple comparisons.

Table 4. Stage at Diagnosis for Invasive Breast Cancer, Goodhue County and All Minnesota, 1995-97

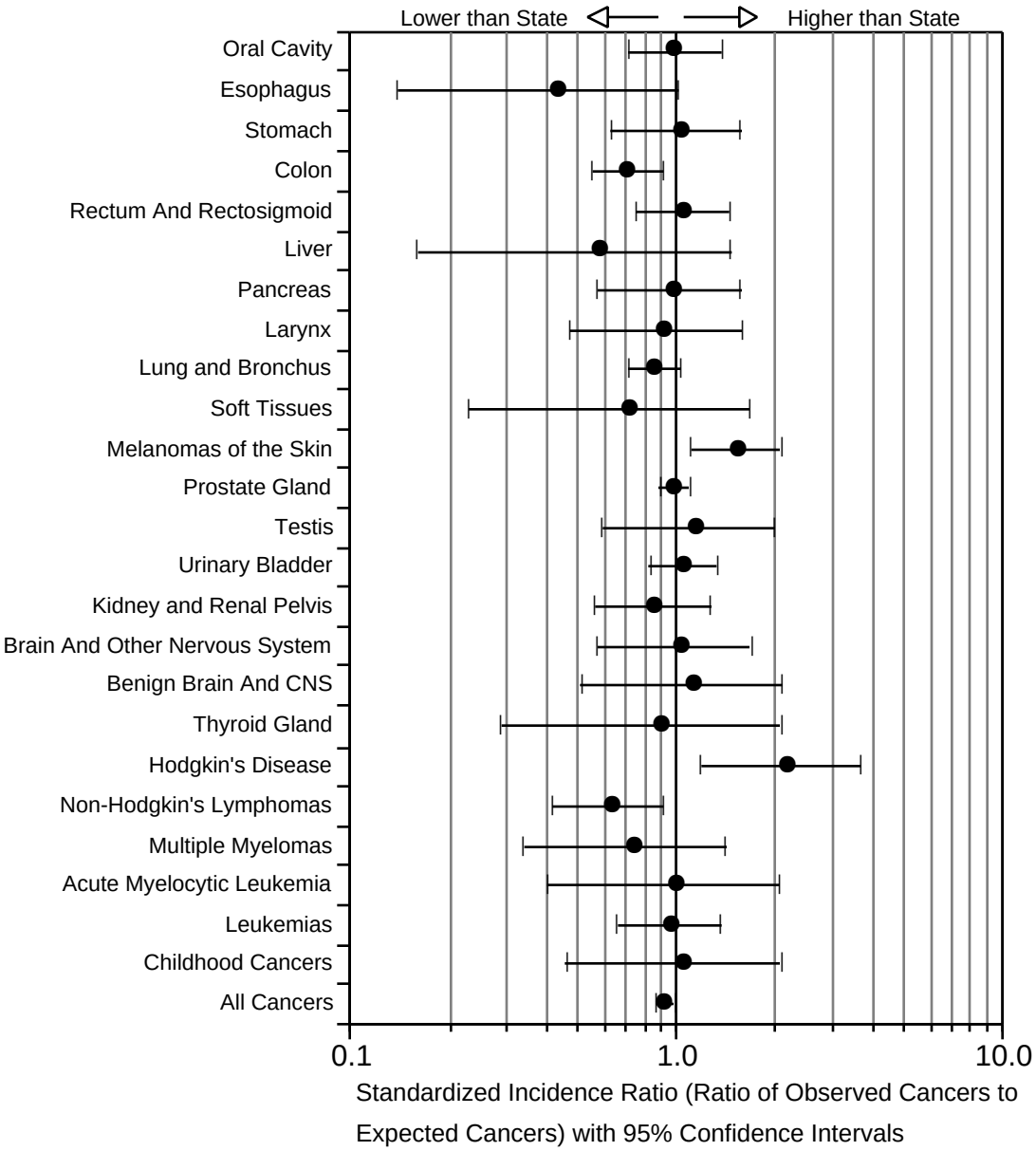
	Minnesota		*Goodhue County*	
Stage[1]	Cases	% of Total	Cases	% of Total
Localized	6348	(66.6%)	62	(62.6%)
Regional	2604	(27.3%)	26	(26.3%)
Distant	372	(3.9%)	10	(10.1%)*
Unknown	203	(2.1%)	1	(1.0%)
Total	9527		99	

[1] Localized: an invasive neoplasm confined entirely to the organ of origin.
Regional: neoplasm that has extended beyond the limits of the organ of origin into surrounding organs or tissues; into regional lymph nodes; or both direct extension and lymph node involvement.
Distant: neoplasm that has spread to parts of the body remote from the primary site through direct extension or metastasis.
Unknown: Insufficient information to determine stage.

* Proportion of Distant stage cancers significantly different from state average ($p<0.05$).

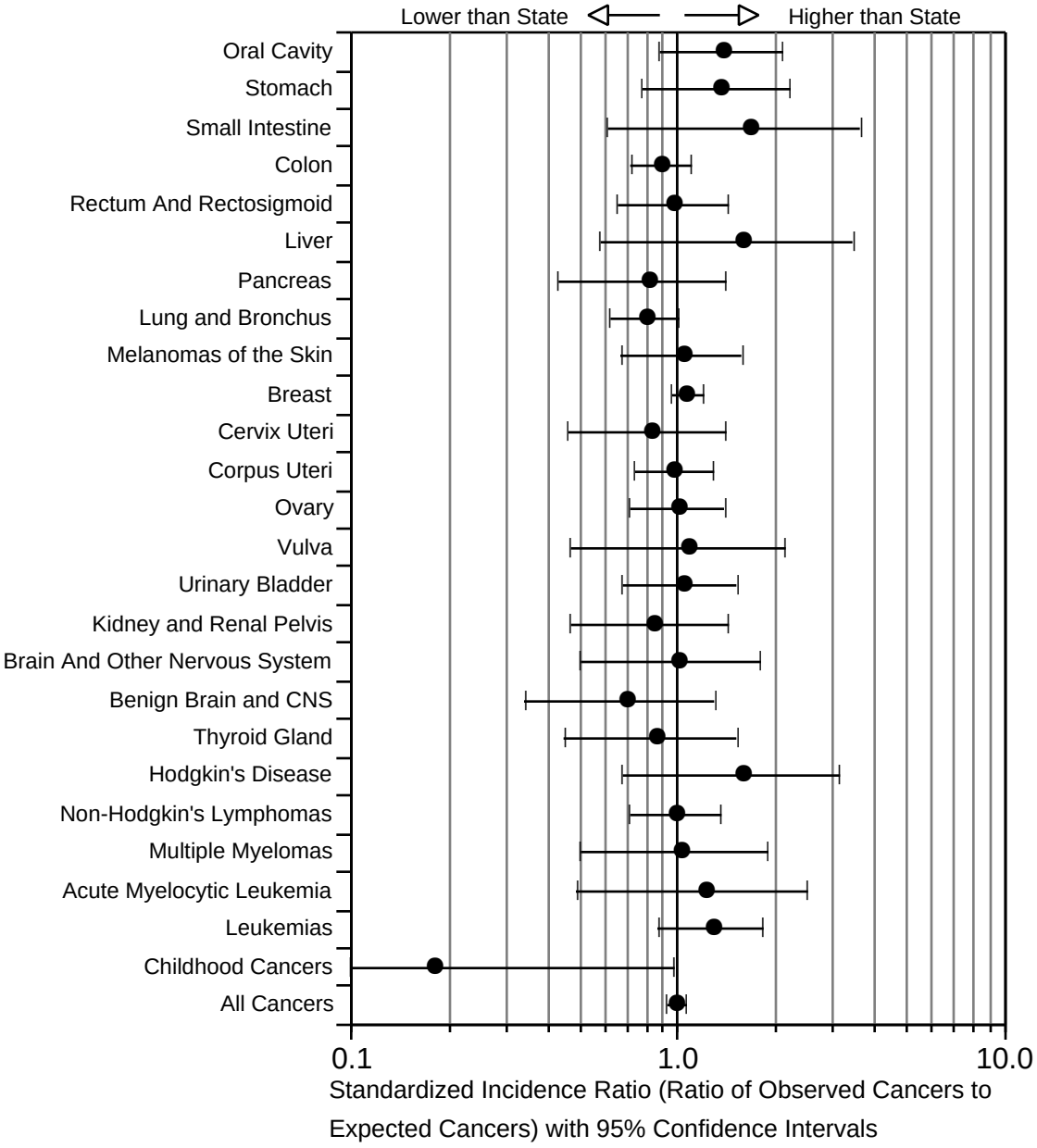
Figure 1. Location of Goodhue County, Minnesota

