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Prostate Cancer Incidence Rates, by County in Nebraska, 1990 - 1991

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This article is a reprint of a report which appeared first in the Nebraska Health Information Project: 1995 Databook. Dr. Cowles is a former member of the faculty of the Department of Preventive and Societal Medicine. She is currently at the University of Iowa, Department of Statistics and Actuarial Science. Dr. Anderson, Dr. Mueller, and Mr. Ullrich are members of the Department of Preventive and Societal Medicine at the University of Nebraska Medical Center.

Data archived in the **Nebraska Cancer Registry** are reported in this Brief. These data have been made available to the *Nebraska Health Information Project* by the *Nebraska Health and Human Services System*. More about the Nebraska Health Information Project and about other project reports can be found on the last page of this document.

Abstract

*Data from the **Nebraska Cancer Registry** for the years 1990 and 1991 are examined in this report. Because prostate cancer rarely occurs in young men, we considered only males aged 45 and older. The purpose of this study was to determine whether there were counties whose rates differed substantially enough from the state average to warrant further investigation. During the early 1990s in Nebraska, deaths from prostate cancer had been increasing on an annual basis. This trend paralleled a national pattern of increase in those same years. The five-year prostate cancer incidence rate for 1989-1993 was 144.1 cases per 100,000 population in Nebraska. This exceeded the national rate for that time, 128.9 cases per 100,000 population. The Nebraska Year 2000 objective is to lower the incidence of death due to this disease to an age-adjusted rate of no more than 20 deaths per 100,000 men. At the time this study was undertaken, prostate cancer claimed 23.4 deaths per 100,000 men annually, based upon 1989-1993 data). In sum, this is a health condition worthy of further examination so that appropriate steps can be taken to achieve or exceed the Nebraska Year 2000 objective.*

This study found that two counties appeared to have significantly higher prostate incidence rates than Nebraska as a whole, while several had lower than average rates. Further investigation is needed to explain why this is so. More recent data should be studied to see whether these trends continue. In addition, further inquiry, particularly into physician referral patterns to prostate-specific antigen (PSA) testing, may be appropriate to attempt to explain these differences.

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PURPOSE

Death from prostate cancer had been increasing, on an annual basis in Nebraska during the early 1990s, the years from which data are analyzed in this report. This paralleled a national pattern of increase in those same years (Potosky, et al., 1995). Through 1993, the rate of prostate cancer in Nebraska had increased; the five-year rate 1989-1993 was 144.1 cases per 100,000 population, exceeding the national rate for that time, 128.9 cases per 100,000 population. The number of deaths from this disease fluctuated, from 226 in 1992 to 232 in 1995, before declining to 174 in 1996 (Nebraska Vital Statistics Reports, 1992-1996). The Nebraska objective for the year 2000 is an age-adjusted rate of no more than 20 deaths per 100,000 men; the rate between 1989 and 1993 was 23.4 deaths per 100,000 men. In sum, this is a health condition worthy of further examination so that appropriate steps can be taken to achieve or exceed the year 2000 objective (Nebraska Year 2000 Objectives: A MidCourse Review, 1996).

To improve our understanding of the incidence of prostate cancer in Nebraska, we are publishing this report of differences among the 93 counties in the state. Differences among the counties can indicate one of two phenomena, both of which are important to recognize with respect to the year 2000 objective:

* The true incidence of prostate cancer could vary across counties, leading to examination of different causes in the counties (Meade, Florin and Gesler, 1988).

* The availability and use of health services could vary across counties, affecting detection of the disease (Rickets, et al., 1994).

Once any variation in the incidence in prostate cancer is verified, both explanations can be explored and addressed with policy interventions. A true variation in rates would indicate the need for epidemiological study to identify causes specific to certain regions of the state (which could include the population demographics), and interventions could be designed to address those causes. For example, variation related to the intensity of screening could lead to the study of the reasons for and appropriateness of regional variation in screening rates.

