Original Article

Patterns of Colorectal Cancer Incidence, Risk Factors, and Screening in Kentucky

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Background: Colorectal cancer incidence rates are higher in Kentucky than in the United States in general, and there are regional variations within the state.

Methods: This study investigates these variations in relation to lifestyle and health behaviors, combining data from the Kentucky Behavioral Risk Factor Surveillance System (BRFSS), and from the Kentucky Cancer Registry. We used Kentucky's fifteen Area Development Districts (ADDs) as units of analysis across a five-year period from 1993 to 97.

Results: Differences were observed across ADDs. ADDs with a higher prevalence of risk factors, with the exception of chronic alcohol drinking, had lower CRC rates. ADDs with a higher proportion of respondents having had recent routine check-ups had higher CRC incidence rates.

Conclusions: In general, healthier lifestyles and positive health-related behaviors were associated with increased colorectal cancer incidence. This may be explained by the tendency for healthier individuals to receive regular check-ups and screening, thus increasing the detection rate of colorectal cancer.

Key Words: colorectal cancer, Kentucky, Behavioral Risk Factor Surveillance System, behavioral risk factors, screening

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Colorectal cancer (CRC), ranks third in cancer incidence in the United States and constitutes the second leading cause of cancer death for both sexes combined, with approximately 57,100 deaths predicted to occur nationwide in 2003.[1] The risk of developing CRC increases with age. The American Cancer Society estimates the risk at ages 40 to 59 years to be 1 in 114 for men, and 1 in 145 for women, compared with 1 in 25, and 1 in 33, respectively, at ages 60 to 79.[1]

There are several well-established risk factors for CRC, mostly related to lifestyle behaviors. Numerous studies have examined the relationship between diet and risk for CRC. Although the exact nutrients that modify the risk are currently under discussion,[2–3] it is generally accepted that consumption of fruits and vegetables lowers the risk,[4–6] while diets high in fat and/or low in fiber intake increase it.[2] There is also a relationship between lack of physical activity and large body mass index and increased CRC risk.[7–11] Alcohol consumption[13–15] and cigarette smoking[13–16] are also positively associated with increased risk.

The population of Kentucky has a high prevalence of

Key Points

- Among the poorer areas of Kentucky there is a higher prevalence of colorectal cancer risk factors (smoking, obesity) and a lower prevalence of protective factors (consumption of fruits and vegetables, exercise), yet lower colorectal cancer incidence rates are found there.
- Among respondents to the Kentucky Behavioral Risk Factor Surveillance System, those more than 50 years of age who had a check-up within the past two years were approximately four to five times more likely to be screened for colorectal cancer than those who did not have a regular check-up.
- The variation of colorectal cancer rates within Kentucky are likely due to a complex combination of risk factors, health care access and utilization patterns, socioeconomic status, screening, and competing causes of disease.

known CRC lifestyle risk factors. Kentucky ranks among the five states with the highest prevalence of smoking and obesity, and among the lowest of regular exercise.[17] The CRC incidence and mortality rates in Kentucky are higher than the national average, represented by the Surveillance, Epidemiology and End Results data. In addition, these rates vary substantially among different geographical areas within the state.[18–20]

Since 1985, CRC mortality rates have declined steadily in the United States, partly due to improvements in early detection and treatment.[21] Proper screening can identify precancerous polyps and prevent progression to cancer, or can detect the CRC at an earlier stage, improving the effectiveness of treatment and increased survival. Screening is typically accomplished by examination for fecal occult blood (FOBT), by visual inspection via sigmoidoscopy or colonoscopy, or by double-contrast enema.[1] FOBT testing can reduce CRC mortality because of its specificity,[22–23] but it is less sensitive than visual inspection of all or part of the large intestine.[24] A digital rectal examination (DRE) should accompany the other procedures.[1]

The goal of this study was to examine regional variations in CRC occurrence in Kentucky and their relationship with potential regional differences in lifestyle risk factors, screening practices, and health care access. We based these analyses on secondary data, including incidence and mortality rates at the state and substate level, data from the Kentucky Behavioral Risk Factor Surveillance System (BRFSS), and the 1990 Census.

