

Colorectal Cancer Incidence Rates in North Dakota: A Geographical Exploration of Potential Risk Factors

Gary G. Schwartz, Professor and Chair¹; Marilyn G. Klug, Associate Professor¹; and Bradley C. Rundquist, Professor²

¹Department of Population Health, School of Medicine & Health Sciences; ²Department of Geography & GISc, College of Arts & Sciences



Abstract

Colorectal cancer (CRC) is the third most common cancer in the U.S. but its etiology is incompletely understood. North Dakota has the highest incidence rate for CRC among males in the U.S., and the third highest among females.

We explored demographic and geographic determinants of CRC incidence in an ecologic study using data from 51 of North Dakota's 53 counties. We used incidence data from the state cancer registry for 1997 to 2014. We examined candidate environmental (geographic) and socioeconomic factors at the county level, including median household income, poverty rate, fertilizer application rates, size of the cattle population, source of drinking water (municipal or self-supplied domestic well), uranium levels and indoor radon concentration. CRC rates and demographic variables were mapped and analyzed by county using GIS software. Using Path Analysis, we found a significant relationship between CRC incidence rate and the percentage of the population using self-supplying domestic water.

Contaminants of well water have been implicated in analytic epidemiologic studies of colorectal cancer; thus these results are plausible biologically. Although preliminary, these findings suggest that case-control studies of colorectal cancer and well water use in North Dakota are warranted.

Introduction

- Colorectal cancer (CRC) is the third most common cancer in the U.S. but its causes are poorly understood.
- North Dakota has the nation's highest incidence rate of CRC. Rates of CRC within North Dakota counties vary 3-fold.
- We conducted a hypothesis-generating study to identify factors that might explain the variation of CRC incidence rates within North Dakota.

Methods

There were 51 counties with data on 10 variables. Demographics included median income, population density and cattle per person. Farm-related variables included average amount of nitrates used per farm, percent of county fertilized, and average farm acres. Other variables were uranium in the soil, radon, and well water. CRC incidence rate was the dependent variable. Some variables were significantly skewed (e.g., nitrogen applied, farm size, population density, and cattle per person) and logarithmic or square root transformations were used to normalize them (Table 1).

Methods (continued)

We also used path analysis, a form of structured equation modelling, to determine indirect relationships and correlations between variables.

Table 1: Descriptive statistics of variables used in statistical analyses

Variable	Mean	Std Dev	Min	Max
CRC Incidence per 100,000 ¹	53.13	9.56	29.20	86.40
Avg. N Applied/Year (kg) ²	7,904,525	5,687,733	721,509	24,866,946
Avg. N Applied/Year (\log_{10})	6.79	0.32	5.86	7.40
% of a County's Acres Fertilized ^{2,3}	41.29	15.56	8.72	71.35
Avg. Farm Size (acres) ³	1,350	478.1	823	3,256
Avg. Farm Size (\log_{10})	3.11	0.13	2.92	3.51
Cattle per Person ^{3,4}	8.69	9.16	0.09	32.36
Cattle per Person ($\sqrt{\text{qt}}$)	2.56	1.47	0.30	5.69
Median HH Income (\$) ⁴	31,200	4,768	22,483	43,500
Pop. Density per sq. mi ⁴	8.76	9.16	0.09	32.36
Pop. Density (\log_{10})	0.67	0.43	-0.22	1.929
Median Radon (pCi/l) ⁵	6.37	2.06	2.60	11.70
Uranium in Soil (ppm) ⁶	1.53	0.25	1.10	20.07
% Self-Supplying Water for Domestic Use ⁷	12.77	4.89	1.65	25.86

Table 2: Multiple linear regression predicting CRC rate with adj. variables

Variable	b	Std. Error	t	p
Intercept	32.80	93.09	0.39	0.695
Avg. N Applied/Year (kg)	-3.17	7.82	-0.41	0.687
% of a County's Acres Fertilized	0.11	0.154	0.69	0.493
Avg. Farm Size (\log_{10})	2.53	18.32	0.14	0.891
Cattle per Person ($\sqrt{\text{qt}}$)	2.63	1.93	1.36	0.182
Median HH Income (\$)	0.18	0.40	1.71	0.653
Pop. Density (\log_{10})	10.53	6.18	1.71	0.096
Median Radon (pCi/l)	0.65	0.77	0.85	0.402
Uranium in Soil (ppm)	-2.91	8.08	-0.36	0.721
% Self-Supplying Water for Domestic Use	0.815	0.41	1.99	0.054

Results

Two of the maps produced (CRC incidence rate and percent self-supplying water for domestic use) are shown (Figs. 1 & 2).