Figure 2. Cancer Incidence in Goodhue County vs. Minnesota: Males, 1988-1996.



*A ratio of 1.0 means that the observed number of cancers in the county was exactly equal to the number of cancers expected based on the statewide average

Figure 3. Cancer Incidence in Goodhue County vs. Minnesota: Females, 1988-1996.



*A ratio of 1.0 means that the observed number of cancers in the county was exactly equal to the number of cancers expected based on the statewide average

Figure 4. Cancer Deaths in Goodhue County vs. Minnesota: Males, 1988-96

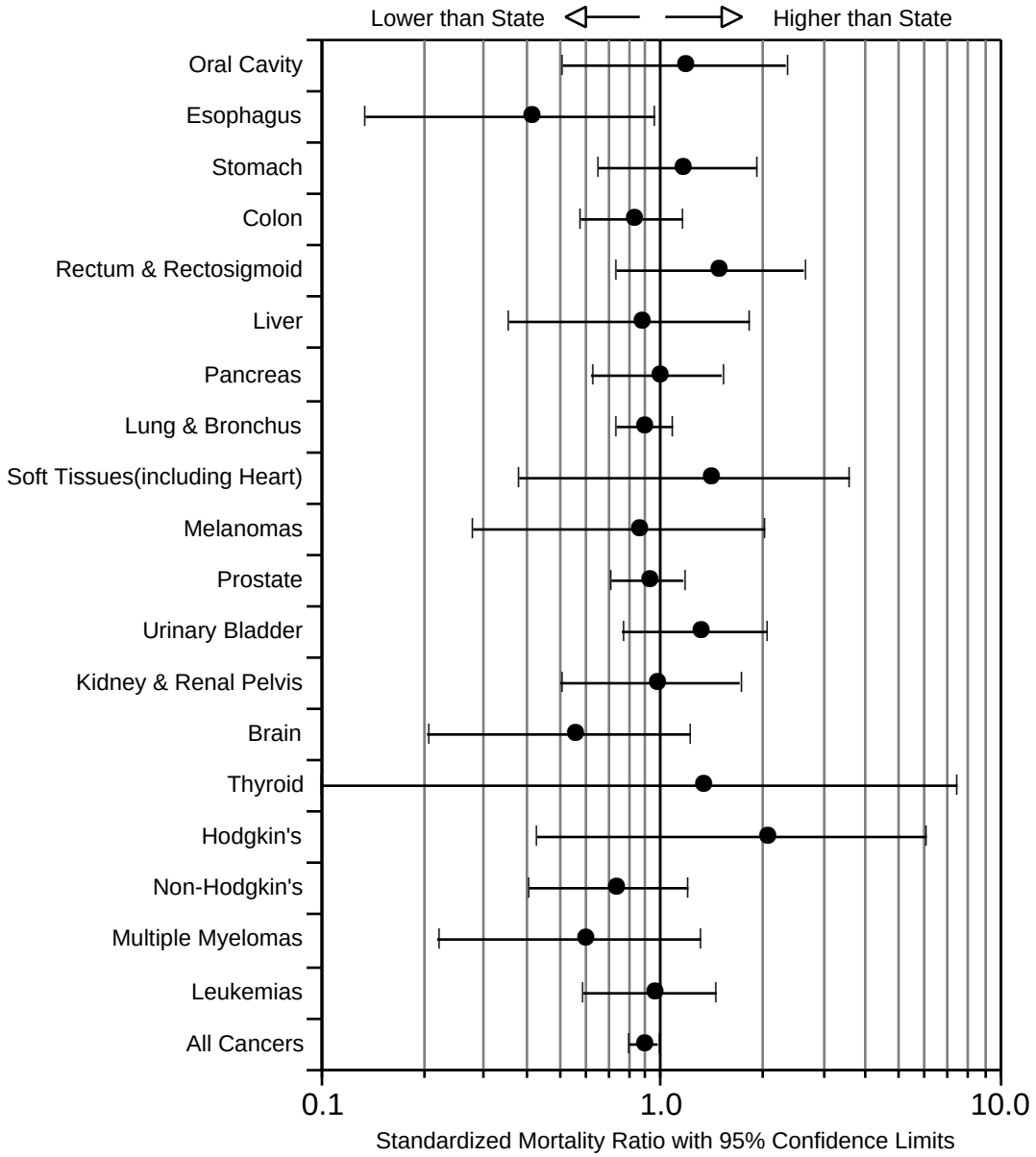


Figure 5. Cancer Deaths in Goodhue County vs. Minnesota: Females, 1988-1996

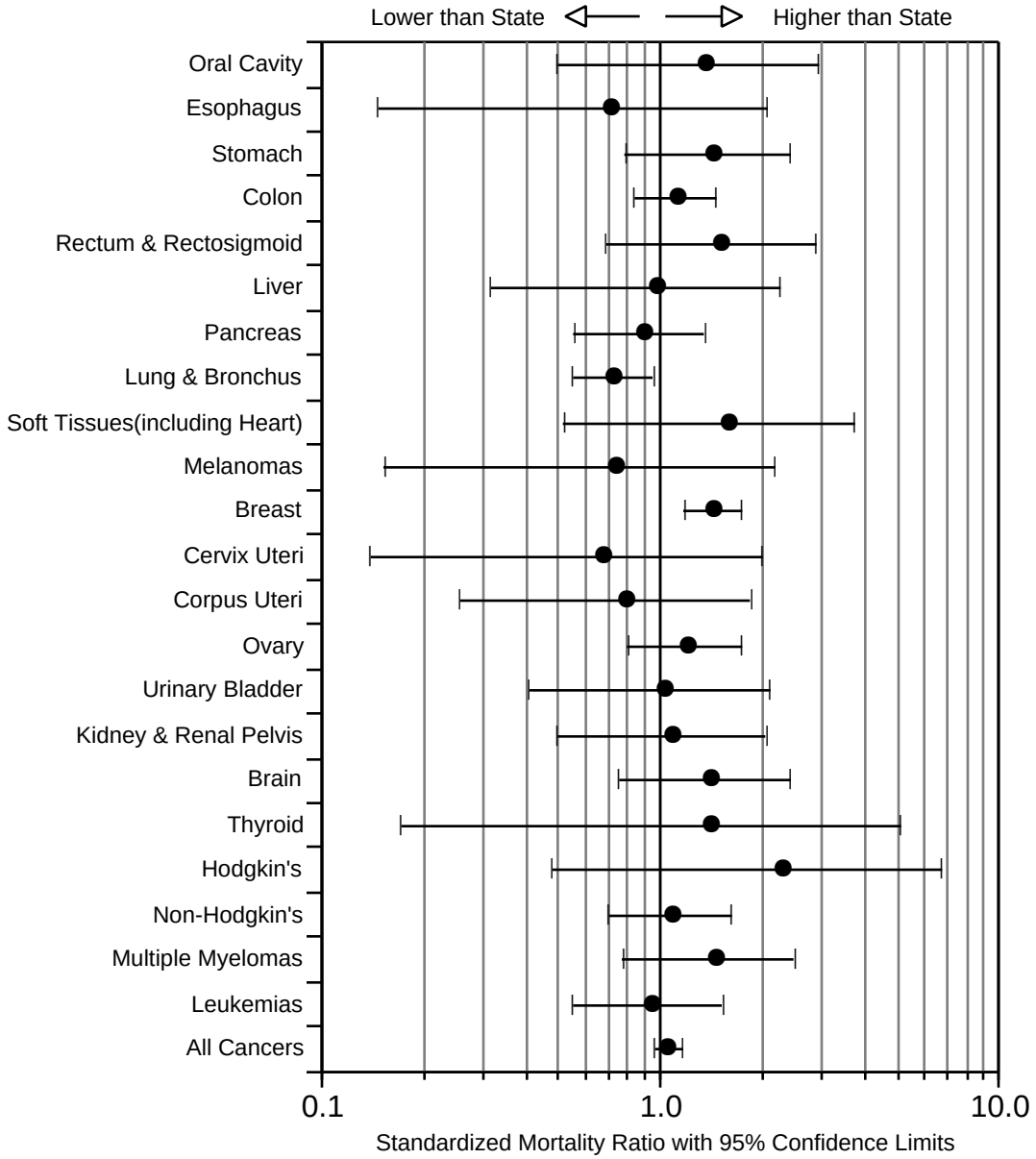


Figure 6. Breast Cancer Death Rates by Age: Goodhue County vs. All Minnesota

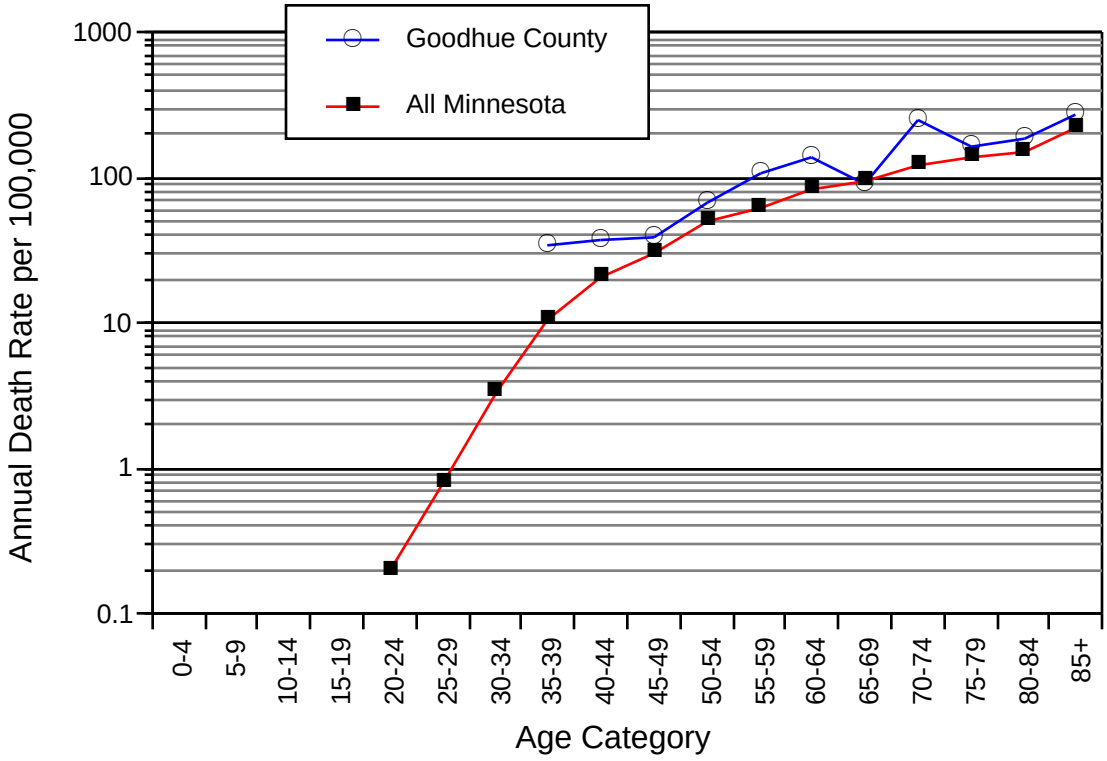


Figure 7. Annual Breast Cancer Incidence and Mortality Rates: Goodhue County and Minnesota

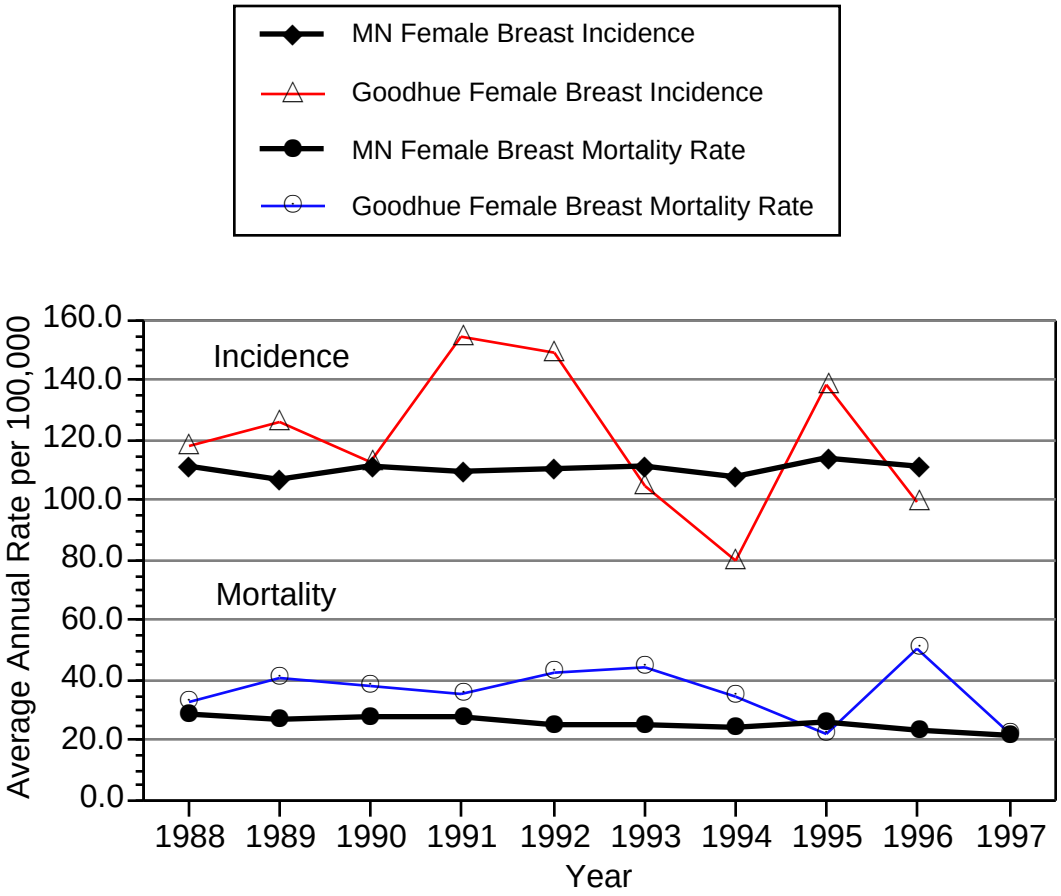


Figure 8. Annual Breast Cancer Mortality Rates, 1950-1997. Goodhue County and All Minnesota

