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Geographic Variation in Health Indicators across North Carolina Counties and Regions: A Comparison of Direct and Synthetic Estimates from the North Carolina BRFSS

by

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ABSTRACT

Objectives: The objectives of this study are: 1) to investigate if county and regional differences in selected health indicators are statistically significant before and after age adjustment and 2) to compare these crude and age-adjusted direct estimates with synthetic estimates (county-level estimates based on statewide rates).

Methods: Survey data from the 2001 North Carolina Behavioral Risk Factor Surveillance System (BRFSS) were used for this study. The BRFSS is a random-digit-dialed telephone survey of non-institutionalized adults ages 18 and older. In 2001, the North Carolina BRFSS sampling frame consisted of the 10 most populated counties and three regions that contained the remaining 90 counties. Three domains of health were compared: chronic diseases, high-risk behaviors, and access to health care. Within each domain, four key indicators were assessed across the 10 counties and three regions of North Carolina. All analyses were performed with the SUDAAN software, designed for the analysis of complex sample designs such as the BRFSS survey.

Results: Based on chi square tests, crude rates differed significantly across the 10 counties and three regions for all but two health outcomes, diabetes and current asthma. Similarly, age-adjusted rates also differed significantly across the 10 counties and three regions for all health indicators except current asthma. The Eastern North Carolina region had either the highest rate or a rate not significantly different from the highest rate for most health indicators. The synthetic estimates differed substantially from both the crude and age-adjusted rates and there was much less variation among the synthetic estimates. The synthetic estimates were over-estimates in counties where direct survey estimates were significantly lower than the state rate, and were under-estimates in counties where direct survey estimates were significantly higher than the state rate.

Conclusions: Health indicators vary significantly across North Carolina. A county should generally use crude rates for their own public health planning purposes and age-adjusted rates to compare with other counties and regions on the relative level of health risks. An underlying factor contributing to the geographical health disparities in North Carolina is access to health care, which is strongly correlated with economic conditions. The use of synthetic estimates does not capture the variation across counties in health risks and behaviors and can be misleading. Our study provides strong evidence for the importance of direct local-level sampling to detect sub-state geographical variation in health indicators.

Introduction

Health-related research has shown that morbidity and mortality are influenced by personal behaviors. Prior to 1983, only national estimates of health risk behaviors among the U.S. adult population were regularly available, from surveys conducted by the National Center for Health Statistics. State-specific data about health behaviors were not generally available. It was clear that state-level data were needed to support intervention plans, monitor trends, and target resources. As a result, the Centers for Disease Control and Prevention worked with states to develop the Behavioral Risk Factor Surveillance System (BRFSS), which is a state-based surveillance system.

Realizing that behaviors vary within states – e.g., between urban and rural communities and between racial and ethnic groups – many states have attempted to derive estimates of health risk behaviors for counties and cities by combining BRFSS data over several years. Results from these analyses have demonstrated geographic differences in health insurance coverage,[1] physician practices,[2] and health behaviors.[3] The awareness of local differences in health behaviors has generated a steady demand on the state-based BRFSS surveys for sub-state estimates that will give state and local health agencies a better picture of health variations within a state. In recent years, a number of states have conducted their BRFSS surveys in counties or regions (e.g., Idaho, Kentucky, North Carolina). The combined nationwide sample size for the BRFSS has dramatically increased from 113,934 respondents in 1995 to 212,510 in 2001. This sample size is expected to exceed 250,000 in 2003. Moreover, a number of states have conducted BRFSS-like surveys at local levels (e.g., Illinois, Massachusetts, Florida).

Survey sample size increases are quite costly and require additional staff for the effective collection and analysis of the data. Due to these factors, there have been a number of studies exploring the use of statistical techniques to produce small area estimates. Most commonly, synthetic estimates are used to generate small-area estimates from state-level rates. While statistical modeling approaches require significant expertise and computing skills, synthetic estimates are relatively easy to compute and are often used by epidemiologists and health statisticians to produce local-level estimates from state-level BRFSS data. However, synthetic estimates usually assume that rates of health behaviors are constant across small areas such as counties and health districts and that the overall county-level differences in health behaviors are due only to differences in the socio-demographic structure of the populations. Synthetic estimates do not account for differences in local health priorities, differences in local program focus, or unique aspects of a county's population.

Increases in the BRFSS sample size in North Carolina have made it possible to produce direct county estimates. This report features the results of the first county-level data from North Carolina's BRFSS for the year 2001. In this report, our first objective is to investigate if the county and regional differences in selected health indicators are statistically significant before and after age adjustment. The second objective is to compare these crude and age-adjusted direct estimates with synthetic estimates based on the gender, race, and age distributions of each area.