All of the Pearson's correlation coefficients between CRC incidence rate and the variables in Table 1 were non-significant ($p > 0.05$). When entered into a multiple linear regression, only population density (\log_{10}) and self-supplied domestic water had $p < 0.10$. All other variables show no significant direct relationship with CRC incidence rate (Table 2). Because none of the variables had a direct relationship with CRC a path analysis was performed to determine indirect relationships and correlations (Fig. 3).

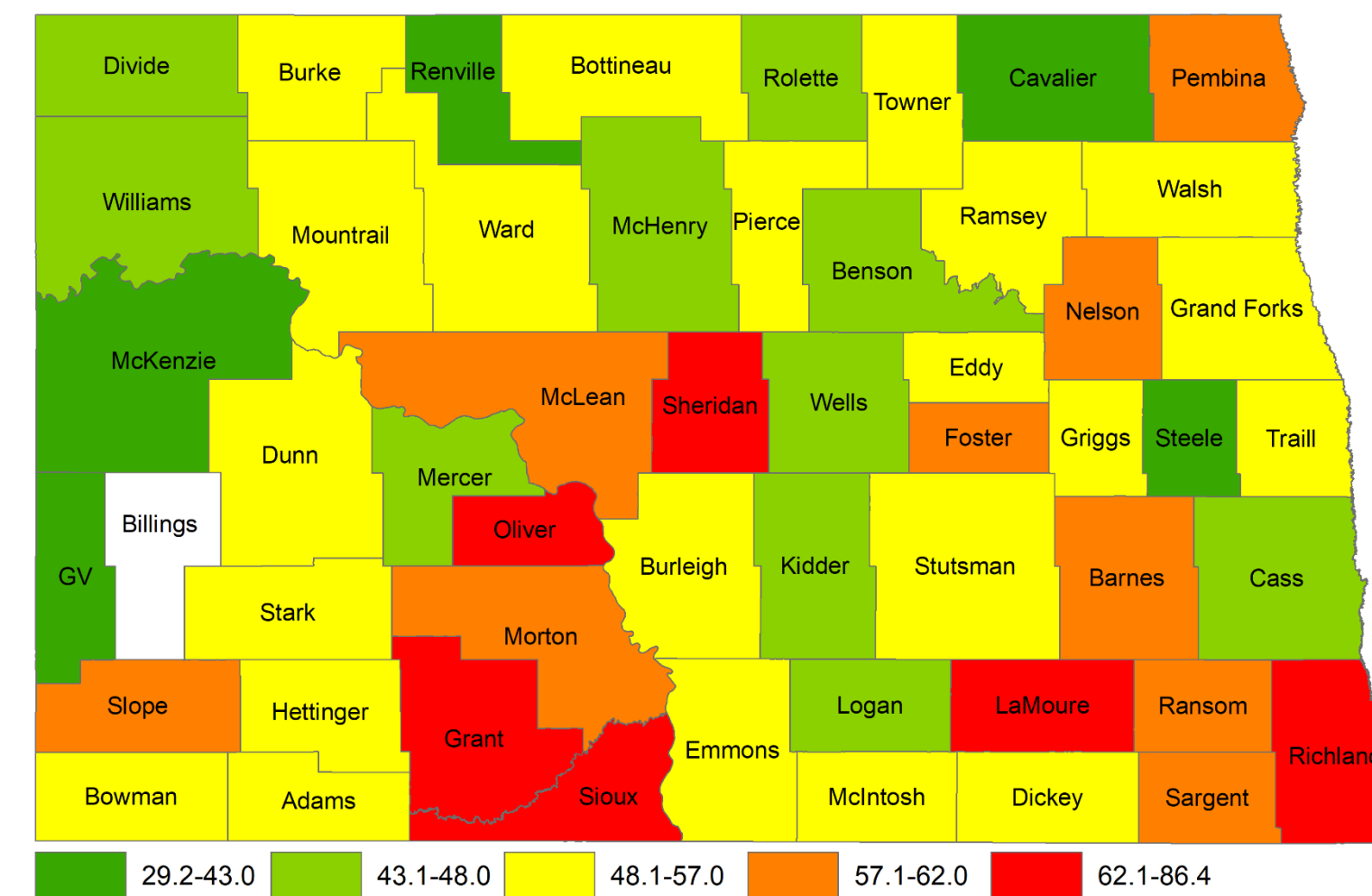


Figure 1: CRC incidence rate per 100,000 by county. No data for Billings Co.