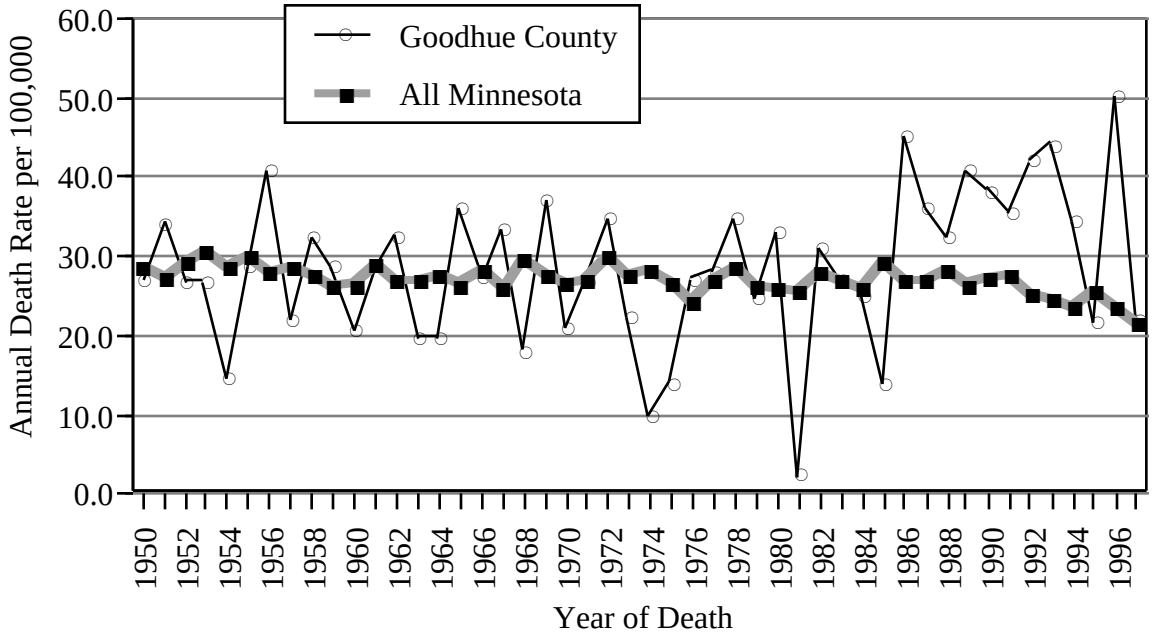


Figure 9. Annual Breast Cancer Mortality and Incidence Rates by County, 1988-1996