Methods

Survey data from the 2001 North Carolina BRFSS were used for this study. The BRFSS is a random-digit-dialed telephone survey of non-institutionalized adults ages 18 and older. All analyses were performed with the SUDAAN software, designed for the analysis of complex sample designs such as the BRFSS survey.

In 2001, the North Carolina BRFSS sampling frame consisted of the ten most populated counties (Buncombe, Cumberland, Durham, Forsyth, Gaston, Guilford, Mecklenburg, New Hanover, Onslow, and Wake) and three regions (Piedmont, Eastern, and Western) containing the remaining 90 counties. Representative samples of adults ages 18 and older were selected from each of the ten counties and three regions. To accommodate separate estimates for each of the ten counties, the annual N.C. BRFSS sample size was tripled compared to previous years' sample sizes, resulting in a total of 6,205 completed interviews for 2001. Each county was assured a minimum of 400 completed interviews, providing a reasonable degree of precision (95% confidence interval +/- 5%) for estimating the prevalence of health-related conditions, such as the prevalence of smoking or obesity. A target of 700 completed interviews was set for each of the three regions. Table 1 displays the population and sample distribution for each of the sampling units. Weighted data were used for all of the analyses in this report.

Table 1. 2000 census population and 2001 BRFSS sample size for 10 North Carolina counties and 3 regions (age 18+).

	2000 Census Population		2001 BRFSS Sample		
County/Region*	Number	%	Sample Size	% Unweighted	% Weighted
Buncombe	163,936	2.7	424	6.8	2.5
Cumberland	219,575	3.6	429	6.9	3.9
Durham	174,111	2.8	400	6.4	2.7
Forsyth	236,390	3.8	457	7.4	3.4
Gaston	144,930	2.4	467	7.5	2.1
Guilford	325,654	5.3	418	6.7	4.6
Mecklenburg	526,370	8.5	431	6.9	7.7
New Hanover	128,163	2.1	405	6.5	2.2
Onslow	111,493	1.8	436	7.0	1.7
Wake	474,073	7.7	428	6.9	8.0
Western Region	688,236	11.2	619	10.0	11.2
Piedmont Region	1,623,181	26.4	670	10.8	27.2
Eastern Region	1,341,810	21.8	621	10.0	22.8
Total	6,157,922		6,205		

*Eastern Region: Beaufort, Bertie, Bladen, Brunswick, Camden, Carteret, Chowan, Columbus, Craven, Currituck, Dare, Duplin, Edgecombe, Gates, Greene, Halifax, Harnett, Hertford, Hoke, Hyde, Johnston, Jones, Lenoir, Martin, Nash, Northampton, Pamlico, Pasquotank, Pender, Perquimans, Pitt, Robeson, Sampson, Scotland, Tyrrell, Washington, Wayne, Wilson.

Piedmont Region: Alamance, Alexander, Anson, Cabarrus, Caswell, Catawba, Chatham, Cleveland, Davidson, Davie, Franklin, Granville, Iredell, Lee, Lincoln, Montgomery, Moore, Orange, Person, Randolph, Richmond, Rockingham, Rowan, Stanly, Stokes, Union, Vance, Warren, Yadkin.

Western Region: Alleghany, Ashe, Avery, Burke, Caldwell, Cherokee, Clay, Graham, Haywood, Henderson, Jackson, McDowell, Macon, Madison, Mitchell, Polk, Rutherford, Surry, Swain, Transylvania, Watauga, Wilkes, Yancey.

Three domains of health were compared: chronic diseases, high-risk behaviors, and access to health care. Within each domain, four key indicators were identified. For chronic diseases, the prevalence of disability, arthritis, diabetes, and current asthma was assessed. High-risk behaviors included smoking, obesity, binge drinking, and no leisure-time physical activity. Access to health care consisted of having no health care coverage in the past year, not having a usual place of care, having no dental insurance, and not being able to afford medical care (in the past 12 months) because of cost.

All rates were age-adjusted to the 2000 North Carolina State Census population. Each of the ten counties and the Piedmont and Western regions was compared to the Eastern region to test for significant differences in the crude and age-adjusted rates. The Eastern region was selected as the comparison group because it is the most impoverished area and has experienced the highest prevalence of most adverse health outcomes. Local and regional estimates were also compared with the statewide estimates to determine statistically significant differences (based on t-tests) and the ranges of estimates were examined within North Carolina and across the 48 contiguous states and District of Columbia, when applicable. The overall significance level of the differences among crude rates for each health indicator was determined using a chi square test. Synthetic estimates were calculated by applying the statewide gender-race-age specific BRFSS rates to the comparable 2000 Census populations of each county/region. The synthetic estimates were compared to the direct estimates. The same three age groups (18-39, 40-59, and 60+) were used in the age adjustment and synthetic rate estimates.