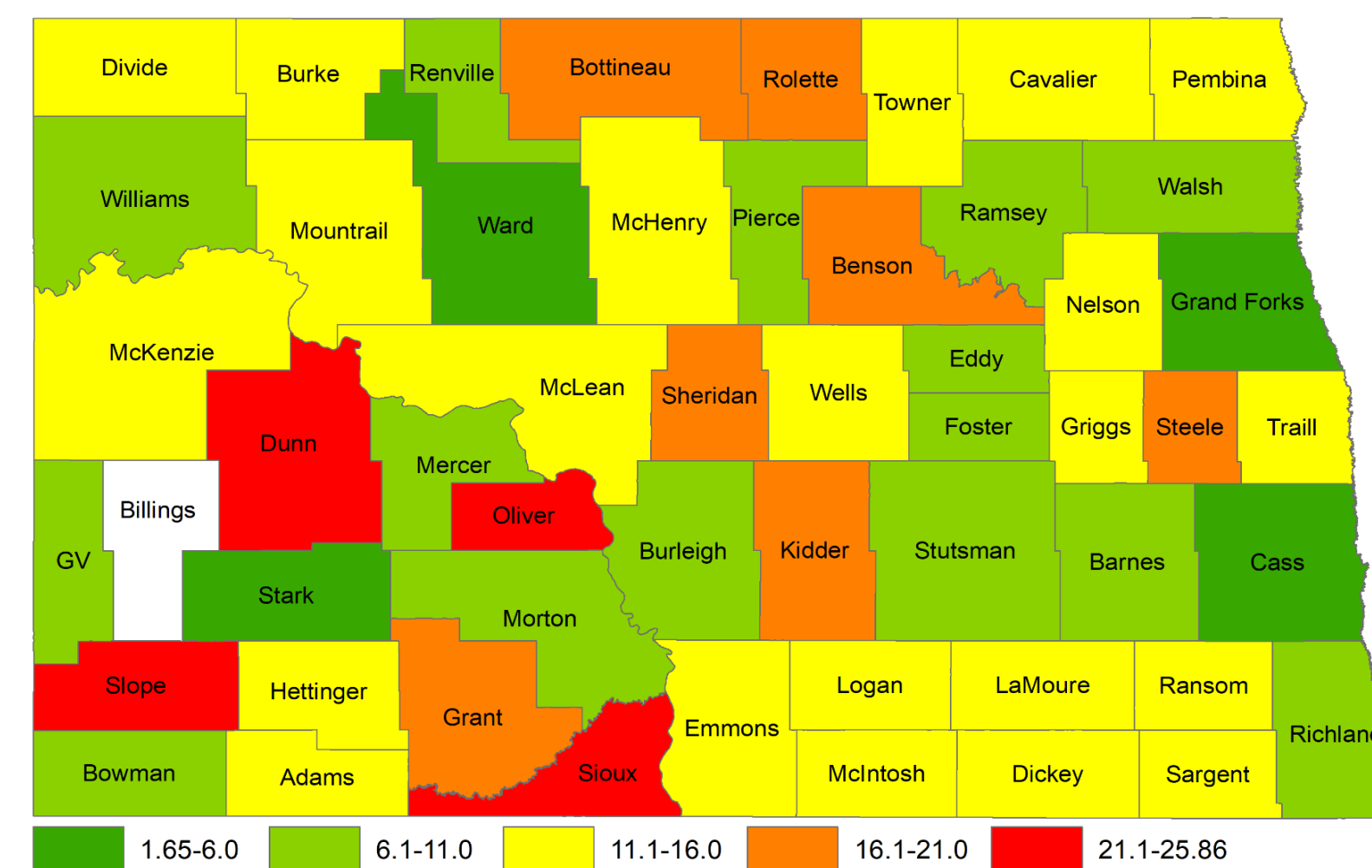


Figure 2: Percent of population self-supplying water for domestic purposes.