DATA

Data for this report are taken from the Nebraska Cancer Registry for the years 1990 and 1991. The purpose of the Nebraska Cancer Registry (NCR) is to gather data which can be used to describe cancer incidence, mortality, treatment and survival in Nebraska. Registry data are gathered from every hospital in the state of Nebraska, and include Nebraska residents diagnosed and/or treated at hospitals in the states of Colorado, Missouri, Wyoming, Iowa, and South Dakota. Additionally, data include cases diagnosed and treated at Nebraska outpatient facilities. Cancer mortality rates are obtained from death certificate data, for every deceased Nebraska resident who died from cancer. In order to assure quality and completeness, data are screened extensively for inconsistencies using a computerized editing process.

The NCR also evaluates the accuracy of its data. In this context, accuracy is defined as the degree to which the registry data represents the data from the original source, the medical record. In 1993, the North American Association of Central Cancer Registries (NAACCR) conducted a reabstracting study for the NCR and the results indicated an accuracy rate of nearly 95%. Since 1995, the registry has maintained its own program of refinding cases and reabstracting the data from them. Results to date show that the accuracy of the data has consistently remained high. At the time of the 1993 NAACCR study, the completeness of case finding was reviewed. It was determined that the registry had collected 97% of the estimated number of cancer cases.

For this report, data from 1991 and 1992 are combined into one dataset for analysis by county. The data are available for each of the 93 counties in the state. After combining these two years, only two counties (Arthur and Grant) are shown as having no observations for the time period studied.

ANALYTICAL TECHNIQUE

Standard Morbidity Ratios for Prostate Cancer Incidence

Since the incidence rate of prostate cancer increases with increasing age, comparisons of counties must adjust for the differences in the distribution of the ages of men in those counties. We used the Standardized Morbidity Ratio (SMR) to adjust for differences among counties in age distributions. The SMR for each county is the ratio of the observed number of new cases to the expected number given that county's age distribution and the age-specific incidence rates for the state. Thus, we computed state wide incident rates for each of eight age groups (45-54, 54-59, 60-64, 65-69, 70-74, 75-79, 80-84, and 85+) for 1990 and 1991 separately. Census data from 1990 were used to determine the number of men in each age group in each county for both years. The number of expected cases in each county is then the result of multiplying the number of men in each age group times the rate, and summing that calculation for all ages:

$$E_i = \sum_t \sum_j n_{ij} r_{jt}$$

To calculate the SMR we divide the number of actual cases (observed, O) by the number of expected cases from the previous calculation (E):

$$SMR_i = \frac{O_i}{E_i}$$

An SMR greater than 1.0 indicates that the age-adjusted incidence rate for that county is higher than that for the state as a whole. **Table 1** shows the observed and expected counts of incident cases in each county as well as the resulting SMRs, which are mapped in **Figure 1.**

Correcting for Small Numbers and Spatial Correlation: Finding the True Variation

Smoothing the SMRs Using Hierarchical Bayes Models.

Much of the variation in county rates may be due to counties having small populations and therefore yielding very small and very large Standardized Morbidity Ratios (SMRs). These extremes ought not be treated as valid (measuring true rates) measures; some adjustment is needed. The variability can be reduced by using empirical Bayes methods which "borrow strength" from the full data set (Clayton and Kaldor 1987). As a basic model (Gamma model), estimates of individual SMRs are "shrunk" toward the overall mean SMR for the whole collection of regions. Estimates from areas with very uncertain rates due to small populations are shrunk more than those from larger counties. The optimal approach applying this methodology is to use fully Bayesian hierarchical models (Bernardinelli and Monomoli 1992); in this analysis we employ the fully Bayesian Gamma model.

When fully Bayes models are used, the 95 percent posterior credible set (similar to a 95 percent confidence interval) is the range within which we are 95 percent certain that the quantity of interest lies. In this problem, if the 95 percent credible set does not contain 1.0, then we are 95 percent certain that the true underlying SMR is different from 1.0; that is that the age-adjusted rate for the county is different from the expected rate based on state averages.

We used the BUGS software package (Spiegelhalter et al., 1994) to implement a fully Bayesian Gamma model for the Nebraska prostate cancer incidence data. The results are presented in the "Hierarchical Bayes" column of **Table 1** and in **Figure 2**.