Methods

Data Sources

Kentucky Cancer Registry. The Kentucky Cancer Registry (KCR) has been actively obtaining data on incident cases of cancer since 1991 as part of approved legislation from the Kentucky General Assembly, and has received recognition for the accuracy and completeness of the data. In February 2001, KCR joined the Surveillance, Epidemiology and End Results program, which is considered to be the most reliable population-based source of cancer data for the United States.

According to one KCR study,[25] approximately 2,500 incident cases of CRC occur each year in Kentucky. We obtained data from KCR for incident cases of CRC from 1993 to 1997, matching these years for BRFSS analysis. The data included age-adjusted incidence rates by gender, geographical subgroupings, and stage at diagnosis. In addition, KCR calculated mortality rates based on data from the National Center for Health Statistics. All age-adjustments were performed using the 1970 U.S. population as the standard.

Behavioral Risk Factor Surveillance System. The BRFSS, currently conducted in all fifty states, the District of Columbia, Puerto Rico, Guam, and the Virgin Islands, is an ongoing random digit dialing telephone survey of noninstitutionalized persons ages eighteen and older, supported by the Centers for Disease Control and Prevention (CDC).[26]

The BRFSS questions are divided into three categories: core questions, optional modules, and state-added questions. The core questions are included each year in all state questionnaires. There are fixed and rotating core questions. Fixed core questions are asked every year, and include basic demographic and health-status questions. Those in the rotating core are asked every other year, and include CRC screening and exercise questions. The optional modules are chosen by states individually. Finally, each state may add questions not provided by the CDC.

Although the BRFSS was originally designed to be representative at the state level and used for comparisons among states or for assessing trends over time, intrastate BRFSS analyses have been conducted for other states. In Alaska, BRFSS data were used to compare the distribution of Healthy People 2000 health-status indicators in four geographic regions.[27] A study in Iowa[28] examined the correlation between rurality and cervical cancer screening according to population density, and a study in Florida[29] investigated stroke mortality patterns among different labor-market area groups.

In conducting regional ecologic analyses in epidemiologic studies, choosing homogeneous geographic units minimizes the effects of extraneous variables. Generally, smaller areas provide more homogeneity; however, they are often too small to render statistically meaningful results. To increase the statistical power of the study, we used BRFSS data covering a span of five years.

For the purpose of maximizing homogeneity we considered using the county as the unit of analysis, but many of the 120 counties in Kentucky had insufficient BRFSS respondents even across the 5-year study period, some well below 50 for certain questions, which is fewer than the baseline minimum number per cell proposed by the CDC for accurate analysis.[30] Kentucky's counties are grouped into fifteen Area Development Districts (ADDs), which are public bodies under Kentucky Law that share common features based on geographical or economic development (Fig. 1). We chose the ADD as a convenient unit of analysis since it is commonly used for health surveillance, making results comparable across various secondary data sources.

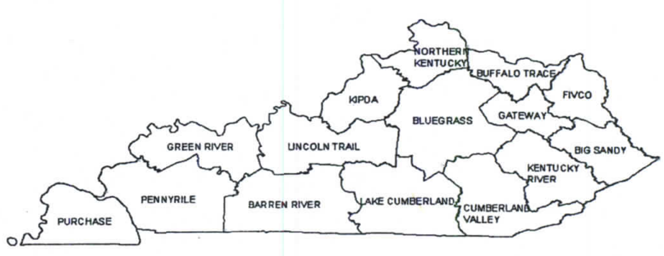

Fig. 1 **Map of Kentucky, subdivided into the 15 Area Development Districts.**

The Kentucky BRFSS used the Mitofsky-Waksberg sampling design up until 1997, changing to the Disproportionate Stratified Random Sampling in 1998.[31] To further increase the statistical power of the ADD-level analysis, in addition to using a five-year sample period we also chose to use data drawn from years during which the same sampling methodology was employed. We therefore combined BRFSS data from 1993 to 1997, totaling 14,425 respondents for the entire state.

During these 5 years, there were variations in the Kentucky BRFSS questionnaires which resulted in varying numbers of respondents, depending on the health topic. For example, smoking information was obtained for 14,425 persons, while questions regarding exercise were asked of 7,816 respondents. Questions regarding CRC screening were restricted to persons 40 years or older.

