CANCER INCIDENCE STUDY

Cancer Incidence Statistical Review Investigating Western Bear River Valley, Box Elder County, Utah Covering the Period from 1975 to 2009

May 21, 2013

Prepared by the

Utah Department of Health
Division of Disease Control and Prevention
Bureau of Epidemiology
Environmental Epidemiology Program

TABLE OF CONTENTS

ACKNOWLEDGMENT

Cancer data used for this investigation was obtained from the Utah Cancer Registry (UCR). The UCR is funded by contract N01-PC-35141 from the National Cancer Institute (NCI)'s Surveillance, Epidemiology and End Results (SEER) Program with additional support from the Utah Department of Health (UDOH) and University of Utah.

Other data and analytical tools used for this investigation were obtained from the Utah Environmental Public Health Tracking Network (UEPHTN). In addition, the UEPHTN provides geocoding services to UCR data. The UEPHTN is funded by a grant from the Centers for Disease Control and Prevention (CDC), Environmental Public Health Tracking Branch. The current UEPHTN award is number 1U38EH000954.

EXECUTIVE SUMMARY

Cancer is a dominating environmental public health concern. A function of epidemiology is to investigate cancer incidence starting with a statistical review of cancer cases. This report presents a statistical review of cancer incidence among residents of Bothwell, Howell, Marble Hills, Penrose, and Thatcher, located in the western part of Bear River Valley, Blue Springs Hills and Blue Creek Valley. The Environmental Epidemiology Program (EEP), within the Utah Department of Health (UDOH), conducted this statistical review by comparing the cancer incidence of seven sequential 5-year time periods for 42 anatomical site-specific cancer categories to expected counts derived from the state age-adjusted cancer rate for the corresponding site and time period.

The EEP considers the incidence of cancer to be meaningfully elevated when two or more sequential time periods have statistically elevated cancer incidence counts, or when the ratio of the observed incidence count to the expected count is greater than five. The EEP did not find meaningfully elevated incidence of cancer for any of the 42 site-specific cancer categories. In addition, there was no trend of increasing incidence of cancer for any of the site-specific cancer categories. There were three categories of cancer where the incidence of cancer was elevated for a single analytical time period. Among males, lung and bronchial cancer incidence was elevated (SIR = 3.3 [95% confidence interval = 1.1 – 7.7]) in the 1985-1989 analytical period, and prostate cancer was elevated (2.1 [1.2 – 3.3]) in the 2000-2004 analytical period. Among females, non-Hodgkin lymphoma incidence was elevated (4.3 [1.1 – 10.9]) for the 2005-2009 analytical period. The EEP could not determine if these findings are suggestive of higher risk or random statistical artifacts. Risk factors for these three cancer types are not associated with any of the commercial or industrial environmental concerns in or near the area outside of workplace exposure. Non-Hodgkin lymphoma has been associated with agricultural related environmental exposures.

Lung and prostate cancer are preventable cancers. For persons developing these cancers, early detection and early intervention improve the prognosis for recovery and quality of life experience. The EEP recommends that the Bear River Health Department work with the Utah Cancer Control Program within the UDOH for screening and health education services that could be made available to the study communities. In addition, a follow-up cancer statistical review should be conducted for non-Hodgkin lymphoma among female residents of the study area.

INTRODUCTION

Cancer Incidence Statistical Reviews: A core function of epidemiology is to track and evaluate disease patterns. This function helps public health officials and policy makers identify and assess communities with public health challenges, define public health priorities, monitor and evaluate public health actions, and discover knowledge about public health concerns (Dicker 2002; Stanbury et al. 2012; Thacker 2000; Thacker et al. 2012). Cancer is a dominating environmental public health concern. Public fear of cancer resulting from environmental hazards is reinforced by U.S. environmental regulatory actions that use cancer as a mechanism for making regulatory decisions (Morrone 2011). Public concerns about excess cancer risk often result in requests made to public health agencies to conduct investigations. Public health conducts investigations of cancer incidence using one of several methods. The first is a cancer incidence statistical review. This method focuses on determining if a particular community is experiencing more cancer than would be expected. A cancer statistical review is usually conducted by linking cancer registry and population data and evaluating trends. From the public health perspective, cancer incidence statistical review is most useful in identifying community needs about cancer-related health education and awareness building, public health screening services and other public health interventions. For the community, these kinds of studies empower the community to make improvements in governmental policymaking and health care services (Bell et al. 2006; Kingsley et al. 2007). Another method available to public health practitioners is a cancer cluster investigation. Cancer cluster investigations focus on characterizing the size and extent of a population with known cancer excess and determining potential causal factors. The cancer cluster methodology involves linking many causal variables, usually collected by medical record review and individual surveys or interviews, followed by complex statistical analysis to identify the few variables that seem to explain the risk (Kingsley et al. 2007). Cluster investigations rarely result in important discoveries of causality (Goodman et al. 2012; Kingsley et al. 2007).

Study Objectives: This report presents a statistical review of cancer incidence among residents of the rural communities (Bothwell, Howell, Marble Hills, Penrose, and Thatcher) that are located in the western part of Bear River Valley, Blue Springs Hills and Blue Creek Valley. The Environmental Epidemiology Program (EEP), within the Utah Department of Health (UDOH) conducted this statistical review by analyzing periodic cancer rates and trends in rates of cancer incidence in the study area, compared to corresponding rates of the state of Utah. The objective of a statistical review is to identify significantly elevated cancer incidence rates. The statistical review methodology does not quantify the linkage of cancer rates to possible causal risk factors. Specific hazardous chemicals of concern and exposure risk are not addressed by this report.

Authority and Funding: This study was requested by the Utah Department of Environmental Quality (UDEQ) and authorized by the UDOH Executive Director. Cancer, population, and geographic data for this investigation are collected, maintained and made available by the Utah Environmental Public Health Tracking Network (UEPHTN). The UEPHTN also funds the SAS® and ArcGIS® analytical software application licenses that were used to conduct this investigation. The UEPHTN is funded by a grant from the Centers for Disease Control and Prevention (CDC) (UEPHTN 2012). Personnel time used to conduct this investigation was charged against state-funded Environmental Health Administrative funds. No federal funds were directly used to conduct this investigation.

DATA AND METHODS

Study Design: This investigation is a retrospective statistical review of cancer incidence among residents of the study area (defined below). Statistical reviews are not cancer cluster investigations, and lack the power to link cancer incidence to putative risk factors (Jekel et al. 1996; Kingsley et al. 2007; Mann 2003). Statistical reviews are a tool used by the EEP to review the health status of a population and assess public health activities.

The incidence of cancer, quantified in sequential 5-year incidence rates for each cancer category among residents of the study area, is compared to cancer incidence rates for the state of Utah. The study's null hypothesis is that the incidence of cancer in the study area is not significantly different from the incidence of cancer for the state of Utah.

Cancer Data: Cancer incidence data on people diagnosed with primary invasive cancer between 1973 and 2009 were obtained from the Utah Cancer Registry (UCR). The EEP receives cancer data for all invasive cancers on an annual basis. The UCR completes a rigorous data review for completion and data quality before data are released to the EEP. The most recent years of data are not made available to the EEP until they have been finalized. The UCR data includes diagnostic information, patient demographics, and residential addresses of the cases, as well as information about the behavior of the cancer. The residential address information provided by the UCR includes the city and ZIP code (UCR 2012). The EEP geocodes each cancer case's residential address data to obtain an x- and y-coordinate for that address. Using those coordinates the EEP is able to geo-reference cancer case data to their respective U.S. 2000 census block group areas.

Individuals with multiple primary invasive cancers have multiple records in the data set in sequential order. These cancers are distinguished by unique cancer registry tracking numbers and a cancer sequence number. The sequence number allows discrimination between the first cancer diagnosis and subsequent diagnoses (UCR 2012). Diagnostic coding of cancers includes the International Classification of Disease Oncology, 3rd Edition (ICD-O-3) codes for site, histology and behavior (WHO 2012). The UCR groups cancer into 42 major cancer types by site following the guidance provided by the National Cancer Institute's Surveillance, Epidemiology and End Results (SEER) Program (NCI 2012a). These 42 UCR site codes are a convenient grouping for conducting surveillance analyses (UCR 2012).

Certain kinds of medical treatment for cancer and other diseases, such as radiation therapy, increase an individual's risk for developing subsequent leukemia, particularly myeloid leukemia (sometimes known as therapy-induced leukemia) (Godley and Larson 2008; Leone et al. 1999, 2011; Sill et al. 2011; Wilkins and Woodgate 2008). Myeloid leukemia cases that were the first of any sequence of cancers for an individual were included for this investigation. Myeloid leukemia cases that were subsequent to a previous cancer and could be therapy-induced leukemia were excluded.

Statewide between 1975 and 2009, 169,973 invasive primary cancer incidence reports among 148,943 individuals were registered by UCR. Of those, 183 persons living in the study area experienced 202 cancer incidences between 1975 and 2009.

Population Data: The 2000 U.S. census divides Utah into 1,481 census block groups (USCB 2004) with a median population of 1,364 persons per census block group in the year 2000. Commercially available U.S. census population data for Utah for the 1970, 1980, 1990, 2000 and 2010 censuses (Geolytics 2002a, 2002b, 2002c; Geolytics 2012a, 2012b) were used to estimate annual age-group and sex population counts for each census block group for each intercensal year. These estimates were made by applying annual population growth rates derived from the previous and subsequent decennial data. This method follows national population estimation guidelines (USCB 2012a).

Analytical Periods: Seven 5-year analytical periods: 1975-1979, 1980-1984, 1985-1989, 1990-1994, 1995-1999, 2000-2004 and 2005-2009 were evaluated for temporal cancer incidence trends.