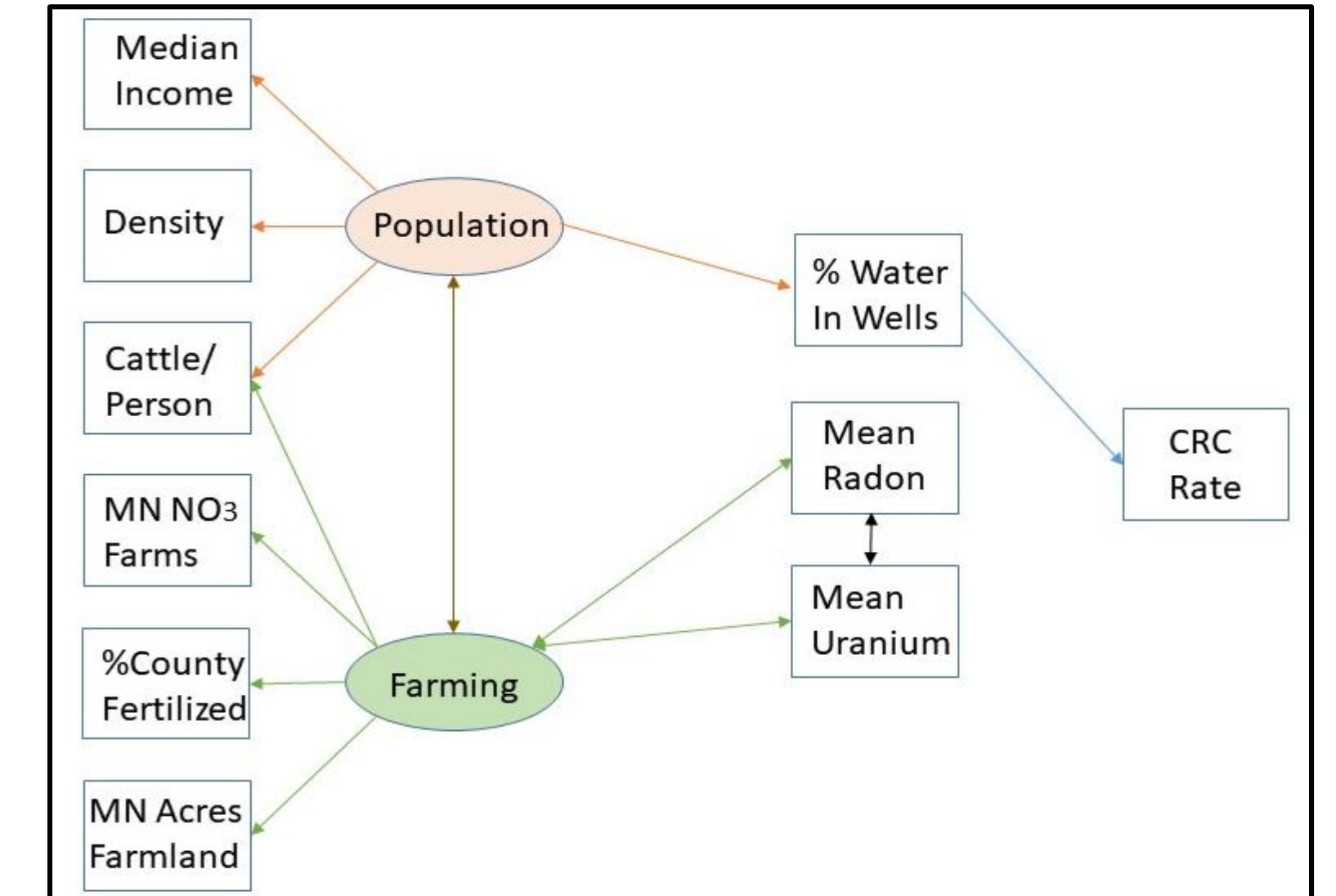


Figure 3: Path analysis of CRC rates. CRC rates are significantly associated with the use of well water ($p < .05$)

Conclusions

- CRC incidence rates in North Dakota counties are significantly associated with the use of well water.
- Well water contains known CRC carcinogens, including *Helicobacter pylori*.
- Chlorination by-products, used to treat well water, also are known carcinogens.
- The hypothesis that CRC is associated with well water could be tested in a case-control study that examines water sources among CRC cases and controls.

Data Sources

¹CINA+Online Cancer in North America. www.cancer-rates.info/naaccr/
²County-Level Estimates of Nitrogen and Phosphorus from Commercial Fertilizer for the Conterminous U.S., 1987-2006. https://water.usgs.gov/GIS/metadata/usgswrd/XML/sir2012-5207_county_fertilizer.xml
³U.S. Census of Agriculture, 2012. <https://www.agcensus.usda.gov/Publications/2012/>
⁴U.S. Census, 2010. <https://www.census.gov/2010census/>
⁵Radon Home Survey in North Dakota, 1988. <https://www.ndhealth.gov/air/iaq/radon/Home88.htm>
⁶Aeromagnetic and Aeroradiometric Data for the Conterminous U.S. and Alaska, National Uranium Resource Evaluation (NURE), U.S. Department of Energy. <https://pubs.usgs.gov/of/2009/1129/NURE.html>
⁷Water Use for the Nation. <http://waterdata.usgs.gov/nwis>