In our analysis we included three types of BRFSS questions related to lifestyle characteristics associated with CRC: 1) smoking, alcohol consumption, intake of fruits and vegetables, exercise and body mass index; 2) CRC screening, FOBT, proctoscopy and sigmoidoscopy (colonoscopy was not included among the questions until after 1997), and DRE; and 3) health care behavior and access.

Data analysis

We compared the CRC incidence and mortality rates across the ADDs. We calculated the standard incidence ratio for each ADD, using the national rates as the standard. We also compared the proportion of CRCs detected at a localized (early) versus those in a regional or distant stage of development. This was accomplished by combining cases diagnosed as either "in situ" or "local" into an "early stage" group, and those diagnosed as "regional" or "distant" into a "late stage" group.

For analysis of the five-year combined BRFSS data, we included the CDC calculated weights, to ensure the representativeness of the survey sample. The weights provided by the CDC follow several criteria for adjustment, including number of telephones per household, number of adults per household, number of interviews completed in each sample, and the population distribution according to age and gender. Using these criteria, the CDC creates a weight for each specific BRFSS respondent, which can be used in analyses that include any subset of respondents.

The frequency of each BRFSS answer was calculated using "PROC SURVEYMEANS" in SAS version 8.0 (SAS Institute, Inc., Cary, NC), which accounts for sampling variations. We excluded from the denominator respondents with "missing," "don't know," and "refused" answers. However, we separately calculated the proportion of missing/unknown/refused answers for each variable. The prevalence of these types of answers combined was low (range from 1.0 to 3.8%). The results for each question were correlated with CRC incidence data, using "PROC CORR." Although questions related to CRC screening were asked of all respondents aged 40 years or older, we restricted the analysis of screening questions to persons aged 50 years or older, following the current American Cancer Society recommendations for CRC for the general population.[1] In addition to the three CRC screening variables, we created a new variable: any type of screening (ever having had a FOBT, proctoscopy/sigmoidoscopy, or DRE).

Initial results showed that healthier lifestyle factors, screening, and greater health care utilization were correlated with increased CRC incidence (see Results section below). To further elucidate the relationship between these variables, we used individual level BRFSS data to determine if health care access and utilization predicted screening usage, which is known to influence incidence.[32] We used logistic regression to derive an odds ratio (OR) and 95% confidence interval (95% CI) for each variable of interest using PROC RLOGIST from SUDAAN version 7.5.4A (Research Triangle Institute, Research Triangle Park, NC).

Results

Demographic characteristics are presented in Table 1. The ADDs in Eastern Kentucky generally have lower socioeconomic status, indicated by their relatively lower educational and income levels. They are also less densely populated and more rural. A third of Kentucky's population is centered around the urban areas of Louisville (in the KIPDA ADD), Lexington (in the Bluegrass ADD) and the north-central part of the state which contributes to the greater Cincinnati, Ohio residential area (Northern KY ADD region).

CRC incidence and mortality rates varied among the ADDs, as shown in Table 2. The highest incidence rates were found in Gateway, Purchase, and KIPDA (58.7, 56.7, and 53.7 per 100,000 respectively), while those in Barren River, Lake Cumberland, and Big Sandy were lowest (40.9, 42.5 and 43.2 per 100,000 respectively). Thus, the highest CRC incidence rates for the combined five-year period (1993–1997) occurred in three noncontiguous regions of the state: two primarily rural areas in western and northeastern Kentucky, and the most urban and heavily populated ADD (including Louisville and surrounding areas). The lowest rates concentrated around the central-western, southern, and southeastern areas. The standard incidence ratios reflected these differences in incidence rates. (Table 2)

Most ADDs had similar ratios of incidence to mortality rates (between 2.2–2.8), consistent with a significant correlation ($r = 0.57$, $P = 0.026$). The Purchase ADD, however, had the second highest incidence rate and the lowest mortality rate (incidence to mortality ratio 3.8). This may be related to a differential stage at diagnosis, since the likelihood of survival increases substantially when CRC is detected at an early stage. Indeed, the Purchase ADD had the greatest percentage of cases diagnosed at an early stage (47.7%). When Purchase

Table 1. General demographic characteristics of Kentucky's population by ADD (1990 Census Data)[a]