Study Population: The study population was defined as all residents living in census block groups 49.003.960100.2 and 49.003.960400.1 (See Figure 1, in Appendix). These two census block groups include Bothell, Marble Hills, Penrose, and Thatcher in the western part of Bear River Valley and Howell located in Blue Creek Valley. The 2010 estimated study area population is 2,749 persons (GeoLytics 2012b).

Cancer cases and population data were aggregated into six age group strata: 0-19 years of age, 20-34 years of age, 35-49 years of age, 50-64 years of age, 65-74 years of age, and 75 years and older. The cancer incidence by cancer types and population counts for each age group, sex and analytical period strata for each of the study area census block groups were added together to generate the age group, sex and analytical period cancer incidence and population counts for the study population.

Comparison Population: The comparison population for this investigation was defined as the state population excluding the study population. Similar to the process of developing the study population, the cancer incidence by cancer type and population counts for each age group, sex and analytical period for all of the census block groups in the state not included in the study population were added together to generate the comparison population. The 2010 estimated population for the state is 2,763,885 (GeoLytics 2012b).

Socio-Economic Assessment of the Study and Comparison Populations: Social determinants of health are complex, integrated, and overlapping social structures and economic systems that are now thought to affect disease morbidity and mortality. Education level is an example. A better education leads to higher income and financial stability, which in turn leads to better health care access, which leads to healthier lifestyles, and to earlier detection and better treatment options for disease (Song et al. 2011). The 2010 census collected basic information about the population distribution, home life structure, and housing (GeoLytics 2012b).

Estimate	Study Area	State of Utah	Box Elder County
2010 Population (People Count)	2,749	2,763,885	49,975
Percent of Population is of Minority Race	5.2%	13.9%	8.2%
Percent of Population is Hispanic or Latino	3.9%	13.0%	8.3%
Median Age of Population (Years)	30.6	29.2	30.6
Percent Population are Children 0-17 Years Old	33.5%	31.5%	34.0%
Percent Population are Adults 65 Years or Older	11.1%	9.0%	11.1%
Households	852	877,692	16,058
Percent Family Households (2 or more related persons)	83.6%	75.2%	80.3%
Percent Single Person Households	14.9%	18.7%	17.2%
Percent Married Couple Households	76.2%	61.0%	67.4%
Average Family Size	3.5	3.6	3.5
Percent Population in Family Households	90.7%	85.0%	90.3%
Housing Units	997	979,709	17,326
Percent Housing Units Occupied	85.8%	89.6%	92.7%
Percent Owned Occupied Homes	86.9%	70.4%	79.5%

The 2010 census did not collect information about education, income or occupation that was previously gathered in the 2000 census. Since 2000, the U.S. Census Bureau has used the American Community Survey (ACS) to sample a small percentage of the U.S. population each year to collect this kind of information. Data from the ACS are not available at the census block group level. For this comparison, the two census tracts (49.003.960100 and 49.003.960400) that include the study area census block groups were used. The study area population represents approximately 34.4% of the population in these two census tracts.

The ACS 5-Year Estimates for 2005-2009 figures were used to compare selected demographic and economic characteristics that are important social determinants of health for cancer. These risk factors contribute to the burden of disease, but are not the risk of concern for this investigation. Ideally, the social determinants of health metrics for the study area should be similar to the comparison population. If the social determinants of health between the two groups are disproportionate, the social determinants of health may confound the investigation of environmental risk assessment. The study area was compared to the county and state (USCB 2012b, 2012c, 2012d).

Estimate	Western Bear River Valley	State of Utah	Box Elder County
Percent Adults with at least a High School Education	93.4%	90.4%	90.5%
Percent Adults Employed	68.1%	65.9%	65.8%
Percent Adults Employed in Jobs at High Risk for Chemical Exposure (Military, Agriculture, Construction, Manufacturing, Transportation, etc.)	47.9%	15.4%	39.7%
Average Household Income	$57,565	$69,686	$54,638

Estimate	Western Bear River Valley	State of Utah	Box Elder County
Percent Families Living Below Poverty	9.0%	7.2%	7.4%
Percent Families with Children 0-18 Years Living Below Poverty	13.7%	9.8%	8.8%
Percent Persons 65 Years or Older Living Below Poverty	5.3%	7.6%	5.7%
Percent Population Foreign Born	3.4%	7.9%	3.4%
Percent Population Not U. S. Citizens	1.4%	5.4%	1.7%

For those social determinants of health with more than a ten percent difference, the study area is better with respect to the percentage of households that are comprised of families, but worse off with respect to the population age distribution, income, high-risk employment, and poverty. The percentage of employed adults working in jobs that have a high-risk for chemical exposure for the study group is three times higher than the comparison population. The percentage of people who are foreign born, or are not U.S. citizens in the study area is higher than the state percentage. These indicators may indicate a variety of barriers to health care service and preventive health knowledge including cultural, language, and legal barriers. This statistical review does not control for these potential confounders.

Behavioral Risk Factors: Tobacco use, chronic alcohol use, and obesity are well-known risk factors for many types of cancer. The UDOH conducts annual behavioral risk factors telephone surveys in Utah. These data are made available publicly on the Indicator-Based Information System for Public Health (IBIS-PH) Web site tabulated using a small area geography known as health statistical units. The health statistical units are aggregations of one or more ZIP code areas to achieve an annual population of at least 20,000 persons. Box Elder County has two units, Brigham City (ZIP Code 84302) and the rest of Box Elder County (ZIP Codes 84301 – Bear River City, 84306 – Colliston, 84307 – Corrine, 84309 – Deweyville, 84311 – Fielding, 84312 – Garland, 84313 – Grouse Creek, 84314 – Honeyville, 84316 – Howell, 84324 – Mantua, 84329 – Park Valley, 84330 – Plymouth, 84331 – Portage, 84334 – Riverside, 84336 – Snowville, 84337 – Tremonton, 84340 – Willard, and all surrounding areas supported by these ZIP codes). The Behavioral Risk Factors Survey System (BRFSS) data was queried for these behavioral risks as well as access and utilization of health care. All available years of data from 2001 through 2010 were used for the queries (UDOH 2012).

Estimate	Box Elder County Except Brigham City	State of Utah
Smoking Rates among Adult Men	7.0%	12.6%
Smoking Rates among Adult Women	8.9%	9.2%
Chronic Drinking (Alcohol) Rates among Adult Men	2.6%	3.5%
Chronic Drinking Rates among Adult Women	Insufficient data	2.3%

Estimate	Box Elder County Except Brigham City	State of Utah
Body Mass Index (BMI) greater than 25 among Men	46.7%	64.7%
BMI greater than 25 among Women	29.0%	47.7%
Percent of Population with No Health Coverage	15.6%	15.0%
Percent of Population not Receiving Health Care in Last Year	44.1%	44.6%

These data suggest that the communities in western Box Elder County, which includes the study area, practice better life choices with respect to tobacco use, alcohol consumption, and obesity than the state population as a whole. The study area population's access to health care appears to be similar to that of the state.

Indirect Age-Standardized Incidence Rates: The statistical analyses program SAS® version 9.2 was used to manage and analyze the data. The sex-specific and sex-nonspecific indirect age-standardized incidence rate for each cancer type and analytical period was calculated using standard methods (Anderson and Rosenberg 1998; Jekel et al. 1996; Selvin 1996). This is the preferred method for analysis of disease with small case counts per analytical period. The expected incidence count and rate was computed by applying the comparison population incidence rate to the study area population for each analytical period using the indirect age-standardization method.

Standardized Incidence Ratio: The standardized incidence count of cancer for the study area was evaluated against the expected incidence count in the form of standardized incidence ratio (SIR). An SIR greater than one (1.0) indicates that the incidence of cancer in the study area population is greater than the proportional cancer incidence in the comparison population for that period of analysis. Conversely, an SIR less than one indicates that the incidence of cancer in the study area population is less than expected based on the comparison population's rate. Statistical significance is determined by applying the Byar's 95% confidence interval for the SIR (Breslow and Day 1987; Rothman and Boice 1979, 1982; Sahai and Khurshid 1983, 1996). For statistical validity, SIRs and corresponding 95% confidence intervals were only calculated for time periods with three or more cases (Bender et al. 1990; Caldwell 1990; Thun and Sinks 2004). The EEP is required to protect confidential data from unlawful disclosure; therefore, the EEP suppresses results for analytical time periods containing three or less cases (Langeberg et al. 2004).

An SIR for a specific cancer greater than one (1.0) and a confidence interval (expressed by the lower and upper limits) that does not include one (1.0) is considered to be statistically significant. Using a 95% confidence interval is a well-established standard for interpretation of an SIR with respect to statistical significance. It should be noted that an SIR may be statistically significant using this interpretation criteria, and may be a mathematical artifact and not biologically meaningful or relevant (Bender et al. 1990; Besag and Newell 1991). When conducting multiple analyses using the 95% confidence interval to interpret the data, one would expect one in twenty (5%) of the analyses to have a statistically significant interpretation as a result of random chance. For this investigation, 784 independent analyses (35 cancer type categories x 3 sex groups x 7 analytical periods and 7 sex-specific cancer types x 1 sex group x 7

analytical periods) were conducted. This means as many as 39 (784 x 5%) of the analytical results could be due to chance. The EEP uses interpretive rules to distinguish results that are meaningfully significant from those that are not. The EEP considers the results meaningful when there are two consecutive time periods with a statistically significant result or when the SIR is greater than five (Bender et al. 1990; Caldwell 1990; Langeberg et al. 2004; Thun and Sinks 2004).

Analysis of Temporal Trend: The Kendall Tau-c (or Kendall rank correlation coefficient) test for trend was used to test for temporal trends of increasing or decreasing rates (Kendall 1938). The Kendal Tau-c statistic is an appropriate method to investigate trends when there are only a few analytical periods. The Kendall Tau-c tests the correlation between the analytical period rate and the ordered numeric designation of the analytical periods (i.e., analytical period 1975-1979 is number 1, period 1980-1984 is number 2, etc. till period 2005-2009 is number 7). The values of Tau-c range from -1 (a consistent decreasing trend) to +1 (a consistent increasing trend). Values near zero indicate no trend. Trend was indicated by statistically significant (p-value ≤ 0.05) correlation coefficients (approximately equaled to $\pm$ 0.70).