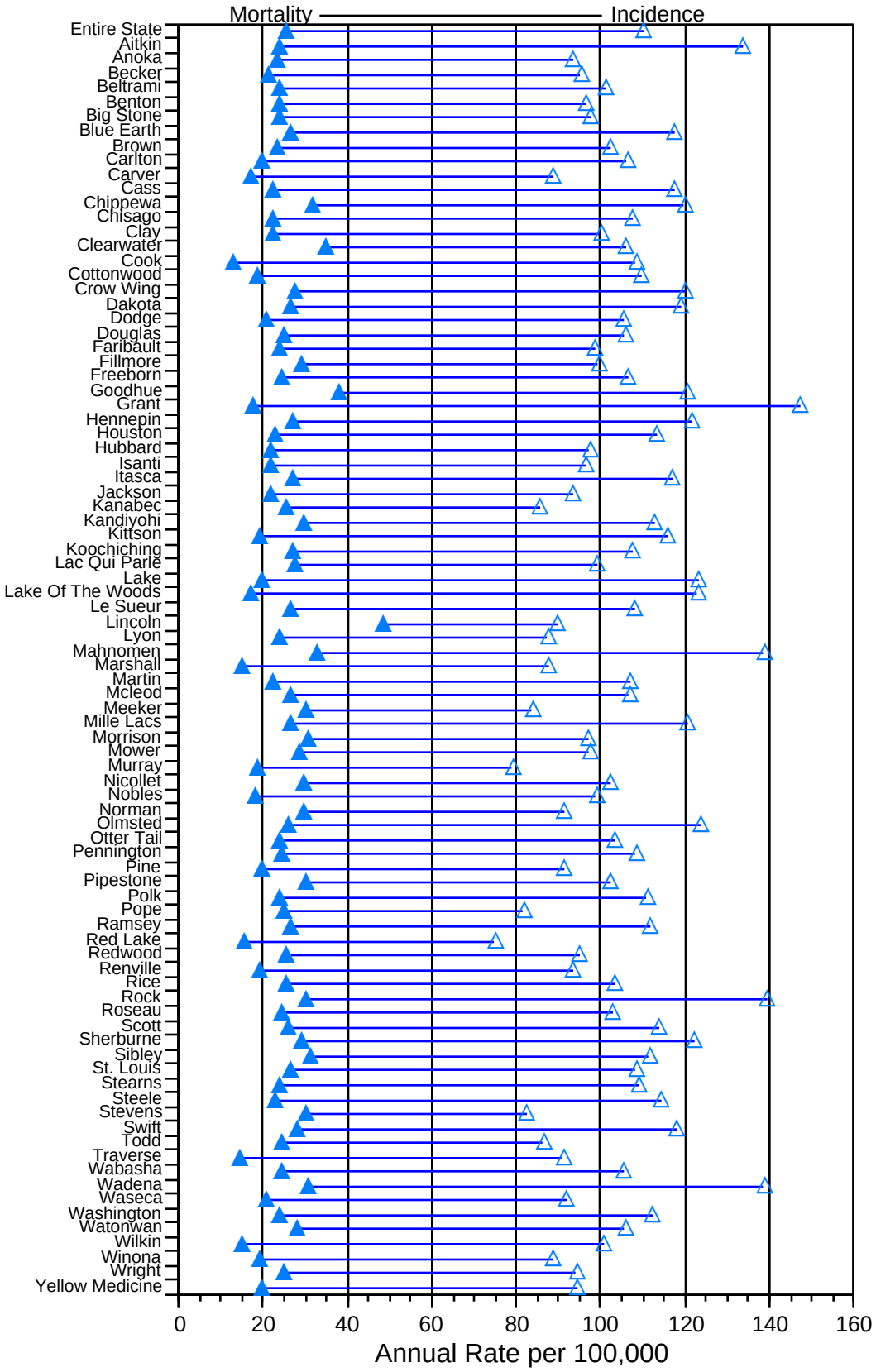


Figure 10. Goodhue County Census Tracts