ADD	Population	Race (% white)	Median income ($/household/yr)	% High school graduates	College education (% with ≥ 4 years)	% Rural population
Purchase	181,346	93.4	21,366	67.4	21.2	55.7
Pennyrile	205,800	86.4	20,933	63.2	19.3	58.7
Green River	199,342	94.4	23,519	67.4	19.6	49.6
Barren River	222,766	93.2	20,243	58.2	15.3	66.1
Lincoln Trail	219,101	90.0	22,554	66.6	19.5	60.7
KIPDA	796,491	84.2	27,787	73.3	23.8	15.2
Northern Kentucky	334,979	97.7	29,576	71.6	22.1	27.5
Buffalo Trace	51,877	96.6	18,674	54.2	13.5	80.3
Gateway	66,346	97.2	17,003	52.0	13.6	79.3
Fivco	132,685	98.6	21,581	61.3	18.3	55.1
Big Sandy	165,020	99.3	16,524	49.7	13.4	91.4
Kentucky River	123,495	99.1	14,170	45.0	11.2	93.4
Cumberland Valley	223,024	98.3	14,664	48.0	12.1	81.2
Lake Cumberland	174,283	97.7	16,087	49.7	12.2	83.8
Bluegrass	590,336	90.6	25,708	70.6	21.1	35.2
All Kentucky	**3,686,891**	**94.4**	**20,693**	**59.9**	**17.1**	**62.2**

[a]*ADD, Area Development District.*

was excluded, the correlation between incidence and mortality was much higher ($r = 0.86$).

The patterns of response to the BRFSS questions included in the analysis are presented in Table 3. Although the regional patterns are not clearly distinct, ADDs in eastern Kentucky, which represent the Appalachian and poorer areas of the state, tend to have a higher prevalence of risk factors (eg, smoking and proportion of overweight persons) and a

Table 2. Comparison of colorectal cancer incidence and mortality age-adjusted rates (per 100,000 persons) 1993-1997[a]

ADD	Incidence	(n)	Mortality	(n)	Incidence/mortality	% Diagnosed at early stage[b]	SIR (95% C.I.)[c]
Purchase	56.73	849	14.99	237	3.78	47.74	1.30 (1.22,1.39)
Pennyrile	49.42	665	18.40	267	2.69	45.16	1.12 (1.03,1.21)
Green River	44.46	590	18.97	265	2.34	42.86	1.00 (0.92,1.08)
Barren River	40.91	635	16.37	271	2.50	42.49	0.94 (0.87,1.02)
Lincoln Trail	50.47	634	19.89	259	2.54	40.55	1.16 (1.07,1.25)
KIPDA	53.65	2,771	19.80	1,058	2.71	43.63	1.21 (1.17,1.26)
Northern Kentucky	52.85	1,104	23.25	496	2.27	42.86	1.23 (1.15,1.30)
Buffalo Trace	52.62	196	23.71	93	2.22	36.81	1.20 (1.04,1.38)
Gateway	58.67	251	22.84	105	2.57	44.00	1.35 (1.19,1.53)
Fivco	52.27	483	21.09	200	2.48	44.60	1.19 (1.09,1.30)
Big Sandy	43.23	409	17.01	166	2.54	41.13	0.98 (0.88,1.08)
Kentucky River	44.27	313	16.37	122	2.70	39.50	1.00 (0.90,1.12)
Cumberland Valley	44.44	624	16.12	236	2.76	39.20	1.00 (0.93,1.09)
Lake Cumberland	42.47	537	17.25	231	2.46	36.09	0.93 (0.86,1.02)
Bluegrass	50.55	1,825	19.05	712	2.65	40.53	1.16 (1.11,1.21)
Total	**49.75**	**11,886**	**18.95**	**4,718**	**2.62**	**4239**	**1.13 (1.11,1.15)**

[a]*ADD, Area Development District.*

[b]*Not including unstaged cases.*

[c]*Standardized incidence ratio compared to U.S. incidence rates, with 95% confidence intervals.*

Table 3. Prevalence of selected BRFSS responses by ADD (Percentage)[a]