FINDINGS

The analytical results for the study area for each of the 42 cancer types and analytical periods are presented in Table 1 (see Appendix). Three cancer types were found to be elevated during at least one analytical period. Those types are: lung and bronchial cancer; prostate cancer; and non-Hodgkin lymphoma.

Statistically Significant Cancer Results: Significantly elevated cancer incidence rates are indicated with an "S" in Table 1. Among males, lung and bronchial cancer incidence was elevated (SIR = 3.3 [95% confidence interval = 1.1 – 7.7]) in the 1985-1989 analytical period, and prostate cancer was elevated (2.1 [1.2 – 3.3]) in the 2000-2004 analytical period. Among females, non-Hodgkin lymphoma incidence was elevated (4.3 [1.1 – 10.9]) for the 2005-2009 analytical period.

Meaningful Cancer Results: No cancer site categories had two or more consecutive analytical periods or an SIR greater than five. The EEP cannot determine if there is meaningful cancer excess in the study area.

Trends: Analysis of the changes of the rate of cancer incidence through time (trend analysis) identified types of cancer with increasing or decreasing trends. Not all cancer types with a significant trend have significantly elevated cancer incidence. However, it is possible, that cancer types with a significant trend of increasing incidence will eventually reach a time where the incidence is significantly elevated. Not all cancer types that were elevated during one or more analytical periods present a significant trend.

For this study, no significant increasing or decreasing trends in the cancer incidence through the 5-year analytical periods were found.

DISCUSSION

Cancer: Cancer is a broad group of more than 100 diseases that involve uncontrollable cell replication and growth. Often these cells are "undifferentiated," meaning they have lost their tissue-specific characteristics. As these cells grow to form tumor tissue, they invade nearby healthy tissue or spread through metastasis to other tissues. This invasion, or spread, disrupts the functions of the affected healthy tissues. Cancer cells may also produce metabolic products that can be transported to other parts of the body resulting in adverse health effects (NCI 2012b). The American Cancer Society (ACS) estimates that about one in two men and one in three women will develop cancer (all invasive sites) sometime in their life (lifetime risk) (ACS 2009; NCI 2011a, 2011b). In the U.S., cancer is the second leading cause of death (CDC 2012). Among all causes of death, approximately one in four men and one in five women will die of cancer (ACS 2009; NCI 2011a, 2011b). On average, about one in nine people will develop two or more cancers in his or her lifetime (Wilkins and Woodgate 2008).

Risk factors that contribute to the development of cancer include both inherent and external factors. Inherent factors include a variety of genetic susceptibilities. External factors include life choices and behaviors (e.g., tobacco use, alcohol use, poor diet, obesity, lack of physical activity, excessive sunlight exposure, and sexual behavior), medical conditions and medications, oncogenic pathogens, and chemical or radiological environmental exposures. Cancer may be the result of several factors interacting together with a triggering event (NCI 2012b).

Cancer of the lung and bronchus, cancer of the prostate and non-Hodgkin lymphoma were elevated during one analytical period. While these findings were not found to have public health relevance, the following discussion of each of these cancer site categories is provided for public health education about cancer.

Lung and bronchial cancer: Lung cancer is the leading cause of cancer-related mortality in the U.S. (Alberg and Samet 2003; Alberg et al. 2007; Molina et al. 2009). It is also one of the few types of cancer that has been linked to environmental exposure to alpha-emitting radiation (Coggle et al. 1986; Mould 2001; Nermina 2005; Schottenfeld and Fraumeni 1996; Tomasek et al. 1993). Approximately one in 13 men and one in 16 women will develop lung cancer during their lifetime and one in 15 men and one in 20 women will die of lung cancer (ACS 2009). There are several different kinds of lung cancer. The four major types include squamous cell (also called epidermoid) carcinoma, adenocarcinoma (cancers of the glands of the lung), large cell carcinoma, and small cell undifferentiated carcinoma. Together, these four types of lung cancer account for more than 90% of lung cancer cases in the U.S. (Alberg and Samet 2003; Field et al. 2004). This investigation does not differentiate the different kinds of lung cancer.

The most important risk factors for all types of lung and bronchial cancer include smoking, exposure to secondhand smoke, alcohol use, the presence of certain smoking-related lung diseases (e.g., chronic obstructive pulmonary disease), poor diet, lack of physical activity, a family history (genetic susceptibility) of lung cancer, respiratory exposure to radon gas, respiratory exposure to asbestos, respiratory exposure to polycyclic aromatic hydrocarbons, and respiratory exposure to certain metals such as arsenic, chromium or nickel (Alberg and Samet

2003; Alberg et al. 2007; Armstrong et al. 2004; Brenner et al. 2011; Bronson et al. 2002; Darby et al. 2001; Molina et al. 2009; Samet and Eradze 2000; Samet et al. 2009). Smoking and exposure to secondhand smoke represent approximately 84% of all lung cancer deaths in the U.S. (Giovino 2002). This study does not control for behavior or life choice risk factors (tobacco or alcohol use) or genetic risk factors, and cannot quantify the amount of lung cancer risk that would be associated with environmental exposures.

Environmental exposures of concern include radon and asbestos. Radon is a naturally-occurring radioactive gas that results from the breakdown of uranium in soil and rocks. It cannot be seen, tasted, or smelled. Radon is the second leading cause of lung cancer in this country, and is the leading cause among nonsmokers. Outdoors, there is so little radon that it is not likely to be dangerous. But indoors, radon can be more concentrated. When it is breathed in, it enters the lungs, exposing them to small amounts of radiation. This may increase a person's risk of lung cancer. Houses in some parts of the U.S., built on soil with natural uranium deposits, can have high indoor radon levels (especially in basements). Studies from these areas have found that the risk of lung cancer is higher in people who have lived in a radon-contaminated house for many years. Nearly all homes in Utah have the potential to have radon in the basement part of the home. Homes that are built closer to granite foothills have a higher potential. Exposure to other radioactive ores such as uranium can also increase one’s risk (ACS 2012a, 2012b).

Workplace exposure to asbestos fibers is an important risk factor for lung cancer. Studies have found that people who work with asbestos (in some mines, mills, textile plants, places where insulation is used, shipyards, etc.) are several times more likely to die from lung cancer. In workers exposed to asbestos who also smoke, the lung cancer risk is much greater than even adding the risks from these exposures separately. It's not clear to what extent low-level or short-term exposure to asbestos might raise lung cancer risk (ACS 2012a, 2012b).

Other environmental or occupational risks of concern are inhaled chemicals or minerals such as arsenic, beryllium, cadmium, silica, vinyl chloride, nickel compounds, chromium compounds, coal products, mustard gas, and chloromethyl ethers and exposure to diesel exhaust. Exposure to other air pollutants may increase the risk for lung cancer slightly. High levels of arsenic in drinking water may increase the risk of lung cancer, particularly among smokers (ACS 2012a, 2012b).

People with multiple endocrine neoplasia type 1 (MEN1, an inherited syndrome) are at high risk for tumors in certain endocrine organs, such as the pancreas and the pituitary and parathyroid glands. These people also seem to be at increased risk for lung carcinoid tumors (ACS 2012c).

Prostate cancer: Prostate cancer is now one of the most serious oncological diseases in men. Nationally, the 2008 incidence rate was 156.0 cases of prostate cancer per 100,000 men, based on data reported to the SEER program. Prostate cancer is the second leading cause of cancer mortality. The death rate is 24.4 deaths due to prostate cancer per 100,000 men. Utah has higher rates than the United States. In Utah, the incidence rate for 2008 was 165.6 cases per 100,000 men and the mortality rate is 27.0 deaths per 100,000 men. From 1975 until the early-1990s, annual prostate cancer incidence and mortality rates had been increasing. Since 1990, the rates of prostate cancer have been declining (NCI 2011b). Among the communities around ATK

Promontory, the incidence rate from 1998 to 2007 was 188.2 cases per 100,000 men. This rate is statistically higher than the state rate and represents an increase in the risk for prostate cancer among the male residents of those communities.

The risk for prostate cancer increases with age (Bostwick et al. 2004, Gallagher and Fleshner 1998). African American men have a higher risk than other races, and men with a family history of prostate cancer have a higher risk (Bostwick et al. 2004; Gallagher and Fleshner 1998; Kral et al. 2011). High animal fat diets and vitamin D and/or E deficiency may increase the risk for prostate cancer (Bostwick et al. 2004; Gallagher and Fleshner 1998). Exposure to pesticides, particularly organophosphate and triazine pesticides, has been associated with increased risk for prostate cancer (Clapp et al. 2008). Higher incidence of prostate cancer has been noted among men working in agricultural occupations and this may be related to increased risk of exposure to agricultural chemicals (Clapp et al. 2008; Gallagher and Fleshner 1998). Both arsenic and cadmium are significant environmental contaminates and exposure to these contaminates has been associated with a number of carcinogenic outcomes, including the development of prostate cancer (Benbrahim-Tallaa and Waalkes 2008; Bostwick et al. 2004). On the other hand, selenium and possibly zinc, have been shown to be preventive agents for prostate cancer (Gallagher and Fleshner 1998; Platz and Helzisouer 2001). Natural compounds known as carotenoid lycopenes, found in tomatoes and tomato-based products, are thought to be protective (Gallagher and Fleshner 1998; Giovannucci 2002).