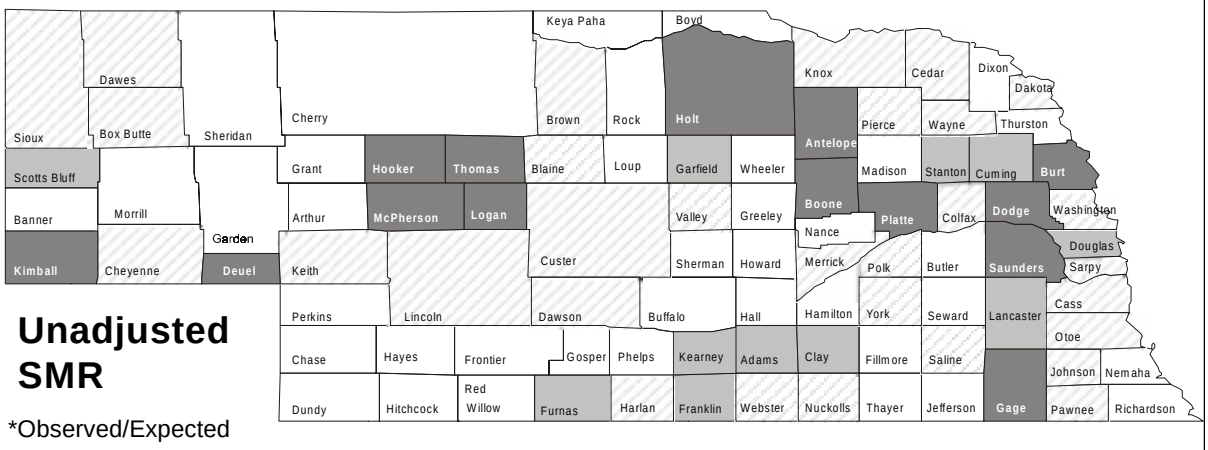
TABLE 1
Nebraska Prostate Cancer Incidence Rates by County, 1990-1991