ADD	Risk factors (all participants)							Screening (≥ 50 years)				Health related behaviors (all participants)		
	Ever Smoked	Current Smoking	Over-Weight[b]	Chronic Alcohol	Any Exercise	Regular Exercise	Fruits/ Vegetables ≥5/day	Any	Proc/ Sig[c]	DRE	Blood Stool Test	Self Reported Good Health[d]	Health Care Coverage	Recent Check-Up
Purchase	49.6	28.5	28.0	2.1	60.1	36.4	17.4	62.9	35.6	61.9	46.6	81.0	86.9	81.5
Pennyrile	50.7	29.4	31.4	2.1	47.6	28.4	14.4	60.3	36.9	60.2	34.4	74.0	86.1	81.6
Green River	58.0	31.8	30.8	1.8	48.6	25.7	16.9	61.8	38.9	58.1	42.8	78.3	85.2	79.3
Barren River	53.2	30.9	27.6	2.0	56.2	29.7	15.7	50.7	30.4	53.8	29.1	75.4	82.9	79.2
Lincoln Trail	55.0	29.7	31.1	2.0	58.4	32.8	19.3	52.6	32.5	55.1	27.2	78.8	87.2	81.8
KIPDA	52.4	28.0	31.6	3.3	61.8	38.0	18.6	63.5	34.5	66.6	42.6	84.4	89.9	81.3
Northern Kentucky	52.8	30.4	30.0	3.4	59.2	37.2	16.9	61.9	31.8	61.0	42.6	85.6	89.1	80.6
Buffalo Trace	53.3	34.6	34.7	1.2	52.2	28.3	15.8	45.0	21.3	42.6	35.5	80.8	82.7	74.9
Gateway	49.6	28.8	30.7	3.2	55.6	32.7	17.5	54.7	37.2	58.6	40.3	75.1	80.8	82.0
Fivco	55.8	30.5	37.4	2.5	49.2	29.2	11.5	52.7	26.3	55.6	33.9	71.8	79.0	76.5
Big Sandy	53.5	31.6	41.9	1.0	45.0	22.0	9.0	57.0	19.6	58.5	34.2	63.6	75.4	73.3
Kentucky River	54.6	33.9	32.8	2.2	46.7	22.6	17.9	54.0	32.6	47.5	42.8	63.3	64.4	72.0
Cumberland Valley	57.4	31.6	36.0	1.4	48.6	25.6	15.6	60.5	35.6	56.8	41.0	65.6	77.8	75.4
Lake Cumberland	57.5	34.8	37.9	1.1	45.4	25.5	14.8	57.4	29.0	57.5	32.6	72.8	80.8	75.9
Bluegrass	50.2	28.0	29.0	3.7	59.2	34.1	18.7	66.4	35.8	63.6	47.5	84.6	87.5	80.6
Total	**53.1**	**29.8**	**31.7**	**2.6**	**55.9**	**32.5**	**17.0**	**60.1**	**33.1**	**60.1**	**39.8**	**79.1**	**85.2**	**79.5**

[a]*BRFSS, Kentucky Behavioral Risk Factor Surveillance System; ADD, Area Development Districts; DRE, Digital Rectal Exam.*

[b]*CDC-calculated variable: female BMI > 27.3, male BMI > 27.8 a measure of overweightness or obesity. CDC = calculates BMI using self-reported height and weight, by dividing weight in kilograms by height in meters squared.*

[c]*Proctoscopy or sigmoidoscopy.*

[d]*Participants reporting Good, Very Good or Excellent Health.*

Table 4. Correlation of selected variables and colorectal cancer incidence by ADD[a]

	All Participants	
Variable	**R**	***P* value**
Ever smoked	−0.65	0.01
Current smoke	−0.58	0.02
Overweight	−0.35	0.20
Chronic alcohol	0.59	0.02
Ever exercise	0.62	0.01
Regular exercise	0.74	<0.01
Fruits/vegetables ≥5 servings/day	0.34	0.21
Proctoscopy or sigmoidoscopy	0.21	0.44
Digital Rectal Exam	0.26	0.35
FOBT	0.36	0.18
Any screening	0.11	0.70
Self-Report good health	0.57	0.03
Health care coverage	0.45	0.09
Recent check-up	0.58	0.02

[a]*FOBT, fecal occult blood test.*

lower prevalence of protective factors (eg, consumption of fruit and vegetables and exercise). They also show lower screening rates for CRC and use of medical care.