Non-Hodgkin lymphoma: There are two kinds of lymphomas: Hodgkin lymphoma (named after Dr. Thomas Hodgkin, who recognized it in 1832), and non-Hodgkin lymphoma. These two main types of lymphomas differ in how they behave, spread, and respond to treatment. Lymphomas are cancers that arise in lymphocytes. Lymphocytes are a type of white blood cell that helps the body fight infections. There are two major types of lymphocytes, B-cell lymphocytes and T-cell lymphocytes. T-cell lymphocytes are involved in producing substances that help other kinds of white blood cells fight infections or respond to injuries. B-cell lymphocytes make antibodies against germs. Lymphocytes are found throughout the body, but tend to collect in certain kinds of tissues including the lymph nodes (hence their name), spleen, bone marrow, and thymus. Lymphoma can start anyplace where lymphocytes are found, but most often start in the lymph nodes in the upper part of the body. Lymphoma occurs when lymphocytes are produced in an out-of-control, excessive rate (ACS 2012d; NCI 2007).

There are many types of non-Hodgkin lymphoma and classifying them (even for doctors) can be confusing. Non-Hodgkin lymphoma can start with either B-cell or the different kinds of T-cell lymphocytes. Overall, the risk of non-Hodgkin lymphoma is higher in men than in women, but there are certain types of non-Hodgkin lymphoma that are more common in women. In the U.S., whites are more likely than African Americans and Asian Americans to develop non-Hodgkin lymphoma. Non-Hodgkin lymphoma is more common in older people (ACS 2012d).

People with weakened immune systems have an increased risk for non-Hodgkin lymphoma. For example, people who receive organ transplants (kidney, heart, liver) are treated with drugs that suppress their immune systems to prevent it from attacking the new organ. These people have a higher risk of developing non-Hodgkin lymphoma. Human Immunodeficiency Virus (HIV) can also weaken the immune system. People infected with HIV are at increased risk of non-Hodgkin

lymphoma. Some genetic (inherited) syndromes can cause children to be born with a deficient immune system. Along with an increased risk of serious infections, these children also have a higher risk of developing non-Hodgkin lymphoma. These inherited immune deficiency diseases can be passed on to children, but people with non-Hodgkin lymphoma who do not have these inherited diseases, do not pass an increased risk of lymphoma on to their children (ACS 2012d; NCI 2007).

Some autoimmune diseases such as rheumatoid arthritis, systemic lupus erythematous (SLE, or lupus), celiac sprue (gluten-sensitive enteropathy), and others have been linked with an increased rate of non-Hodgkin lymphoma. In autoimmune diseases, the immune system sees the body's own tissues as foreign and attacks them, as it would a germ. Lymphocytes (the cells from which lymphomas start) are part of the body's immune system. The overactive immune system in autoimmune diseases may cause lymphocytes to grow and divide more often than normal. This may increase the risk of them developing into lymphoma cells (ACS 2012d).

In addition to HIV infections, other types of infections, such as human T-cell leukemia/lymphoma virus (HTLV-1) and the EBV, may raise the risk of non-Hodgkin lymphoma. These viruses infect lymphocytes and can directly affect the DNA of infected cells, helping to transform them into cancer cells. Almost all people living in the U.S. have been infected by EBV, usually in their early childhood (ACS 2012d; NCI 2007).

Exposure to chemicals such as benzene and certain herbicides and insecticides (weed- and insect-killing substances) may be linked with an increased risk of non-Hodgkin lymphoma. Some chemotherapy drugs used to treat other cancers may increase the risk of developing non-Hodgkin lymphoma many years later. For example, patients who have been treated for Hodgkin lymphoma have an increased risk of later developing non-Hodgkin lymphoma. Human herpes virus 8 (HHV8), HCV, and *H. pylori* are also known to increase the risk for developing non-Hodgkin lymphoma (ACS 2012d).

Studies of survivors of atomic bombs and nuclear reactor accidents have shown that they have an increased risk of developing several types of cancer, including leukemia, thyroid cancer, and non-Hodgkin lymphoma. Patients treated with radiation therapy for some other cancers, such as Hodgkin lymphoma, have a slightly increased risk of developing non-Hodgkin lymphoma later in life. This risk is greater for patients treated with both radiation therapy and chemotherapy (ACS 2012d).

Some studies have suggested that being overweight or obese may increase your risk of non-Hodgkin lymphoma. Other studies have suggested that a diet high in fat and meats may raise your risk. More research is needed to confirm these findings (ACS 2012d).

Nearby Environmental Sources: There are three Toxic Release Inventory (TRI) sites; Autoliv, West Liberty Foods, and ATK within ten miles of the study area. Interstate 80 freeway passes through the study area. These sources produce some air emissions including automobile and diesel engine exhaust, some organic compounds such as hexane, and some caustic compounds such as hydrogen chloride or ammonia. More information about TRI sites can be found using the U.S. EPA TRI data explorer tool (http://iaspub.epa.gov/triexplorer/tri_release.facility) (EPA

2013). Risk factors for lung and bronchial cancer, prostate cancer, and non-Hodgkin lymphoma are not associated with air releases reported by the TRI facilities. Lung cancer has been associated with exposure to diesel exhaust. It is unlikely that the concentration of diesel exhaust generated from traffic on I-80 is sufficient to result in increased lung cancer risk in the study area. Non-Hodgkin lymphoma has been associated with agricultural related environmental exposures.

Limitations: The public often wants public health investigations to determine if cancer risk can be linked to a putative environmental concern. The methodology (indirect standardized incidence ratio) used in this investigation does not have the capability to definitively link the study area's elevated cancer rates to any inherent or external risk factors including environmental exposures. These kinds of cancer statistical reviews are based on annual incidence data reported to the UCR. The incidence of cancer per year is dependent on diagnosis of clinically manifested cancer. There are a number of limitations that impede this linkage. There is seldom any knowledge about the frequency, duration, or intensity of cancer victims to putative environmental concern. Cancer can have a variable length latency period between the time of exposure to the actual manifestation and diagnosis of cancer. Cancer can be present for some time before an individual seeks medical assistance that leads to diagnosis. There is seldom sufficient information available to statistically control for the many nonenvironmental factors that contribute to cancer risk, or exposure to other potential environmental risks that are not the putative environmental concern. For small populations, the incidence of cancer has a tendency to manifest arbitrary clusters. This tendency is a common phenomenon encountered when investigating the rate of rare diseases in a small population. Often, a few types of cancer may be statistically elevated for disparate periods, but that conclusion may change if the analytical periods are changed. Overcoming these limitations usually requires a comprehensive assessment of individual risk supported by a clear and consistent trend of elevated rates for a population.

This investigation used data from the UCR and U.S. Census. In Utah, the diagnosis of cancer for all site categories is reportable to the UCR. When a Utah resident seeks diagnosis, a report is generated. The UCR will follow-up on the report to confirm information and collect additional factors about the case. This process occurs when cases are diagnosed in Utah, but may not occur if a case is diagnosed outside of Utah. The UCR may contain records of incidence of cancer in people who recently moved to the study area prior to their diagnosis. The UCR may lack records on individuals who lived most of their life in the study area but moved elsewhere before seeking diagnosis and treatment. These situations create ascertainment biases. For the purposes of diagnosis, the EEP assumes that the ascertainment bias is non-systematic, meaning that the "move-in" and "move-out" situations balance each other. It is highly unlikely that this assumption is true in all cases and can be a significant limitation when the study population is small.

The EEP uses U.S. Census data purchased from a commercial vendor of the data. The vendor has re-tabulated 1980, 1990, and 2010 data for the 2000 census block groups in Utah. Re-tabulation involves population distribution weighting based on census blocks that may not be consistent through time. The EEP estimates intercensal population counts using linear regression between the known census tabulations. This methodology does not account for short-term population

growth dynamics such as the zoning and development of a new subdivision, which can occur in just a few years.

An investigation that uses population-based summary data rather than individual-level data is called an ecologic study by epidemiologists. This investigation is an ecologic study. An interpretation error commonly associated with ecologic investigations is to apply population-level risk findings to the individual. This kind of interpretation error is called an "ecologic fallacy." For example, this study found the risk of lung cancer to be 2.72 times higher for the study population. This risk metric should not be applied to individuals. An individual may have no risk or a risk several times higher than the population risk based on the individual's genetic makeup, behaviors, exposure history, and susceptibility or resiliency to cancer (Greenland 2001; Greenland and Robins 1994; Izquierdo and Schoenbach 2000; Morgenstern 1982, 1995; Rockhill 2005).

CONCLUSIONS AND RECOMMENDATIONS

Significantly elevated cancer incidence rates were found for lung and bronchial cancer and prostate cancer for males for one analytical period each. Lung and bronchial cancer were elevated more than 20 years ago. This finding is likely a random artifact of statistical methodology. The incidence of prostate cancer was elevated more recently. Non-Hodgkin lymphoma was found to be elevated for females in the last analytical period. This investigation was unable to determine if the findings for prostate and non-Hodgkin lymphoma are indicative of an emerging temporal cluster. The findings of this investigation indicate that a cancer cluster investigation is not needed.

Lung and prostate cancer are preventable cancers. For persons developing these cancers, early detection and early intervention for these cancers improve the prognosis for recovery and quality of life experience. Residents of the study area are better at practicing healthy life choices, but improvements can be made. Residents are encouraged to be aware of cancer risk and to work with their health care provider to be screened for these cancers.

The EEP recommends that Bear River Health Department work with the Utah Cancer Control Program for screening and health education services that could be made available to the study area communities. In addition, the EEP recommends that Bear River Health Department request a follow-up cancer statistical review after three to five years (2010 to 2014) of additional cancer data become available to EEP. The follow-up investigation should examine the incidence of non-Hodgkin lymphoma among female residents of the study area to determine if an emerging cluster is occurring.