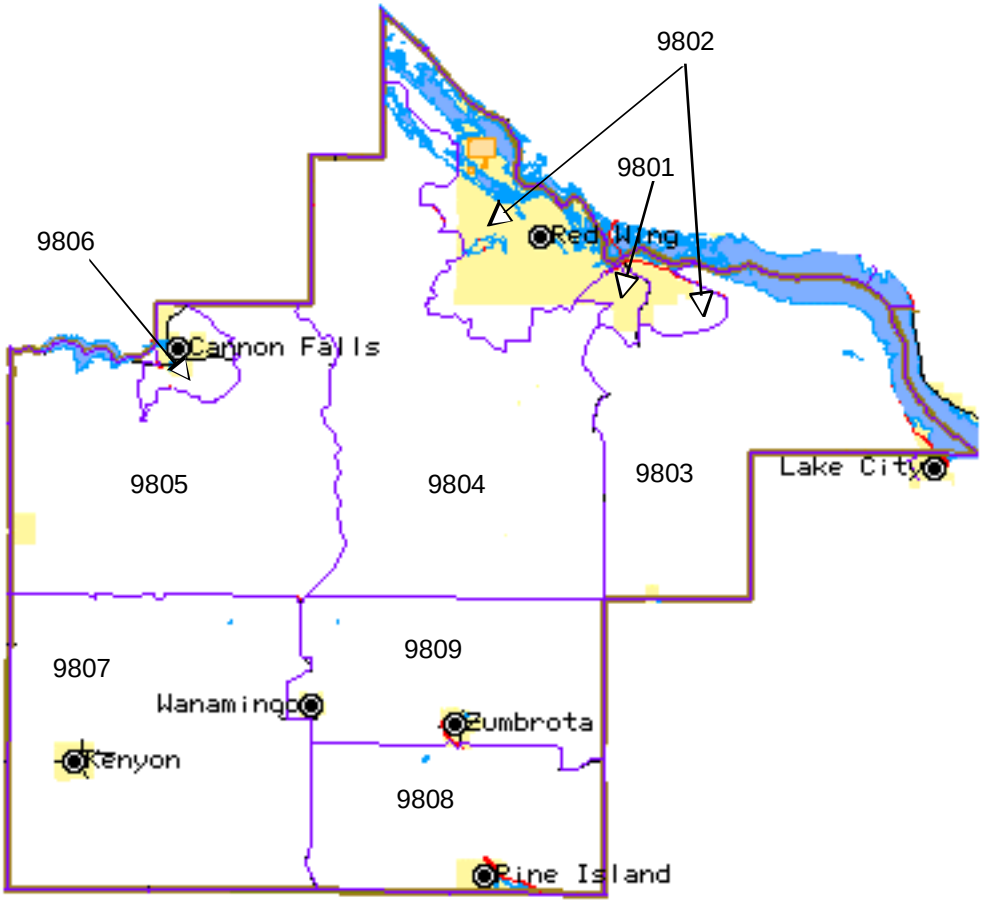
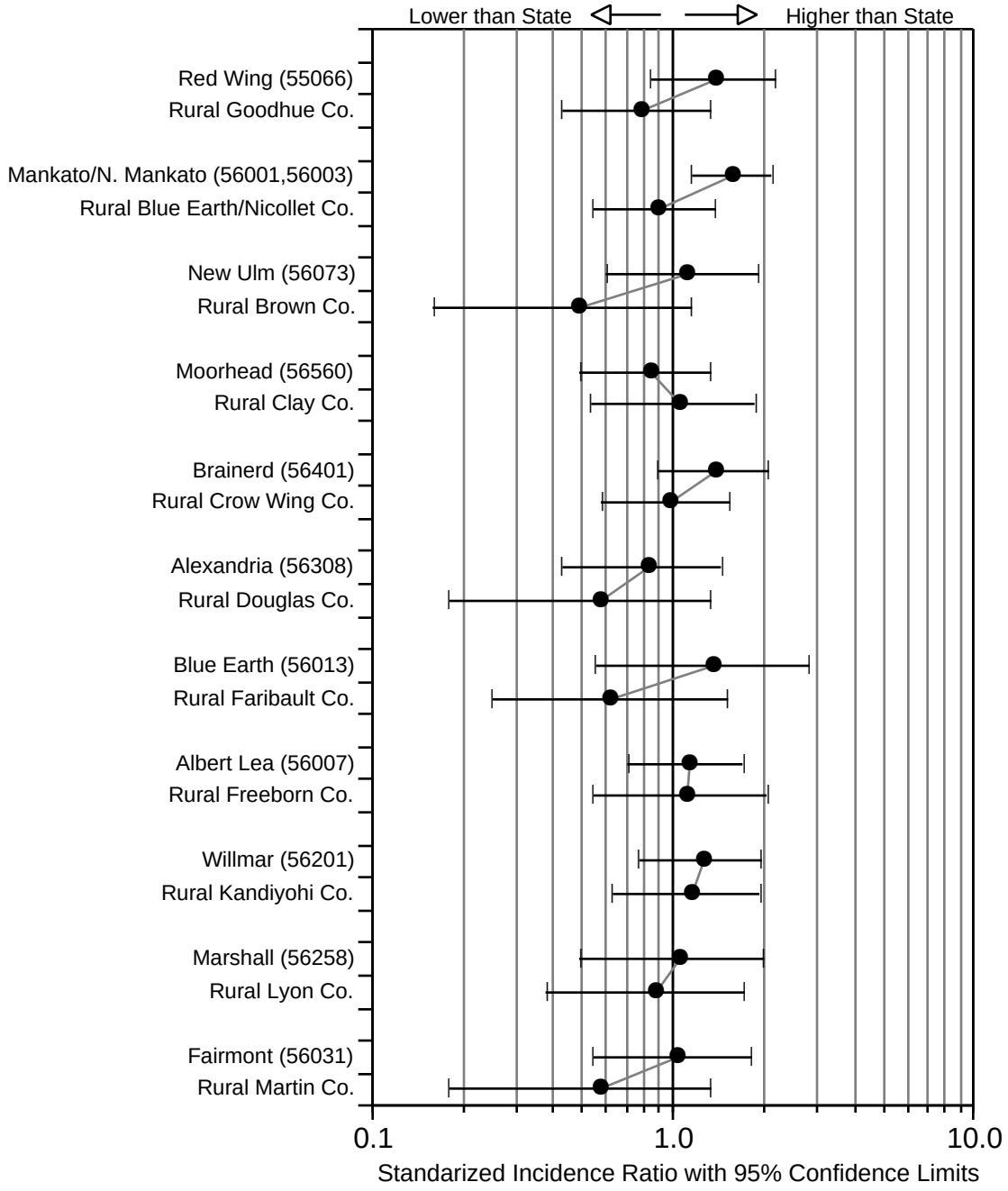
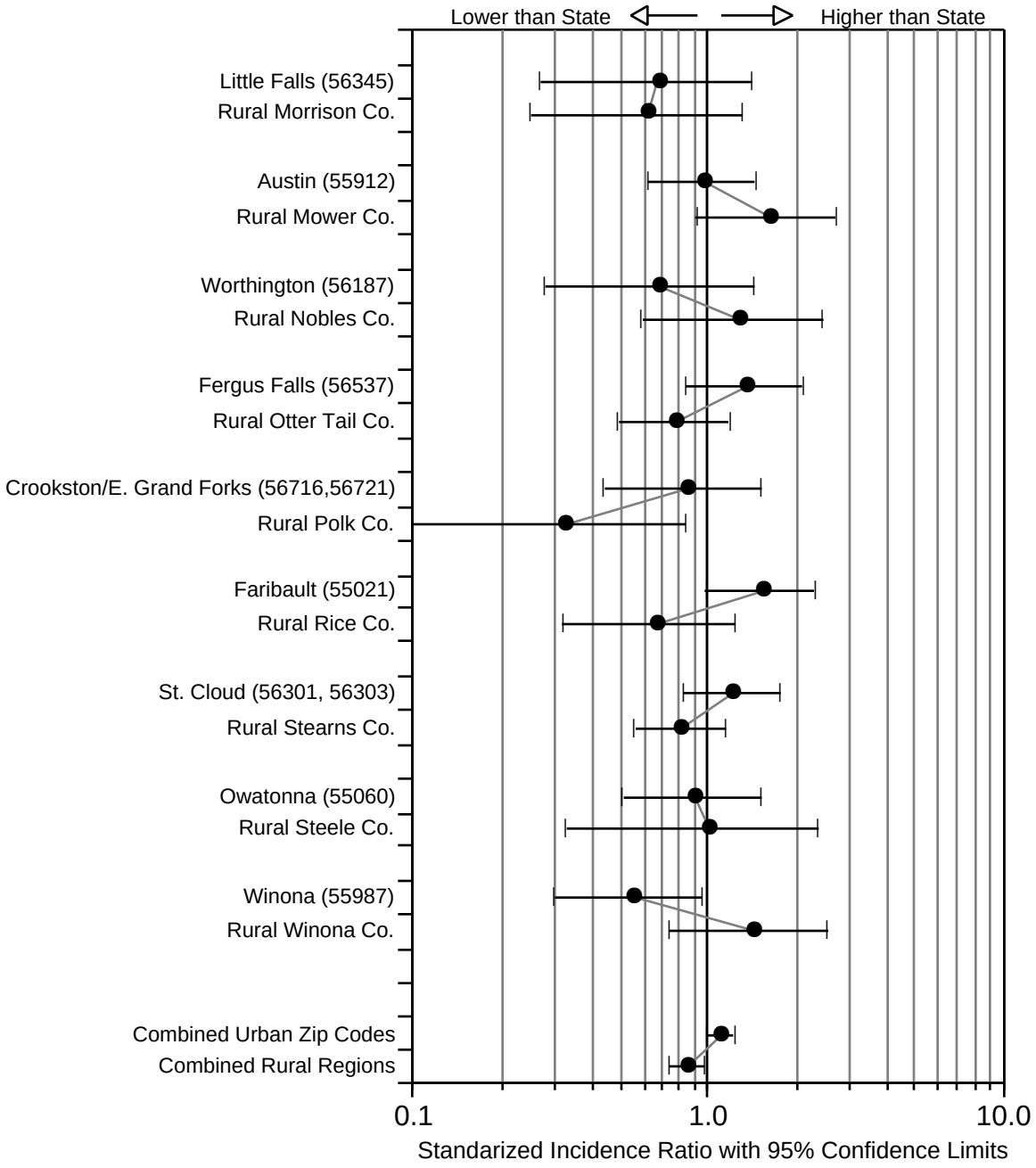