The correlation between the incidence data and the BRFSS prevalence rates at the ADD level showed puzzling results (Table 4). Among the risk factors we investigated with the BRFSS data, only increased prevalence of chronic alcohol drinking (calculated from consumption of 2 or more drinks per day, or 60 or more drinks per month) was positively and significantly associated with increased CRC incidence. Smoking (categorized as either "ever smoked," or "current smoker") was negatively and significantly correlated with CRC incidence, while exercise (either as "any activity" or "regular exercise") was significantly correlated with increased incidence. Neither consumption of fruits and vegetables nor being overweight showed significant associations, but as with smoking and exercise, the correlation coefficients indicated a tendency in the opposite direction of that expected. For respondents 50 years of age or older, ever having had a home blood stool test was positively correlated with CRC incidence. An "excellent," "very good," or "good" health self-report, and having had a routine check-up within the last two years were both positively correlated with CRC incidence.

Since increases in screening practices for CRC can initially increase incidence rates due to the heightened detection of new, early-stage cases, individual-level BRFSS data were used to determine whether health care status and health care access predict screening behavior. The results, presented in Table 5, indicate that respondents ages fifty and older who had a recent check-up within the last two years were approximately four to five times more likely to have any kind of colorectal screening than respondents not having a regular check-up (OR = 3.45 [95% CI 2.66–4.49] for proctoscopy/sigmoidoscopy; OR = 4.07 [3.15–5.25] for DRE; OR = 5.05 [3.41–7.48] for FOBT; OR = 3.99 [3.25–4.89] for any of the three types of screening). Similarly, persons who reported having any health care coverage were between two and three times more likely to be screened for CRC compared with those without health care coverage (ORs ranging from 2.35 for FOBT to 3.05 for DRE, and OR = 2.79 for any of the three types of screening). There was little association between self-reported health status and screening.

Discussion

Areas in Kentucky with a higher prevalence of healthy lifestyles appeared to have higher incidence rates of CRC. Increased alcohol consumption was the only known risk factor positively correlated with increased incidence. However, the prevalence rates for chronic drinking as defined by CDC were low across all ADDs (1.0 to 3.7%), so that the public health significance of this finding appears limited. Higher smoking and lower exercise prevalence were associated with lower CRC rates, contrary to what was expected based on the general current understanding of and knowledge about CRC.[1,2,20,33]

The limitations of using BRFSS data for this type of analysis need to be considered. The BRFSS is restricted to the noninstitutionalized, adult population who live in households with telephones. This excludes special groups such as prisoners and nursing home residents and persons without telephones. In some states, including Kentucky, it also excludes non-English speakers. In 1990, 4.7% of all U.S. households did not have telephones. In Kentucky this figure reached over

Table 5. Comparison of colorectal cancer screening and health-related behaviors[a]

Screening	Recent check-up	Self-report health	Health care coverage
Proctoscopy/sigmoidoscopy	3.45 (2.66, 4.49)	0.85 (0.74, 0.99)	2.76 (1.94, 3.94)
Digital Rectal Exam	4.07 (3.15, 5.25)	0.99 (0.83, 1.19)	3.05 (2.19, 4.26)
Home blood stool test	5.05 (3.41, 7.48)	0.97 (0.81, 1.17)	2.35 (1.47, 3.76)
Any screening	3.99 (3.25, 4.89)	0.91 (0.79, 1.05)	2.79 (2.11, 3.70)

[a]*Odds ratios (95% confidence intervals).*

10%, with variations across ADDs ranging from 5% in Northern Kentucky and KIPDA to 20% in Kentucky River and Cumberland Valley. Assuming that most people without telephones have a low socioeconomic status, they are more likely to share characteristics with those who are in the lowest income group, and therefore also having a higher prevalence of risk factors (results not shown here by SES). If they had been included, the puzzling association between increased risk factors and lower CRC incidence would have been more pronounced.