AUTHORSHIP, REVIEW AND CITATION

This report was prepared by:

Sam LeFevre
Environmental Epidemiology Program
Bureau of Epidemiology
Utah Department of Health

Mail: PO Box 142104, Salt Lake City, Utah 84114-2104
Street: 288 North 1460 West, Salt Lake City, Utah 84116
Phone: (801) 538-6191
Fax: (801) 538-6564
Email: slefevre@utah.gov

Certifying Reviewers:

Allyn K Nakashima, MD
State Epidemiologist
Utah Department of Health

Jennifer Brown, JD
Director, Bureau of Epidemiology
Utah Department of Health

Barry Nangle, PhD
Director, Center for Health Data
Utah Department of Health

Recommended Citation:

Environmental Epidemiology Program. *Cancer Incidence Statistical Review Investigating Western Bear River Valley, Box Elder County, Utah Covering the Period from 1975 to 2009*. May 21, 2013. Salt Lake City, UT: Utah Department of Health.

CERTIFICATION

This report titled "Cancer Incidence Statistical Review Investigating Western Bear River Valley, Box Elder County, Utah Covering the Period from 1975 to 2009" was prepared by the Environmental Epidemiology Program, Utah Department of Health. This report covers an investigation of cancer incidence using standard and approved methodology and procedures existing at the time the investigation herein reported was begun. Editorial and technical review was completed by UDOH certifying reviewers and program partners.

Approved by:

Allyn K Nakashima, MD
State Epidemiologist
Utah Department of Health

Jennifer Brown, JD
Director, Bureau of Epidemiology
Utah Department of Health

Barry Nangle, PhD
Director, Center for Health Data
Utah Department of Health

REFERENCES

Web links for citations of government or organizational websites may wrap onto multiple lines.

ACS (American Cancer Society). 2009. Lifetime risk of developing or dying from cancer web site. Available: http://www.cancer.org/Cancer/CancerBasics/lifetime-probability-of-developing-or-dying-from-cancer [accessed November 26, 2012].

ACS (American Cancer Society). 2012a. Lung cancer (non-small cell). Available: http://www.cancer.org/acs/groups/cid/documents/webcontent/003115-pdf.pdf [accessed November 26, 2012].

ACS (American Cancer Society). 2012b Lung cancer (small cell). Available: http://www.cancer.org/acs/groups/cid/documents/webcontent/003116-pdf.pdf [accessed November 26, 2012].

ACS (American Cancer Society). 2012c. Lung carcinoid tumor. Available: http://www.cancer.org/acs/groups/cid/documents/webcontent/003117-pdf.pdf [accessed November 26, 2012].

ACS (American Cancer Society). 2012d. Non-Hodgkin Lymphoma. Available: http://www.cancer.org/acs/groups/cid/documents/webcontent/003126-pdf.pdf [accessed November 26, 2012].

Alberg AJ, Ford JG, Samet JM. 2007. Epidemiology of lung cancer: ACCP evidence-based clinical practice guidelines (2nd ed). Chest 132(Suppl 3):29S-55S.

Alberg AJ, Samet JM. 2003. Epidemiology of lung cancer. *Chest* 123(Suppl 1):21S-49S.

Anderson RN, Rosenberg HM. 1998. Age standardization for death rates: implementation of the year 2000 standard. *National Vital Statistics Report* 47(3):1-17.

Armstrong B, Hutchinson E, Unwin J, Fletcher T. 2004. Lung cancer risk after exposure to polycyclic aromatic hydrocarbons: a review and meta-analysis. *Environmental Health Perspectives* 112(9):970-978.

Bell BS, Hoskins RE, Pickle LW, Wartenberg D. 2006. Current practices in spatial analysis of cancer data: mapping health statistics to inform policymakers and the public. *International Journal of Health Geographics* 5:49.

Benbrahim-Tallaa L, Waalkes MP. 2008. Inorganic arsenic and human prostate cancer. *Environmental Health Perspectives* 116(2):158-164.

Bender AP, Williams AN, Johnson RA, Jagger HG. 1990. Appropriate public health response to clusters: the art of being responsibly responsive. *American Journal of Epidemiology* 132(Suppl 1):S48-S52.

Besag J, Newell J. 1991. The detection of clusters of rare disease. *Journal of the Royal Statistical Society, Part A* 154:143-155.

Bostwick DG, Burke HB, Djakiew D, Euling S, Ho, S-M, Landolph J, Morrison H, Sonawane B, Shifflett T, Waters DJ, Timms B. 2004. Human prostate cancer risk factors. *Cancer* 101(10 Supplement):2371-2490.

Brenner DR, McLaughlin JR, Hung RJ. 2011. Previous lung disease and lung cancer risk: a systematic review and meta-analysis. *PloS ONE* 6(3):e17479:1-10.

Breslow NE, Day NE. 1987. Rates and Rate Standardization. In: The Design and Analysis of Cohort Studies, Vol 2. IARC Scientific Publication No 82. (BreslowNE, Day NE, eds). Lyon, France: International Agency for Research on Cancer.

Bronson RC, Figgs LW, Caisley LE. 2002. Epidemiology of environmental tobacco smoke exposure. *Oncogene* 21:7341-7348.

Caldwell GG. 1990. Twenty-two years of cancer cluster investigations at the Centers for Disease Control. *American Journal of Epidemiology* 132(Suppl 1):S43-S47.

CDC (Centers for Disease Control and Prevention). 2012. Leading causes of death. Available: http://www.cdc.gov/nchs/fastats/lcod.htm [accessed November 26, 2012].

Clapp RW, Jacobs MM, Loechler EL. 2008. Environmental and occupational causes of cancer new evidence, 2005-2007. *Reviews in Environmental Health* 23(1):1-37.

Coggle JE, Lambert BE, Moores SR. 1986. Radiation effects in the lung. *Environmental Health Perspectives* 70:26-91.

Darby S, Hill D, Doll R. 2001. Radon: a likely carcinogen at all exposures. *Annals of Oncology* 12:1341-1351.

Dicker RC. 2002. A brief review of the basic principles of epidemiology. In: Field Epidemiology, 2nd Ed. (Greg MB, ed.). New York, NY: Oxford University Press.

EPA (U.S. Environmental Protection Agency). 2013. Toxic release inventory (TRI) program. Available: http://www.epa.gov/tri/tridata/index.html [accessed March 30, 2013].

Field RW, Smith BJ, Platz CE, Robinson RA, Neuberger JS, Brus CP, Lynch CF. 2004. Lung cancer histological type in Surveillance, Epidemiology and End Results registry versus independent review. *Journal of the National Cancer Institute* 96(14):1105-1107.

Gallagher RP, Fleshner N. 1998. Prostate cancer: 3. individual risk factors. *Canadian Medical Association Journal* 159(7):807-813.

Geolytics, Inc. 2002a. Census CD 1970, Release 2.0 on digital optical disk (CD). Information: http://www.GeoLytics.com [accessed November 26, 2012].

Geolytics, Inc. 2002b. Census CD 1990 long form in 2000 boundaries, Release 1.0 on digital optical disk (CD). Information: http://www.GeoLytics.com [accessed November 26, 2012].

Geolytics, Inc. 2002c. Census CD 2000 short form blocks for region 4 AK, AZ, CA, CO, HI, ID, MT, NV, NM, OR, UT, WA and WY, release 1.0 on digital optical disk (CD). Information: http://www.GeoLytics.com [accessed November 26, 2012].

Geolytics, Inc. 2012a. Census CD 1980 long form in 2000 boundaries, Release 1.0 on digital optical disk (CD). Information: http://www.GeoLytics.com [accessed November 26, 2012].

Geolytics, Inc. 2012b. Summary file 1 2010 in 2000 boundaries on digital optical disk (CD). Information: http://www.GeoLytics.com [accessed November 26, 2012].

Giovannucci E. 2002. A review of epidemiologic studies of tomatoes, lycopene, and prostate cancer. *Experimental Biology and Medicine* 227:852-859.

Giovino GA. 2002. Epidemiology of tobacco use in the United States. *Oncogene* 21:7326-7340.

Godley LA, Larson RA. 2008. Therapy-related myeloid leukemia. *Seminars in Oncology* 35(4):418-429.

Goodman M, Naiman JS, Goodman D, LaKind JS. 2012. Cancer clusters in the USA: what do the last twenty years of state and federal investigation tell us. *Critical Reviews in Toxicology* 42(6):474-490.

Greenland S. 2001. Ecologic versus individual-level sources of bias in ecologic estimates of contextual health effects. *International Journal of Epidemiology* 30(6):1343-1350.

Greenland S, Robins J. 1994. Ecologic studies – biases, misconceptions, and counter examples. *American Journal of Epidemiology* 139(8):747-760.

Izquierdo JN, Schoenbach VJ. 2000. The potential and limitations of data from population-based state cancer registries. *American Journal of Public Health* 90(5):695-698.

Jekel JF, Elmore JG, Katz DL. 1996. Epidemiology, biostatistics and preventive medicine. Philadelphia, PA: WB Saunders Co.

Kendall M. 1938. A new measure of rank correlation. *Biometrika* 30(1-2):81-93.

Kingsley BS, Schmeichel KL, Rubin CH. 2007. An update on cancer cluster activities at the Centers for Disease Control and Prevention. *Environmental Health Perspectives* 115(1):167-171.

Kral M, Rosinska V, Student V, Grepl M, Hrabec M Bouchal J. 2011. Genetic determinants of prostate cancer: a review. *Biomedical Papers of the Medical Faculty of the University Palacky, Olomouc, Czech Republic* 155(1):3-10.

Langeberg W, Contreras J, Hatch M, Kinney G, Sukhan S, Williams G. 2004. Protocol for investigating cancer clusters in Utah. Salt Lake City, UT: Cancer Cluster Workgroup: Utah Department of Health.

Leone G, Fianchi L, Voso MT. 2011. Therapy-related myeloid neoplasms. *Current Opinion in Oncology* 23(6):672-680.

Leone G, Mele L, Pulsoni A, Equitani F, Pagano L. 1999. The incidence of secondary leukemia. *Haematologica* 84(10):937-945.