Figure 11a. Breast Cancer Incidence (1990) for Urban vs. Rural Zip Codes for 20 Minnesota Regions.*



*"Urban" zip codes were defined as the zip code(s) of the largest city in the county. "Rural" regions were defined as the entire county excluding the "urban" zip code of the largest city.

Figure 11b. Breast Cancer Incidence (1990) for Urban vs. Rural Zip Codes for 20 Minnesota Regions.*



*"Urban" zip codes were defined as the zip code(s) of the largest city in the county. "Rural" regions were defined as the entire county excluding the "urban" zip code of the largest city.

APPENDIX A. Cancer Occurrence in 10 Counties Near Nuclear Power Plants: 1988-1996

In 1995, the MDH reported its findings of an analysis of long-term trends in breast cancer mortality rates in selected counties surrounding Minnesota's two nuclear power plants.[*] That analysis was undertaken following allegations in 1994 that large increases in breast cancer mortality rates had occurred in selected counties[†] close to the Prairie Island and Monticello nuclear power plants. The MDH attempted to replicate and expand those analyses using complete cancer mortality data for the period 1950 through 1992. MCSS data for 1988-92 were also examined for those counties.

The 1995 MCSS analysis found no evidence of excess breast cancer mortality or incidence in the counties examined. The alleged large increases could not be substantiated and were likely due to methodological and/or mathematical errors. In addition, no excesses were found for two other radiosensitive cancers: cancers of the thyroid gland and leukemias. It was also noted that these findings, while addressing the issue of breast cancer rates and trends in these selected counties, cannot be used to either confirm or refute health risks from the operation of nuclear power plants.

In 1997, the previous analysis was updated with two additional years of data on cancer mortality and cancer incidence (1993 and 1994)[‡]. Rates were examined for the seven-year period 1988-1994. The additional data reinforced the previous conclusions that breast cancer incidence and mortality were the same as or less than the statewide averages. In addition, trends over the ten year period (1985-94) were comparable between the ten counties and the state overall.

This second update now provides cancer data through 1996. Cancer incidence data are shown in the Table below for the nine-year period 1988-1996. As with the two previous analyses, no excesses were found for cancers of the breast and thyroid or for leukemias in the 10-county region. Indeed, breast cancer incidence was significantly below the statewide

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[*]Section 5 in *The Occurrence of Cancer in Minnesota 1988-1992: Incidence, Mortality, Trends*. March 1995. Minnesota Department of Health.

[†]The ten Minnesota counties included in the analysis by Ernst Sternglass were Anoka, Benton, Dakota, Goodhue, McLeod, Meeker, Sherburne, Stearns, Wabasha, and Wright. For consistency, these same counties were included in the MDH analysis.

[‡]Section 5 in *The Occurrence of Cancer in Minnesota 1988-1994: Incidence, Mortality, Trends*. May 1997. Minnesota Department of Health.

average (4247 observed, 4426 expected, p=.01). Over the same time period, there was also no excess of breast cancer deaths (1056 observed, 1044 expected).

These data support the same conclusions reached in the two previous analyses: there is no excess of breast cancer incidence or mortality in the ten counties near nuclear power plants in which it was alleged that sharp increases of breast cancer deaths had occurred. Furthermore, there is no difference in the incidence of two other radiation sensitive cancers-thyroid cancer and leukemia.

Table. Minnesota Cancer Incidence Data 1988-1996 (MCSS)

Cancer Type	Statewide	10 "Nuclear" Counties[1]			
	Rate[2]	Rate[2]	Observed[3]	Expected[4]	SIR (95% Conf.Int.)[5]
Breast Female	110.3	106.0	4247	4426	0.96 (0.93-0.99)
Leukemias					
Male	14.8	15.1	514	507	1.01 (0.93-1.11)
Female	8.6	9.2	372	357	1.04 (0.94-1.15)
Thyroid Gland					
Male	2.7	2.7	114	110	1.04 (0.85-1.25)
Female	6.4	6.3	299	299	1.00 (0.89-1.12)

[1]The ten Minnesota counties included in the analysis by Sternglass: Goodhue, Wabasha, Dakota, Wright, Sherburne, Benton, Stearns, Meeker, Anoka, McLeod

[2]Age-Adjusted Annual Incidence Rate (1970 US Standard), All Races

[3]Total number of newly-diagnosed cancers during the 9-year interval

[4]Total number of expected cancers calculated by applying statewide age- and sex-specific rates to the person-years of observation (sum of annual population estimates).