Two other survey-related issues deserve to be mentioned: nonresponse rate and measurement error.[26] The Council of American Survey Research Organizations (CASRO) response rate was 69.6% for the 1997 Kentucky BRFSS consistent with the response rates estimated for other states and the median rates for all states of 68.4%.[34]

The individual-level analysis helped to elucidate the relationship between behavioral risk factors and CRC incidence. Having had a check-up within two years and having any kind of health care coverage were both predictive of having any type of CRC screening. They were also highly correlated with each other ($r = 0.88$), and generally associated with healthier behaviors.

Although the long-term effect of increased screening is to decrease incidence by detecting premalignant lesions that can be removed before cancer develops, the short-term effect is an increase in incidence,[35] due to the detection of new cases that otherwise would not be diagnosed until later. Our results are consistent with this effect, as indicated by the correlation between incidence and the proportion of cases detected in early stage ($r = 0.53$, $P = 0.04$).

Of particular interest is the Purchase ADD, which has the second highest incidence rate in Kentucky, but the lowest mortality rate for CRC. Purchase also has the highest proportion of early stage cases at diagnosis, suggesting a higher rate of initial screening. Conversely, the Appalachian areas of Kentucky, long associated with poverty and higher-risk lifestyle behaviors (also confirmed in our analysis), had some of the lowest screening rates, as well as lower CRC incidence rates. This lends support, at the ecologic level of analysis, to the hypothesis that the higher incidence rates are at least partially due to earlier detection of CRC.

Further studies are needed to better understand the extent to which CRC screening is practiced in Kentucky and the main roadblocks that are limiting its use, which will also help elucidate its effect on incidence rates. The 1999 BRFSS nationwide comparison ranks Kentucky second lowest in prevalence of proctoscopic/sigmoidoscopic screening (28.2 compared with 33.7 U.S. average). Despite this, there seem to be increases in screening prevalence over the last decade, which may account for the apparent increase in CRC incidence in Kentucky over the last few years (results not shown). Identification of the factors leading to earlier detection and lower mortality in Purchase could be useful in implementing intervention studies in other areas.

Although we observed regional differences in screening, correlations with CRC incidence were not statistically significant. A positive association was only evident with having a home blood stool test. The lack of a statistical association with the other screening questions may be explained by limitations in the ecologic nature of the study design. In our investigation, we were limited by the small number of units of analysis (15 ADDs), restricting the statistical power to find significant associations. Using the 120 counties in Kentucky could remediate this problem, as well as increase the homogeneity of the analytical unit, but the sample design and size of the BRFSS do not support this approach. In Kentucky, 46 counties had less than 50 respondents over the 5-year study period, and the numbers become much smaller for selected questions which are not asked yearly, or that are restricted to selected subgroups (for example, age- or gender-specific). In summary, statistical and study design limitations preclude finding significant associations between screenings and incidence rates at the ADD level, while results at the individual level suggest a possible association.

Other limitations of ecologic data include ecologic fallacy, in which the findings at the group level do not represent what is occurring at the individual level.[36] Therefore, seldom can we infer causal associations from the ecologic analysis alone. Inability to control for confounding is also a weakness of this study, as there are CRC risk factor variables not included in the analysis, such as use of nonsteroid anti-inflammatory drugs, family history of CRC, genetic factors, and inflammatory bowel disease.[1,38]

Competing causes of disease and mortality may also contribute to our findings of lower CRC incidence rates in specific areas where risk factors are elevated. Kentucky has the fifth highest cardiovascular disease (CVD) rate in the country.[37] CRC and CVD share many of the same risk factors, including obesity and lack of exercise as well as smoking. Since Kentucky has high rates of inactivity, smoking, and obesity compared with the U.S. as a whole, persons at high risk for developing CRC also have increased risk to develop CVD. Thus, a high rate of CVD may artifactually lower the CRC incidence rates, particularly in areas of lower screening where cases may go undetected. Many of the counties with low CRC rates have high CVD and overall mortality rates.

In summary, the variations of CRC rates found in Kentucky are likely due to a rather complex combination of behavioral risk factors, health care access and utilization, socioeconomic status, screening, and competing diseases. This study was a first step in exploring the relationships of these factors using existing data resources. These associations need to be further addressed using other study design approaches, which may lead to targeted programs to improve detection and lower the occurrence and fatality of CRC.

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