Mann CJ. 2003. Observation research methods. Research design II: cohort, cross sectional, and case-control studies. *Emergency Medicine Journal* 20:54-60.

Molina JR, Yang P, Cassivi SD, Shield SE, Adjei AA. 2009. Non-small cell lung cancer: epidemiology, risk factors, treatment and survivorship. *Mayo Clinic Proceedings* 83(5):584-594.

Morgenstern H. 1982. Uses of ecologic analysis in epidemiologic research. *American Journal of Public Health* 72:1336-1344.

Morgenstern H. 1995. Ecologic studies in epidemiology: concepts, principles, and methods. *Annual Reviews of Public Health* 16:16-81.

Morrone M. 2011. From cancer to diarrhea: the moving target of public concern about environmental health risks. *Environmental Health Insights* 5:87-96.

Mould RF. 2001. Depleted uranium and radiation-induced lung cancer and leukaemia. *British Journal of Radiology* 74(884):677-683.

NCI (National Cancer Institute). 2007. What you need to know about non-Hodgkin lymphoma. Available: http://www.cancer.gov/cancertopics/wyntk/non-hodgkin-lymphoma.pdf [accessed November 26, 2012].

NCI (National Cancer Institute). 2011a. SEER Cancer Statistics Review 1975-2008. Lifetime Risk (Percent) of Being Diagnosed with Cancer by Site and Race/Ethnicity: Males, 17 SEER Areas, 2006-2008 (Table 1.15) and Females, 17 SEER Areas, 2006-2008 (Table 1.16). Available: http://seer.cancer.gov/csr/1975_2008/results_merged/topic_lifetime_risk_diagnosis.pdf [accessed November 26, 2012].

NCI (National Cancer Institute). 2011b. SEER Cancer Statistics Review 1975-2008. Lifetime Risk (Percent) of Dying from Cancer by Site and Race/Ethnicity: Males, Total US, 2006-2008 (Table 1.18) and Females, Total US, 2006-2008 (Table 1.19). 2011b. Available:

http://seer.cancer.gov/csr/1975_2008/results_merged/topic_lifetime_risk_death.pdf [accessed November 26, 2012].

NCI (National Cancer Institute). 2012a. Surveillance, Epidemiology and End Results (SEER) Program. Available: http://seer.cancer.gov [accessed November 26, 2012].

NCI (National Cancer Institute). 2012b. What you need to know about cancer. Available: http://www.cancer.gov/cancertopics/wyntk/cancer [accessed November 26, 2012].

Nermina O. 2005. Cancer incidence in Sarajevo region. *Medical Archives* 59(4):250-254.

Platz EA, Helzisouer KJ. 2001. Selenium, zinc, and prostate cancer. *Epidemiologic Reviews* 23(1):93-101.

Rockhill B. 2005. Theorizing about causes at the individual level while estimating effects at the population level: implications for prevention. *Epidemiology* 16(1):124-129.

Rothman KJ, Boice JD. 1979. Epidemiologic analysis with a programmable calculator. NIH Publication 79-1649. Washington, DC: Government Printing Office.

Rothman KJ, Boice JD. 1982. Epidemiologic analysis with a programmable calculator, New Edition. Boston, MA: Epidemiology Resources, Inc.

Samet JM, Avila-Tang E, Boffetta P, Hannan LM, Olivo-Marston S, Thun MJ, Rudin CM. 2009. Lung cancer in never smokers: clinical epidemiology and environmental risk factors. *Clinical Cancer Research* 15(18):5626-5645.

Samet JM, Eradze GR. 2000. Radon and lung cancer risk: taking stock at the millennium. *Environmental Health Perspectives* 108(Suppl 4):635-641.

Sahai H, Khurshid A. 1983. Confidence intervals for the mean of a Poisson distribution: a review. *Biometrical Journal* 35:857-867.

Sahai H. Khurshid A. 1996. Statistics in Epidemiology: Methods, Techniques and Applications. Boca Raton, FL: CRC Press, Inc.

Schottenfeld D, Fraumeni JF. 1996. Cancer Epidemiology and Prevention, 2nd Ed. New York, NY: Oxford University Press.

Selvin S. 1996. Chapter 1: Measures of risk: rates and probabilities. In: Monographs in epidemiology and biostatistics, Vol 25: Statistical analysis of epidemiologic data. (Selvin S, ed.). Oxford, UK: Oxford University Press.

Sill H, Olipitz W, Zebisch A, Schulz E, Wolfler A. 2011. Therapy-related myeloid neoplasms: pathobiology and clinical characteristics. *British Journal of Pharmacology* 162(4):792-805.

Song R, Hall HI, Harrison KM, Sharpe TT, Lin LS, Dean HD. 2011. Identifying the impact of social determinants of health on disease rates using correlation analysis of area-based summary information. *Public Health Reports* 126(Suppl 3):70-80.

Stanbury M, Anderson H, Blackmore C, Fagliano J, Heumann M, Kass D, McGeehin M. 2012. Functions of environmental epidemiology and surveillance in state health departments. *Journal of Public Health Management and Practice* 18(5):453-460.

Thacker SB. 2000. Historical development. In: Principles and practice of public health surveillance, 2nd Ed. (Teutsch SM, Churchill RE, eds.). New York, NY: Oxford University Press.

Thacker SB, Qualters JR, Lee LM. 2012. Public health surveillance in the United States: evolution and challenges. *Morbidity and Mortality Weekly Report – Surveillance Supplement* 61(3):3-9

Thun MJ, Sinks T. 2004. Understanding cancer clusters. *CA Cancer Journal for Clinicians* 54(5):273-280.

Tomasek L, Darby SC, Swerdlow AJ, Placek V, Kunz E. 1993. Radon exposure and cancers other than lung cancer among uranium miners in West Bohemia. *Lancet* 341:919-923.

USCB (U.S. Census Bureau). 2004. Appendix A. Geographic terms and concepts in summary file 3: 2000 census population and housing, technical documentation. SF3/14 RV. Available: http://www.census.gov/prod/cen2000/doc/sf3.pdf [accessed November 26, 2012].

USCB (U.S. Census Bureau). 2012a. Method for intercensal population estimates: 2000 to 2010. Available: http://www.census.gov/popest/methodology/2000-2010_Intercensal_Estimates_Methodology.pdf [accessed November 26, 2012].

USCB (U.S. Census Bureau). 2012b. 2005-2009 American Community Survey 5-Year estimates: Table DP02 Selected social characteristics in the United States, 2005-2009. *American Fact Finder*. [The geographic location of the query included Utah state, Salt Lake county and 45 census tracts that were contained by the study area.] Available: http://factfinder2.census.gov [accessed November 26, 2012].

USCB(U.S. Census Bureau). 2012c. 2005-2009 American Community Survey 5-Year estimates: Table DP03 Selected economic characteristics, 2005-2009. *American Fact Finder*. [The geographic location of the query included Utah state, Salt Lake county and 45 census tracts that were contained by the study area.] Available: http://factfinder2.census.gov [accessed November 26, 2012].

USCB (U.S. Census Bureau). 2012d. 2005-2009 American Community Survey 5-Year estimates: Table DP05 ACS demographic and housing estimates, 2005-2009. *American Fact Finder*. [The geographic location of the query included Utah state, Salt Lake county and 45 census tracts that were contained by the study area.] Available: http://factfinder2.census.gov [accessed November 26, 2012].

UCR (Utah Cancer Registry). 2012. 2012 cancer dataset for the Utah Environmental Public Health Tracking Network: containing public use data records for primary in-situ Utah resident cancers from 1973 to 2009. Electronic data transfer. Information: http://ucr.utah.edu [accessed November 26, 2012].

UDOH (Utah Department of Health). 2012. Utah Indicator-Based Information System for Public Health (IBIS-PH). [See Dataset Queries; Health Surveys; Behavioral Risk Factors Surveillance System]. Available: http://ibis.health.utah.gov [accessed November 26, 2012].

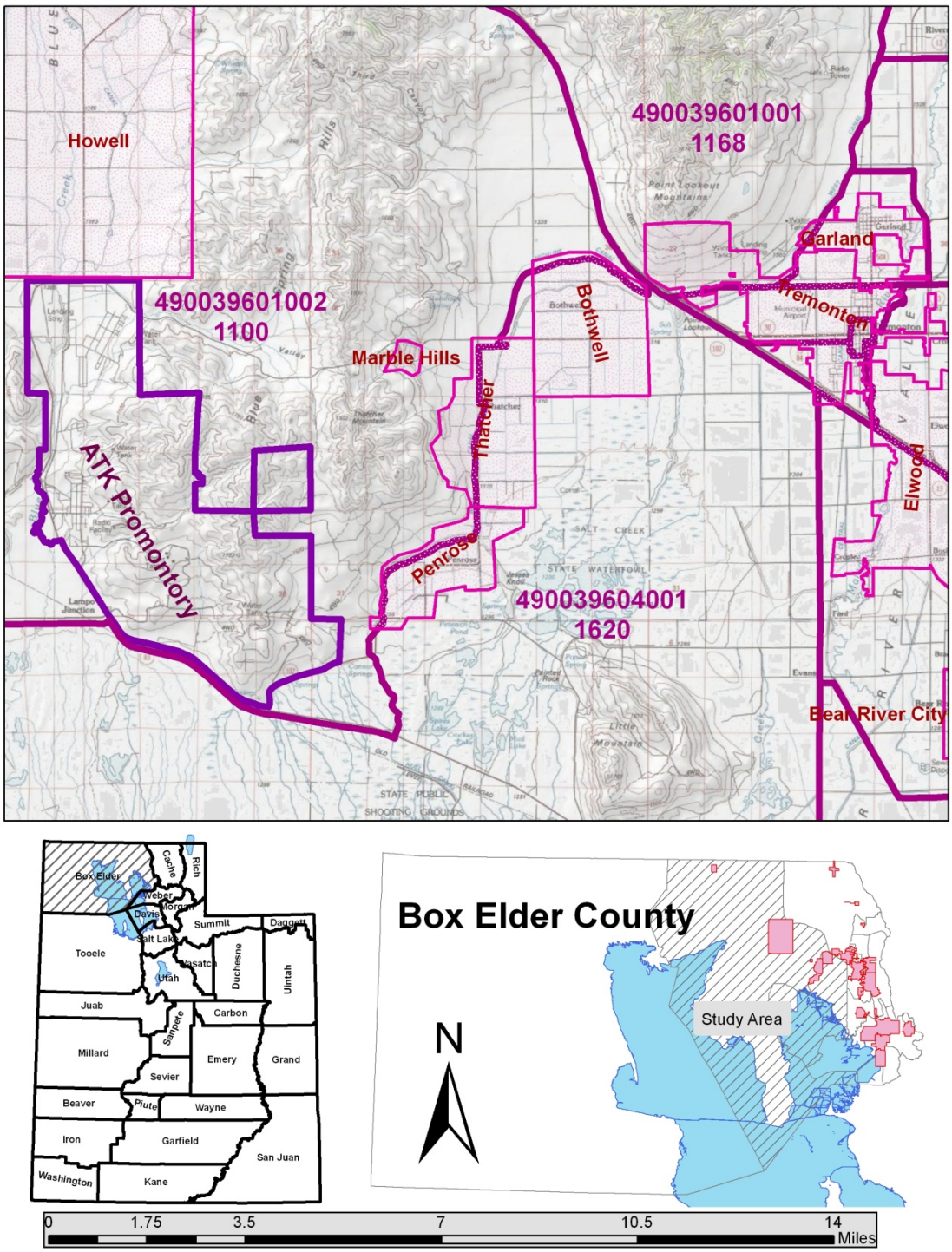
UEPHTN (Utah Environmental Public Health Tracking Network). 2012. Utah environmental public health tracking network. Information: http://health.utah.gov/enviroepi [accessed November 26, 2012].