County	Observations	Expected	Raw Standard Morbidity Ratio	Smoothed SMRs: Without Adjusting for Spatial Correlation	Smoothed SMRs: With Adjusting for Spatial Correlation
Adams	61	49.242	1.239	1.160	1.162
Antelope	22	16.606	1.325	1.127	1.180
Arthur	0	1.044	0.000	0.876	0.932
Banner	1	1.742	0.574	0.884	0.905
Blaine	1	1.307	0.765	0.908	0.937
Boone	24	15.222	1.577	1.238	1.224
Box Butte	17	18.396	0.924	0.915	0.838
Boyd	1	7.979	0.125	0.654	0.735
Brown	7	8.438	0.830	0.895	0.874
Buffalo	35	47.422	0.738	0.788	0.771
Burt	24	18.797	1.277	1.106	1.198
Butler	9	18.986	0.474	0.677	0.821
Cass	28	31.147	0.899	0.899	0.949
Cedar	16	20.994	0.762	0.836	0.856
Chase	5	9.057	0.552	0.782	0.669
Cherry	9	12.047	0.747	0.848	0.863
Cheyenne	14	17.639	0.794	0.853	0.859
Clay	18	15.584	1.155	1.030	1.016
Colfax	19	20.081	0.946	0.940	1.051
Cuming	25	22.833	1.095	1.021	1.098
Custer	29	29.712	0.976	0.961	0.905
Dakota	17	21.245	0.800	0.853	0.816
Dawes	11	14.508	0.758	0.851	0.794
Dawson	33	37.764	0.874	0.895	0.839
Deuel	8	5.544	1.443	1.050	0.998
Dixon	10	13.363	0.748	0.840	0.829
Dodge	113	61.641	1.833	1.636	1.624
Douglas	519	483.568	1.073	1.069	1.076
Dundy	4	6.357	0.629	0.848	0.665
Fillmore	11	6.122	0.682	0.800	0.825
Franklin	14	11.307	1.238	1.064	1.109
Frontier	2	6.268	0.319	0.756	0.723
Furnas	16	15.418	1.038	0.973	0.863
Gage	58	46.169	1.256	1.168	1.133
Garden	1	6.596	0.152	0.695	0.763
Garfield	6	5.632	1.065	0.956	1.027
Gosper	3	4.740	0.633	0.859	0.776
Grant	0	1.314	0.000	0.850	0.846
Greeley	4	6.894	0.580	0.812	0.879
Hall	56	75.298	0.744	0.778	0.784
Hamilton	11	15.313	0.718	0.823	0.833
Harlan	10	10.114	0.989	0.958	0.936
Hayes	1	2.554	0.392	0.846	0.711
Hitchcock	3	8.626	0.348	0.725	0.622
Holt	37	24.812	1.491	1.262	1.200
Hooker	4	2.307	1.734	1.024	1.075
Howard	8	12.915	0.619	0.788	0.741
Jefferson	15	21.974	0.683	0.784	0.816
Johnson	11	11.491	0.957	0.940	0.923
Kearney	17	12.807	1.327	1.105	1.087
Keith	13	16.203	0.802	0.862	0.893
Keya Paha	1	2.683	0.373	0.842	0.804
Kimball	12	8.562	1.402	1.088	1.096
Knox	24	25.069	0.957	0.942	0.968
Lancaster	273	237.689	1.149	1.136	1.117
Lincoln	52	53.279	0.976	0.968	0.938
Logan	2	1.540	1.299	0.952	1.091
Loup	1	1.559	0.641	0.901	0.918
McPherson	73	49.178	1.484	1.337	1.286
Madison	1	1.413	0.708	0.906	1.115
Merrick	16	16.152	0.991	0.956	0.911
Morrill	5	11.409	0.438	0.716	0.755
Nance	5	9.596	0.521	0.767	0.888
Nemaha	9	15.923	0.565	0.749	1.747
Nuckolls	14	14.867	0.942	0.935	0.939
Otoe	26	30.416	0.855	0.878	0.884
Pawnee	10	10.491	0.953	0.924	0.896
Perkins	5	7.563	0.661	0.854	0.766
Phelps	11	17.979	0.612	0.770	0.782
Pierce	16	16.006	1.000	0.952	1.000
Platte	60	42.880	1.399	1.269	1.195
Polk	12	14.334	0.837	0.886	0.892
Red Willow	12	20.896	0.574	0.730	0.654
Richardson	16	24.364	0.657	0.762	0.720
Rock	3	4.267	0.703	0.869	0.909
Saline	26	26.549	0.979	0.957	0.945
Sarpy	47	57.648	0.815	0.841	0.869
Saunders	47	34.283	1.371	1.230	1.219
Scotts Bluff	66	63.776	1.035	1.015	0.982
Seward	15	25.910	0.579	0.710	0.756
Sheridan	10	15.281	0.654	0.787	0.758
Sherman	1	9.288	0.108	0.628	0.649
Sioux	3	3.145	0.954	0.926	0.884
Stanton	10	8.854	1.129	0.986	1.090
Thayer	14	18.753	0.747	0.828	0.811
Thomas	4	1.536	2.605	1.080	1.133
Thurston	8	11.221	0.713	0.830	0.885
Valley	12	13.040	0.920	0.920	0.876
Washington	21	25.463	0.825	0.866	0.997
Wayne	12	13.921	0.862	0.897	0.923
Webster	11	12.228	0.900	0.907	0.998
Wheeler	1	1.874	0.534	0.892	1.065
York	24	25.981	0.924	0.933	0.878

Source: The Nebraska Cancer Registry, 1990-1991.

FIGURE 1

Nebraska Prostate Cancer Incidence: Standard Morbidity Ratio (SMR)* 1990-1991



Source: The Nebraska Cancer Registry, 1990-1991.

A strict interpretation of the results, allowing for variability in the county-specific estimates, reports "significant" differences from the state average only for those counties whose rates remain above or below 1.0 when the 95 percent credible set is examined. **Table 2** shows counties which have higher rates than the state average. **Table 3** shows counties with lower rates than the state average.