[5]Standardized Incidence Ratio (Obs./Expected) with 95% Confidence Interval

Environmental Radiation Monitoring Program

Prepared by

Radiation Unit

Division of Environmental Health

The Minnesota Department of Health (MDH) has developed an environmental radiation monitoring program to help determine whether or not radiation levels are exceeding safe amounts set by state and federal standards.

In Minnesota, sources of radioactivity other than natural background radioactivity include two nuclear generating plants, both owned and operated by Northern States Power Company (NSP). These are the Monticello plant in Monticello and the Prairie Island plant near Red Wing. There are also over 200 medical and industrial facilities around the state that use radioactive materials. Some of these facilities, using Naturally Occurring or Accelerator Produced Radioactive Materials (NARM) or radioactive materials licensed by the U.S. Nuclear Regulatory Commission (NRC), are allowed to routinely release small amounts of radioactivity to the environment within limits specified by their licenses.

Minnesota has maintained an environmental radioactivity monitoring program since 1953, when measurements of radionuclides were initiated in response to the atmospheric testing of nuclear weapons. Monitoring around the Monticello plant started in 1968 and the Prairie Island plant in 1970, before the plants went into operation. This helped establish the baselines for future monitoring. The monitoring program continues to include monitoring around the nuclear plants to provide an independent assessment of releases from the plants. NSP, under its operating licenses with the NRC, maintains its own radiation monitoring programs. When NSP was granted permission to store spent nuclear fuel on site at the Prairie Island plant, the MDH entered into an agreement to share monitoring data with NSP and the Prairie Island Indian community under an order of the Minnesota Public Utilities Commission (PUC) issued on September 9, 1994.

The current MDH environmental radiation monitoring program objectives are:

- to detect any above-normal levels of radioactivity in Minnesota due to natural events or regulated activities;
- to determine long-term trends so that any changes in the radiological environment are identified and corrective actions can be taken;
- to verify that data collected by nuclear utilities are comparable, and
- to maintain a knowledge base for responding to nuclear materials accidents.

These objectives are met by sampling various environmental pathways for human exposure and directly measuring radiation levels near the two plants and at a few other locations around the state. The major pathways are:

- Release--> air--> inhalation
- Release--> air--> deposition--> ingestion
- Release--> water--> ingestion
- Gamma ray--> air--> direct exposure.

To monitor the air-inhalation pathway, the MDH owns and operates an air sampler at each nuclear plant and at the MDH central office building in Minneapolis. The air-deposition-ingestion pathway is monitored by sampling vegetation, food crops and dairy milk near the nuclear plants, and dairy milk statewide. The water-ingestion pathway is monitored by sampling surface and well water near the nuclear power plants.

The MDH environmental monitoring program also consists of the measurement of direct gamma and neutron radiation, radiochemical analysis in the MDH Public Health Laboratory, interpretation of the data, and dose estimation for important isotopes.

Milk

Milk is sampled for radioactivity because it is a good indicator of radioactive contamination from atmospheric sources. Radioactive deposition on grass or feed is naturally concentrated in the milk by cows, making the activity easier to detect.

Contaminated milk presents an important environmental health concern because it is consumed by a large portion of the population near where it is produced.

Air

It is important to determine the degree of air contamination from radioactivity because inhalation is a major pathway for radiation doses.

Water

It is important to monitor water for radioactivity because it is consumed locally by humans in large amounts.

Food Crops and Vegetation

Ingestion of radioactivity in crops and foodstuffs is an important pathway for humans, with the additional potential for concentration in the food chain (for example, in animals and plants consumed by humans).

Sediment

Heavy or insoluble radionuclides can collect in river sediment. Sediment sampling thus provides a good indicator for radioactivity.

Gamma and Neutron Radiation

Gamma radiation is measured regularly by placing dosimeters within a ten-mile radius of the nuclear generating plants to ensure that radiation levels are not exceeding safe levels. In addition, radiation from the spent fuel casks inside the Independent Spent Fuel Storage Installation (ISFSI) at Prairie Island is measured by two pressurized ionization chambers (PIC). The PIC have real-time remote reading capability. This means that the PIC are connected by telephone line to a computer in the MDH office and can provide nearly instantaneous readings. Thermoluminescent dosimeters (TLDs) and neutron meters are also used to detect radiation at the ISFSI.

Sample Collection Around the Two Nuclear Generating Plants

The MDH uses the indicator/control concept to monitor around the nuclear generating plants. An indicator sample is one taken within about two miles and downwind from each facility. A control sample is one taken further than about five miles out and upwind from each facility. Both the indicator sample and the control sample are taken on the same day.

Samples of milk, surface water (from the Mississippi River), air, vegetation, food crops, sediment, and groundwater were collected for laboratory analysis. The Wisconsin Department of Health and Family Services has a similar program.

Radioactivity and Radiation Around the Prairie Island Nuclear Generating Plant

The Prairie Island Nuclear Generating Plant is allowed by the U.S. Nuclear Regulatory Commission to release some radioactivity to the Mississippi River through a discharge canal.

Of the over 40 radioactive isotopes that are monitored, only hydrogen-3 (tritium) has been measured above background in the environment. Tritium was found in the Mississippi River above Lock and Dam No. 3 in 1975, 1976 and 1977; and in an off-site well from 1990 to 1997.

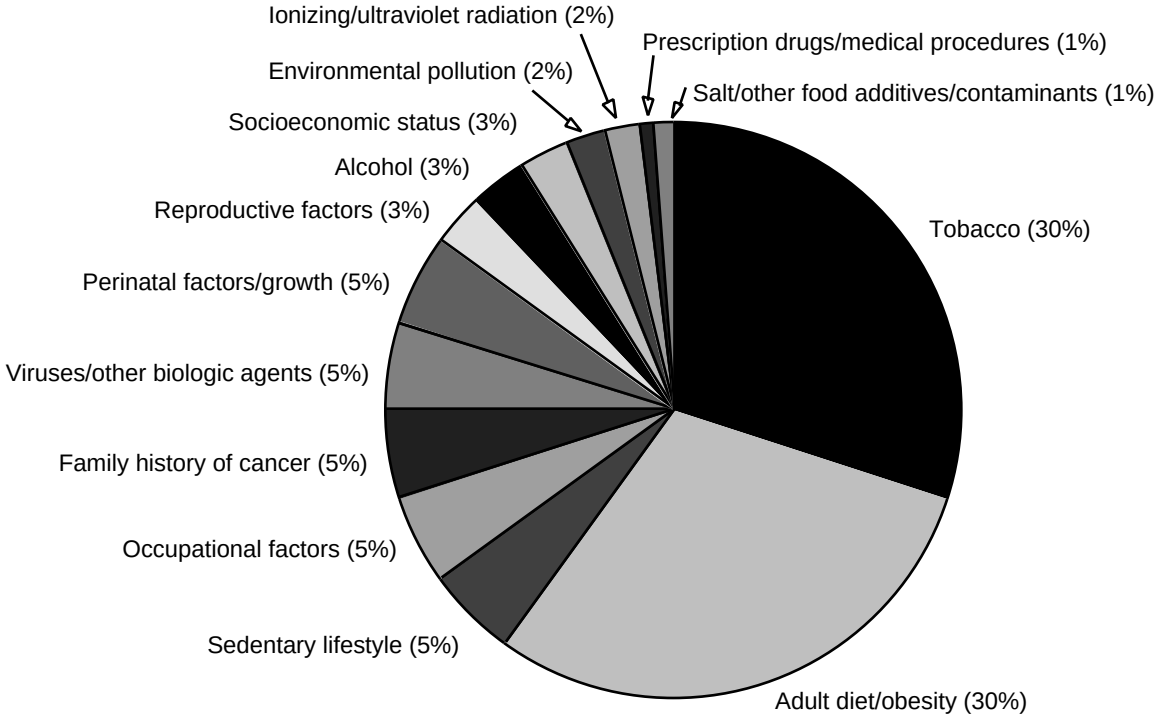
No regulations were exceeded in these cases. NSP did modify its discharge canal in response to these findings; tritium concentrations decreased.