WHO (World Health Organization). 2012. International Classification of Diseases for Oncology, 3rd Edition (ICD-O-3) website. Available: http://www.who.int/classifications/icd/adaptations/oncology/en/ [accessed November 26, 2012].

Wilkins KL, Woodgate RL. 2008. Preventing second cancers in cancer survivors. *Oncology Nursing Forum* 35(2):E12-E22.

FIGURES

Figure 1. Map of the western part of Box Elder County showing the location of the study area for this investigation.



TABLES

Table 1. Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts ≤3 means the count could be 0 to 3. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
01 Oral cavity and pharynx	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts ≤3 means the count could be 0 to 3. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
02 Esophagus	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts ≤3 means the count could be 0 to 3. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
03 Stomach	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
04 Small intestine	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
05 Colon	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	4	35.0	1.68	0.45 – 4.30
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
06 Rectum and recto-sigmoid junction	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
07 Anus, anal canal and anorectum	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
08 Liver and interhepatic bile duct	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
09 Gallbladder and biliary bile ducts	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
10 Pancreas	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
11 Other digestive system	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
12 Larynx	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
13 Lung and bronchus	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	>3	90.4	3.28	1.06 – 7.67 S
		F	≤3			
		B	6	55.5	2.72	0.99 – 5.93
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
14 Other respiratory system	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
15 Bones and joints	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
16 Soft tissue (including heart)	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
17 Cutaneous melanoma	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
18 Other non-melanoma skin cancers	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
19 Breast	1975-1979	F	≤3			
	1980-1984	F	≤3			
	1985-1989	F	4	78.8	0.99	0.27 – 2.54
	1990-1994	F	8	148.1	1.76	0.76 – 3.47
	1995-1999	F	4	65.9	0.73	0.20 – 1.88
	2000-2004	F	≤3			
	2005-2009	F	10	138.9	1.54	0.73 – 2.82

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
20 Cervix	1975-1979	F	≤3			
	1980-1984	F	≤3			
	1985-1989	F	≤3			
	1990-1994	F	≤3			
	1995-1999	F	≤3			
	2000-2004	F	≤3			
	2005-2009	F	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
21 Uterus	1975-1979	F	≤3			
	1980-1984	F	≤3			
	1985-1989	F	≤3			
	1990-1994	F	≤3			
	1995-1999	F	≤3			
	2000-2004	F	≤3			
	2005-2009	F	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
22 Ovary	1975-1979	F	≤3			
	1980-1984	F	≤3			
	1985-1989	F	≤3			
	1990-1994	F	≤3			
	1995-1999	F	≤3			
	2000-2004	F	≤3			
	2005-2009	F	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
23 Other female genital	1975-1979	F	≤3			
	1980-1984	F	≤3			
	1985-1989	F	≤3			
	1990-1994	F	≤3			
	1995-1999	F	≤3			
	2000-2004	F	≤3			
	2005-2009	F	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
24 Prostate	1975-1979	M	≤3			
	1980-1984	M	≤3			
	1985-1989	M	≤3			
	1990-1994	M	5	85.6	0.65	0.21 – 1.51
	1995-1999	M	5	75.5	0.70	0.23 – 1.64
	2000-2004	M	18	239.9	2.06	1.22 – 3.25 S
	2005-2009	M	13	152.4	1.26	0.67 – 2.16

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
25 Testis	1975-1979	M	≤3			
	1980-1984	M	≤3			
	1985-1989	M	≤3			
	1990-1994	M	≤3			
	1995-1999	M	≤3			
	2000-2004	M	≤3			
	2005-2009	M	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
26 Other male genital	1975-1979	M	≤3			
	1980-1984	M	≤3			
	1985-1989	M	≤3			
	1990-1994	M	≤3			
	1995-1999	M	≤3			
	2000-2004	M	≤3			
	2005-2009	M	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
27 Bladder	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
28 Kidney and renal pelvis	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
29 Other urinary	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
30 Eye and orbit	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
31 Brain	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
32 Other central nervous system	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
33 Thyroid	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
34 Other endocrine	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
35 Hodgkin lymphoma	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
36 Non-Hodgkin lymphoma	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	>3	56.0	4.27	1.15 – 10.94 S
		B	>3	32.6	2.17	0.70 – 5.07

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
37 Multiple myeloma	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
38 Lymphocytic leukemia	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
39 Myeloid leukemia	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
40 Monocytic leukemia	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
41 Other leukemia	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

Table 1 (continued). Analysis of the incidence of primary cancer diagnoses among study area residents between 1975 and 2009 reported to the Utah Cancer Registry by site code. The total number of cases is 12,695. Case counts "≤3" means the count could be 0 to 3. Case counts ">3" means the case count was large enough to evaluate but is suppressed. Rates are indirect age-standardized incidence rate per 100,000 person-years. The SIRs are the standardized incidence ratio (SIR) with Byar's 95% confidence intervals (CI). Significance is indicated by an "S." Sex code is "M" for male, "F" for female, and "B" for both.

Cancer Site	Analytical Period	Sex	Case Count	Rate	SIR	95% CI
42 Other sites/types	1975-1979	M	≤3			
		F	≤3			
		B	≤3			
	1980-1984	M	≤3			
		F	≤3			
		B	≤3			
	1985-1989	M	≤3			
		F	≤3			
		B	≤3			
	1990-1994	M	≤3			
		F	≤3			
		B	≤3			
	1995-1999	M	≤3			
		F	≤3			
		B	≤3			
	2000-2004	M	≤3			
		F	≤3			
		B	≤3			
	2005-2009	M	≤3			
		F	≤3			
		B	≤3			

DEFINITIONS

ACS	American Cancer Society. The ACS, first established in 1913, is a nationwide voluntary health organization dedicated to eliminating cancer. The society, headquartered in Atlanta, Georgia, has over 900 offices throughout the United States. ACS funding is used for patient support services, research, prevention, detection and treatment and society operations. For more information see: http://www.cancer.org.
ACS	American Community Survey. The ACS is an ongoing survey that provides annual updates to population and demographic estimates derived from census data. The ACS is operated by the USCB. For more information see: http://www.census.gov/acs/www/.
AGRC	Automated Geographic Reference Center. An agency within the Utah Department of Information Technology, responsible for maintaining a repository of geographic information system (GIS) data files and GIS functionality. For more information see: http://gis.utah.gov/.
ArcGIS	A complete desktop GIS software application for producing maps and conducting spatial analysis. This application is developed and distributed by ESRI. EEP uses version 10.0. For more information see: http://www.esri.com/software/arcgis.
CIS	Carcinoma in-situ is an early form of cancer that is defined by the absence of invasion of tumor cells into the surrounding tissue. Instead, the lesion is flat or follows the existing architecture of the organ. In this state CIS, seldom cause clinical systems sufficient to prompt the person with CIS to seek medical assistance and are generally undetected. CIS can progress to invasive tumors and are therefore considered a precursor or incipient form of cancer.
EEP	Environmental Epidemiology Program. A program within the Bureau of Epidemiology, Division of Disease Control and Prevention, UDOH. The EEP was established in 1996 and is responsible for investigating diseases related to the environment. The program has two sections. One section conducts surveillance and data management activities including managing the UEPHTN. The other section conducts health hazards risk assessment, including cancer investigations. The program is staffed by personnel with experience and expertise in environmental epidemiology, environmental sciences, toxicology, statistics, public health informatics and geomatics, and health education. For more information see: http://health.utah.gov/enviroepi/.
ESRI	ESRI is a leading developer and supplier of GIS software and geographically referenced data. ESRI is headquartered in Redlands, California. The EEP uses the ArcGIS software application developed by ESRI. For more information see: http://www.esri.com.