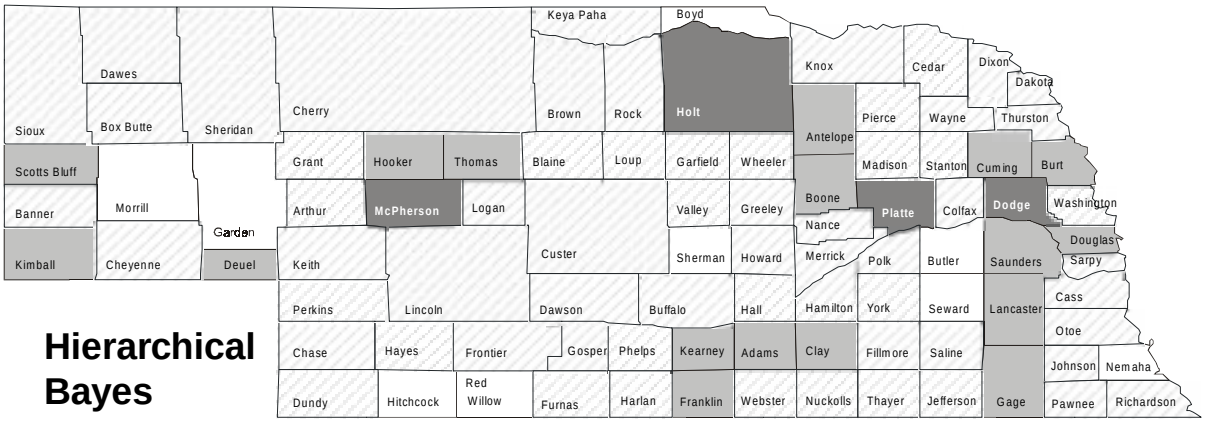
Table 2
Smoothing the SMRs-Hierarchical Bayes Models
Counties with Above Average Rates

Counties	Average	95% Credible Set
Dodge	1.636	1.367-1.905
Lancaster	1.136	1.011-1.133
McPherson	1.337	1.071-1.631
Platte	1.269	1.002-1.555

Table 3
Smoothing the SMRs-Hierarchical Bayes Models
Counties with Below Average Rates

Counties	Average	95% Credible Set
Butler	0.6777	0.429-0.986
Hall	0.7780	0.612-0.969
Sherman	0.0628	0.349-0.953

FIGURE 2
Nebraska Prostate Cancer Incidence: Hierarchical Bayes 1990-1991

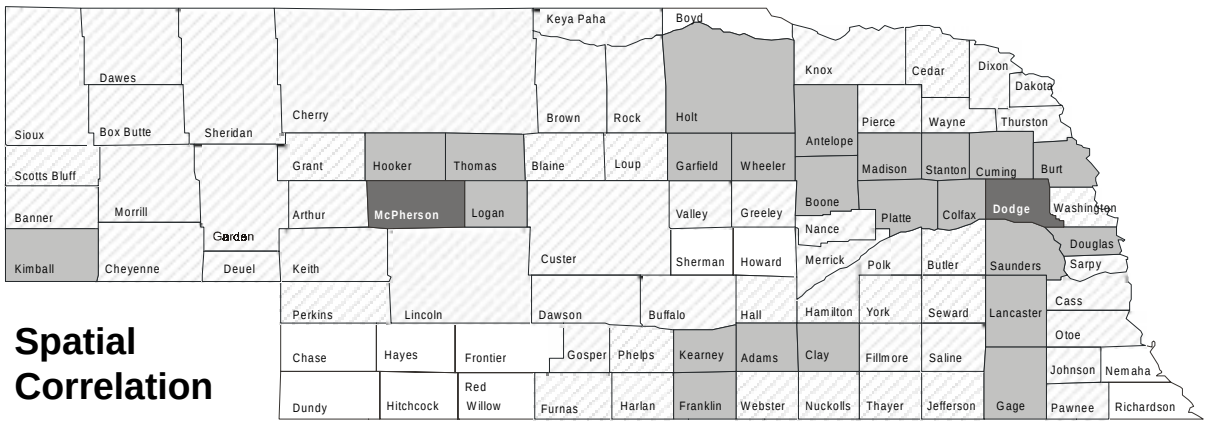


Hierarchical Bayes

0.00 to 0.75 of state ratio
0.75 to 1.00 of state ratio
1.01 to 1.25 of state ratio
1.26 to 2.50 of state ratio

Source: The Nebraska Cancer Registry, 1990-1991.