No other radioactive material has been found above detection limits off site.

Conclusion

No environmental exposures have exceeded any standards since the plant became operational in 1973.

APPENDIX C. Causes of Cancer Mortality in the U.S.



Source: Harvard Report on Cancer Prevention. Volume 1: Causes of Human Cancer. 1996. Cancer Causes and Control, Vol. 7 Supplement. November 1996.

WWW: http://www.hsph.harvard.edu/Organizations/Canprevent/contents.html

APPENDIX D. Population Estimates

1.Goodhue County Census Estimates by Year, Sex

Males

Age	1988	1989	1990	1991	1992	1993	1994	1995	1996	Totals
0-4	1536	1539	1577	1537	1511	1490	1453	1411	1386	13438
5-9	1750	1792	1828	1822	1803	1796	1788	1770	1738	16085
10-14	1621	1615	1617	1672	1728	1776	1787	1792	1790	15396
15-19	1577	1516	1357	1343	1358	1411	1463	1523	1575	13121
20-24	1137	1097	1041	1031	1007	992	967	948	929	9147
25-29	1541	1544	1562	1497	1417	1354	1302	1266	1254	12735
30-34	1622	1655	1714	1731	1730	1733	1703	1648	1582	15116
35-39	1523	1573	1627	1675	1704	1756	1787	1825	1845	15313
40-44	1316	1356	1433	1532	1536	1585	1627	1673	1713	13769
45-49	1031	1051	1084	1095	1194	1241	1295	1358	1447	10794
50-54	925	929	937	965	993	1054	1090	1122	1139	9152
55-59	852	846	827	824	826	856	878	891	916	7714
60-64	839	840	839	842	828	822	811	809	809	7437
65-69	771	768	763	763	758	764	757	757	754	6853
70-74	653	649	655	664	676	689	696	706	699	6085
75-79	505	504	496	516	525	534	541	543	552	4714
80-84	364	371	378	386	393	409	415	428	444	3586
85+	287	292	284	299	302	311	318	325	327	2743
Totals	*19850*	*19937*	*20019*	*20194*	*20289*	*20573*	*20678*	*20795*	*20899*	*183198*

Females

Age	1988	1989	1990	1991	1992	1993	1994	1995	1996	Totals
0-4	1455	1460	1497	1464	1436	1419	1380	1342	1316	12767
5-9	1663	1690	1700	1693	1674	1670	1663	1647	1617	15015
10-14	1531	1529	1558	1615	1663	1712	1722	1725	1724	14777
15-19	1363	1312	1245	1211	1227	1267	1311	1361	1410	11705
20-24	1079	1046	1022	1003	970	962	935	918	888	8821
25-29	1512	1521	1521	1451	1369	1306	1247	1209	1194	12328
30-34	1573	1604	1656	1676	1665	1669	1634	1583	1520	14578
35-39	1493	1537	1574	1607	1627	1673	1701	1729	1746	14685
40-44	1275	1313	1398	1475	1483	1532	1575	1612	1646	13307
45-49	1018	1039	1045	1060	1145	1194	1241	1312	1398	10450
50-54	932	925	923	948	974	1032	1064	1097	1116	9009
55-59	840	831	817	812	815	840	861	878	903	7595
60-64	933	936	924	916	898	887	870	870	866	8098
65-69	884	875	875	873	861	868	863	853	848	7798
70-74	836	836	837	836	843	848	845	851	843	7573
75-79	792	800	810	824	831	842	851	842	843	7433
80-84	609	622	647	653	664	674	683	703	712	5965
85+	702	722	742	758	771	793	807	828	839	6960
Totals	*20490*	*20598*	*20791*	*20875*	*20916*	*21188*	*21253*	*21360*	*21429*	*188864*

APPENDIX D (continued)

2. Goodhue County Census Tracts with Associated Zip Codes, Towns and Populations

Census Tract (BNA)	*1990 Census*	*Zip Code*	*Cities/Towns*	*Population*	*Proportion of Tract Total*
9801	8436	55066	Red Wing	8436	1.00
9802	7094	55009	Cannon Falls	24	0.003
		55066	Red Wing	6998	0.986
		55089	Welch	72	0.01
9803	3257	55026	Frontenac	1698	0.521
		55027	Goodhue	587	0.18
		55066	Red Wing	972	0.298
9804	3558	55009	Cannon Falls	1131	0.318
		55027	Goodhue	1194	0.336
		55066	Red Wing	627	0.176
		55089	Welch	606	0.17
9805	3160	55009	Cannon Falls	1752	0.554
		55018	Stanton	1401	0.443
		55983	Wanamingo	7	0.002
9806	4065	55009	Cannon Falls	3902	0.96
		55018	Stanton	163	0.04
9807	3247	55018	Stanton	445	0.137
		55946	Kenyon	2368	0.729
		55963	Pine Island	2	0.001
		55983	Wanamingo	432	0.133
9808	3508	55946	Kenyon	0	0
		55963	Pine Island	3417	0.974
		55992	Zumbrota	91	0.026
9809	4365	55963	Pine Island	41	0.009
		55983	Wanamingo	880	0.202
		55992	Zumbrota	3444	0.789

APPENDIX E. Breast Cancer Information and Screening Recommendations

General Sources of Information About Breast and Other Cancers

Listed below are a few of the more comprehensive sources of information about breast cancer. These resources have extensive links to other resources. Internet access is available at most public libraries.

- **Minnesota Breast and Cervical Cancer Control Program**
  Phone: 1-888-6-HEALTH
  Internet: http://www.health.state.mn.us/divs/dpc/cc/mbcccp.htm

- **University of Minnesota Cancer Center**
  Phone: 1-888-CANCER MN (1-888-226-2376)
  Internet: www.cancer.umn.edu

- **Mayo Clinic Cancer Center**
  Internet: http://www.mayohealth.org/mayo/common/htm/canhpage.htm

- **American Cancer Society**
  Phone: 1-800-ACS-2345 (Cancer Response Service)
  AOL: Keyword: ACS
  Internet: http://www.cancer.org/ (ACS home page)

- **OncoLink** (The University of Pennsylvania Cancer Center)
  Internet: http://cancer.med.upenn.edu/ (OncoLink home page)
  http://cancer.med.upenn.edu/disease/breast/ (breast cancer information)

- **National Cancer Institute**
  Phone: 1-800-4-CANCER (1-800-422-6237).(Cancer Information Service)
  Internet: http://www.nci.nih.gov/hpage/cis.htm (Cancer Information Service)
  http://cancernet.nci.nih.gov/ (CancerNet)
  http://rex.nci.nih.gov/ (NCI site for Patients, Public, & Media)

American Cancer Society Recommendations for Breast Cancer Screening

- Women age 40 and over should have a mammogram and a breast exam by a health care professional (physician, physician assistant, nurse or nurse practitioner) every year.

- Between the ages of 20 and 39, women should have a clinical breast exam every 3 years, performed by a health care professional.

- All women over 20 should do breast self- examination (BSE) every month.