FAA	The Federal Aviation Administration. The FAA is a federal government agency charged with providing aviation support to airports and U.S. air space. The FAA supports flight operations for aircraft arriving to or departing from SLCIA, including recording radar tracking of inbound and outbound aircraft. For more information see: http://www.faa.gov and http://www.faa.gov/FSDP/SLC.
GeoLytics	GeoLytics is a commercial vendor of census and demographic data calibrated to the 2000 census boundaries. The EEP has purchased 1970, 1980, 1990, 2000 and 2010 census data from GeoLytics to be the basis for estimating intercensal population counts for each of the 1,481 census block group boundaries in Utah. Population counts are aggregated into 5-year age groups for each sex. For more information see: http://www.geolytics.com.
GIS	Geographic Information Systems. A GIS includes computer software and geographically referenced data. The EEP uses ArcGIS as the computer software, and obtains data from ESRI or AGRC.
ICD-O-3	International Classification of Disease - Oncology, 3rd Edition. The ICD-O-3 is one of a number of internationally established coding standards for coding site (topography) and histology (morphology) of neoplasms (cancers). For more information see: http://www.who.int/classifications/icd/adaptations/oncology/en/.
NAACCR	North American Association of Central Cancer Registries. NAACCR was established in 1987 as a collaborative professional organization for cancer registries, governmental agencies and professional associations that work with cancer registries. All central cancer registries in the United States and Canada are members. The purpose of NAACCR is to promote standards and enhance the quality of cancer registry data. The NAACCR also promotes training, epidemiologic research, public health activities and patient care improvement policies related to cancer. For more information see: http://www.naaccr.org.
NCI	National Cancer Institute. The NCI is one of the National Institutes of Health and part of the U.S. Department of Health and Human Services. The NCI was established under the National Cancer Act of 1937 and is primarily responsible for conducting surveillance and research about cancer incidence, diagnosis, prevention, treatment, and rehabilitation. The SEER program is operated by the NCI. For more information see: http://www.cancer.gov/.
SAS	SAS (originally from “Statistical Analysis System”) is a globally recognized system of integrated computer software products provided by SAS Institute Inc. The SAS system includes a large variety of data manipulation and statistical analysis processes. The EEP uses the desktop version 9.2. For more information see: http://www.sas.com.
SEER	Surveillance, Epidemiology and End Results Program. The SEER program is an agency within the NCI. The SEER program works with state cancer registries to

	develop and disseminate incidence and mortality statistics about cancer in the United States. The SEER program also establishes standards for the analysis of cancer data and interpretation of cancer statistics. For more information see: http://seer.cancer.gov/.
TRI	Toxic Release Inventory. The TRI is a database of industrial sites that release reportable hazardous materials into the environment. The TRI database is maintained by the U.S. Environmental Protection Agency. For more information see: http://www.epa.gov/tri.
UBRFS	Utah Behavioral Risk Factors Survey. The UBRFS is an ongoing telephonic survey conducted by the Office of Public Health Assessment, UDOH. This survey collects data about health-related behaviors in the non-institutionalized Utah adult population. For more information, see: http://health.utah.gov/opha/OPHA_BRFSS.htm.
UCR	Utah Cancer Registry. The UCR is operated under authority from the UDOH by the University of Utah. The UCR was established in 1966 to be a statewide population-based cancer registry. Utah administrative rule requires the reporting of cancer diagnoses to the UCR. The UCR collaborates with the NCI, SEER and the North American Association of Central Cancer Registries to implement data standards for cancer data. The UCR provide cancer to the EEP through the UEPHTN. For more information, see: http://ucr.utah.edu/.
UDEQ	Utah Department of Environmental Quality. The UDEQ is one of the executive agencies within Utah state government. The UDEQ strives to safeguard public health and quality of life by protecting and enhancing the environment through the implementation, compliance monitoring and enforcement of environmental laws. For more information, see: http://deq.utah.gov/.
UDOH	Utah Department of Health. The UDOH is one of the executive agencies within Utah state government. The UDOH strives to improve health in Utah through promoting healthy lifestyles, evidence-based interventions, creating healthy and safe communities and eliminating health disparities. The EEP is a program within the UDOH. For more information, see: http://health.utah.gov/.
UEPHTN	Utah Environmental Public Health Tracking Network. The UEPHTN is a data warehouse that contains health outcomes, environmental and supporting data. Data from the UCR and population data derived from the USCB is warehoused in the UEPHTN. For more information see: http://health.utah.gov/enviroepi/activities/EPHTP/NewEPHT/ephtpnew.htm.
U.S. EPA	U.S. Environmental Protection Agency (also EPA). The U.S. EPA is one of the executive agencies within the federal government. The U.S. EPA is responsible for regulatory actions that protect human health and the environment from environmental health hazards. For more information, see: http://www.epa.gov.

USCB U.S. Census Bureau. Officially the "Bureau of the Census," the USCB is an agency authorized by Federal law, within the U.S. Department of Commerce that is charged with preparing and conducting regular surveys and censuses of the U.S. population. In addition to the decennial population survey, the USCB conducts a number of other surveys and has recently implemented the ACS. For more information, see: http://www.census.gov/.

WHO The World Health Organization is an agency of the United Nations that deals with international health concerns and policies. For more information see: http://www.who.int/en/.

Cancer Incidence: The term incidence refers to new cases occurring in a period of time, usually annually. Cancer incidence is the number of new cases that occurred in a year. New cancer cases occur when a diagnosis is made. The 2009 national age-adjusted incidence rate is 4.64 cancer cases per 1,000 population per year. For more information, see: http://www.cancer.gov/statistics/glossary/incidence.

Cancer Prevalence: The term prevalence refers to the number of cases that exist either at a moment in time or during a period of time (e.g., annual, lifetime, etc.). When using this term, the time should be included. The 2009 national lifetime cancer prevalence rate is approximately 414.65 cases of cancer among 1,000 population. Cancer prevalence is the total number of cases that exist. For more information, see: http://www.cancer.gov/statistics/glossary/prevalence.

Cancer Incidence Rate: This is a ratio of the cancer incidence (the number of new cancer diagnoses) over the total population. When computing a multiple year rate, the total population added from each year of the rate period is used to get the rate. For more information, see: http://www.cancer.gov/statistics/glossary/incidence.

Indirect Standardized Incidence Rate. The raw (sometimes called "crude") disease incidence rate (number of case incidences per time period divided by the person-years per period) reflects reality. The raw rate is the simplest and most straightforward summary of the population experience. Interpretation of a disease incidence rate involves a comparison of that rate with some comparison or acceptable rate to determine if the rate in question is high or low. Because rates will almost always involve comparing two populations with two different age distributions, comparison of a raw disease incidence rate with a comparison rate is problematic. It does not make sense to compare the rate of disease of a relatively young population with a relatively older population for a disease that is more common in the elderly and be able to state with confidence that the disease rate is higher or lower than expected. For this reason, when the objective is to compare two rates, age standardized rates are preferable. However, it should be noted that the rate itself, once standardized, is not the exact disease burden. The standardized rate should be of the same magnitude as the raw rate.

The indirect standardization method is the preferable method when the disease count in each age group is small or zero. A disadvantage of the indirect method is that the rate is comparable to the comparison population used in its computation, but is not comparable to other population rates. For example, for this study, the study area cancer rates are adjusted using the Utah state population and therefore are comparable to the Utah state rates. However, they are not comparable to the county rates or to national rates.

$$ISR_M = \frac{C_M}{\sum_{age}\left(\frac{C_{U,age}}{P_{U,age}} P_{M,age}\right)} \times \left(\frac{C_U}{P_U}\right) \times 100{,}000$$

The Indirect Standardized Rate for The study area (ISR_M) is calculated by:

Where: ISR_M is the Indirect Standardized Incidence Rate for the study area.

C_M is the total cancer incidence count for the study area for a specific analytical period (e.g., 1990 - 1994).

$C_{U,age}$ is an age-group (e.g., 0 to 19 year in age, etc.) specific cancer incidence count for the state of Utah for a specific analytical period.

$P_{U,age}$ is the age-group specific count of person-years (e.g., number of 0-19 year olds in 1990 plus number of 0-19 year olds in 1991 plus number of 0-19 year olds in 1992 ...) for the state of Utah for a specific analytical period.

$P_{M,age}$ is the age-group specific count of person-years for the study area for a specific analytical period.

C_U is the total cancer incidence count for the state of Utah for a specific analytical period.

P_U is the total count of person-years for the state of Utah for a specific analytical period.

For purposes of presentation, it is standard practice to present rates per a population of 100,000 people. For example 60 cases per 100,000 people is easier to understand than 0.00006 cases per person.

E_M is the expected case count of cancer incidence for the study area for a specific analytical period. This is the denominator factor of the first term of the rate formula.

$$E_M = \sum_{age} \left(\frac{C_{U,age}}{P_{U,age}} P_{M,age} \right)$$

Standardized Incidence Ratio. The standardized incidence ratio (SIR) is a way of comparing two rates. When using the indirect standardized rate method, the SIR is the first term of the

$$SIR = \frac{C_M}{\sum_{age}\left(\frac{C_{U,age}}{P_{U,age}} P_{M,age}\right)} = \frac{C_M}{E_M}$$

formula to compute the rate.

$$\overline{\underline{SIR}} = \frac{(C_M + k)}{E_M} \times \left[1 - \left(\frac{1}{3 \cdot (C_M + k)}\right) + \left(\frac{\pm 1.96}{3 \cdot \sqrt{C_M + k}}\right)\right]^3$$

The Byar's 95% confidence limits ($Z_\alpha = 1.96$) can be calculated for the SIR by:

Where:

SIR is the standardized incidence ratio. The bar over and under means the upper and lower confidence limits of the SIR.

C_M is the total case count of cancer incidence count for the study area for a specific analytical period.

E_M is the expected case count of cancer incidence for the study area for a specific analytical period.

K is a constant for symmetry. For the upper confidence limit, k = 1. For the lower confidence limit, k = 0.

±1.96 is the normal distribution (Z_α) function for a 95% confidence interval. For the upper confidence interval it is a positive value. For the lower confidence interval it is a negative value.