FIGURE 3
Nebraska Prostate Cancer Incidence: Spatial Correlation 1990-1991



Spatial Correlation

0.00 to 0.75 of state ratio
0.75 to 1.00 of state ratio
1.01 to 1.25 of state ratio
1.26 to 2.50 of state ratio

Source: The Nebraska Cancer Registry, 1990-1991.

Accommodating Spatial Correlation

Figure 2 shows that there are several clusters of contiguous counties with SMRs greater than 1.25 in east and central Nebraska, and that the counties with SMRs lower than 0.76 also tend to be clustered. This visual evidence of spatial correlation is confirmed by use of the rank adjacency statistic, for which Walter (1994) approximated a Z statistic. For the Nebraska raw SMRs, the value of Walter's statistic for the hypothesis of no spatial correlation is -2.42, with a p-value of .016. Thus, a model incorporating spatial correlation would be more appropriate than the simple independent Gamma model.

To model spatial correlation we used the so-called "conditional autoregressive" or "CAR" model, in which individual SMRs are shrunk toward the mean of their adjacent neighbor counties, instead of toward the overall mean. For details of this model, see section 2.2 of Clayton and Kaldor (1987) and the "Method" section of Mollie and Richardson (1991). Results are shown in the "Spatial Correlation" column of **Table 1** and in **Figure 3.** The counties with higher than average rates (again using the 95 percent credible set) are summarized in **Table 4**. **Table 5** shows counties with lower than average rates.

Table 4
Accomodating Spatial Correlation:
Counties with Above Average Rates

Counties	Average	95% Credible Set
Dodge	1.624	1.326-1.942
McPherson	1.286	1.011-1.571

Table 5
Accomodating Spatial Correlation:
Counties with Below Average Rates

Counties	Average	95% Credible Set
Buffalo	0.771	0.4870 - 0.9750
Frontier	0.723	0.0498 - 0.9990
Hall	0.784	0.0617 - 0.9690
Hitchcock	0.622	0.3730 - 0.9470
Red Willow	0.654	0.4410 - 0.9130
Sherman	0.649	0.4020 - 0.9550

DISCUSSION

We found differences in the incidence of prostate cancer among the 93 counties in Nebraska. We adjusted the Standardized Morbidity Ratios (SMRs) (observed divided by expected) to account for variation due to small numbers, and for spatial correlation. After doing so and applying a standard of reporting as “statistically significant,” only those counties whose 95 percent credible set for the true SMR excluded the value 1.0, we found two counties with elevated ratios (greater than the state average) and 6 with lower ratios than the state average. Differences in referral for prostate cancer screening (for instance the intensity of prostate specific antigen [PSA] screening) could be an explanation for all of the differences found.

The data presented in this report are suggestive of important variation in prostate cancer incidence within Nebraska. Further investigation is needed to verify the differences with more years of data, and to identify other differences across counties that might explain these differences incidence rates.

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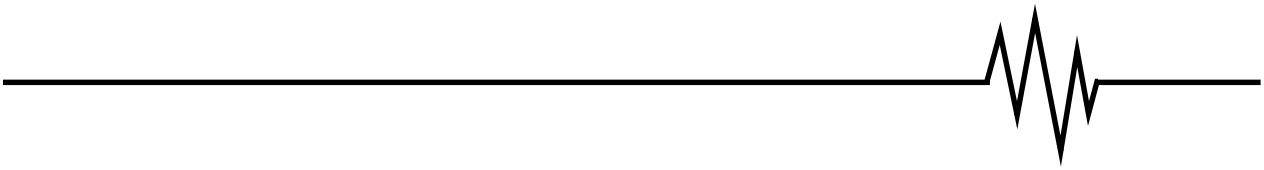

About the Nebraska Health Information Project

The Nebraska Health Information Project is a partnership project made possible with the financial support of the State of Nebraska and through additional personal and other resources provided by the University of Nebraska Medical Center. While initiated by Nebraska Unicameral, the ongoing success of the project results from cooperation and collaboration among a number of organizations and individuals, particularly those involved in delivering health care services, financing health care and analyzing health related data.

Other reports have been published by the Nebraska Health Information Project including annual databooks which present Nebraska health and demographic data at the county, area and state levels. To find out more about the Project visit our homepage at **http://www.unmc.edu/nebraska**

The Nebraska Center for Rural Health Research
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