Table 2. Crude, age-adjusted, and synthetic rates (percentages) for the ten over-sampled North Carolina counties and three regions for 12 selected health indicators from the 2001 BRFSS.

	Disability			Arthritis			Diabetes			Current Asthma		
	Crude	Age Adjusted	Synthetic	Crude	Age Adjusted	Synthetic	Crude	Age Adjusted	Synthetic	Crude	Age Adjusted	Synthetic
Buncombe	26.8	25.8	26.1	25.2	24.0	25.1	7.2	6.9	6.5	6.5	6.4	6.3
Cumberland	24.4	27.4	22.7	18.7*	22.9	19.4	7.7	10.2	5.8	4.5	4.1	6.4
Durham	22.4*	24.2	23.4	15.1*	17.7*	20.5	6.5	7.5	6.3	6.8	6.3	6.5
Forsyth	25.8	24.3	25.2	21.2	19.2*	23.5	5.9	5.2	6.7	8.0	8.0	6.4
Gaston	26.6	25.5	25.1	28.0	25.7	23.6	7.9	7.3	6.2	5.4	5.5	6.3
Guilford	20.1*	19.6*	24.7	18.5*	17.6*	22.6	7.4	7.1	6.6	5.9	5.7	6.5
Mecklenburg	20.2*	21.6*	23.2	14.2*	16.0*	20.5	5.0*	5.7	5.8	5.3	5.3	6.4
New Hanover	24.7	25.5	24.9	21.1	23.2	23.1	5.0*	5.5	6.2	6.4	6.7	6.3
Onslow	20.7*	24.1	20.8	18.4*	24.1	16.8	5.2	7.0	4.3	5.5	5.3	6.1
Wake	16.9*	20.7*	22.7	11.5*	15.5*	19.8	4.6*	6.2	5.3	6.5	6.9	6.4
Western NC	28.0	25.5	26.5	30.3	25.8	25.7	8.5	7.3	6.5	4.9	4.6	6.2
Piedmont NC	26.3	25.2	25.3	26.2	25.0	23.7	5.7	5.0*	6.5	6.9	7.2	6.3
Eastern NC	29.2	28.3	25.8	26.6	25.6	24.0	8.5	8.2	7.4	7.2	7.1	6.3
Chi-square	33.3*			105.2*			15.9			7.8		
NC Rate	25.3	25.0		23.3	22.9		6.7	6.6		6.4	6.4	
95% CI**	23.7-27.1	23.3-26.6		21.8-24.3	21.5-24.4		5.9-7.7	5.8-7.4		5.5-7.5	5.5-7.5	
Range (NC)	16.9-29.2	19.6-28.3	20.8-26.5	11.5-30.3	15.5-25.7	16.8-25.7	4.6-8.5	5.0-0.2	4.3-7.4	4.5-8.0	4.1-8.0	6.1-6.5
Range (US)#				18.9-28.7			4.3-9.6			5.3-9.5		
	Smoking			**Obesity**			**Binge Drinking**			**No Leisure-Time Physical Activity**		
Buncombe	30.7	31.6	25.9	19.2*	19.1*	21.3	10.7	11.6	9.9	22.7*	22.1*	24.9
Cumberland	26.5	27.4	26.6	21.4	23.8	24.1	12.2	10.6	11.4	21.0*	22.9*	26.9
Durham	18.2*	18.9*	26.0	20.7	21.4	24.3	13.6	12.5	10.4	22.4*	23.1*	27.7
Forsyth	24.1	24.7	25.8	21.6	21.4	23.1	8.5	8.7	9.8	26.0*	25.5*	26.6
Gaston	27.4	28.3	26.3	26.5	26.4	21.8	10.0	10.7	10.3	29.3	29.0	25.2
Guilford	21.0*	20.9*	25.8	20.6	20.7	23.5	10.6	10.9	9.9	24.6*	24.9*	27.0
Mecklenburg	19.9*	19.5*	26.7	18.9*	18.9*	23.3	10.6	10.1	10.9	21.1*	21.5*	26.4
New Hanover	24.5	24.4	26.3	16.9*	17.6*	22.1	16.7*	16.2*	10.5	18.8*	19.6*	25.3
Onslow	34.3	30.8	28.0	18.3*	21.4	21.7	15.1	12.5	14.0	24.4*	26.6	23.6
Wake	21.9*	21.0*	27.3	19.2*	18.7*	22.5	16.0*	13.7	11.5	20.9*	21.4*	25.4
Western NC	26.5	28.1	25.7	18.3*	18.8*	21.0	6.0	6.9	9.8	28.5	28.3	24.6
Piedmont NC	25.2	25.4	26.1	25.7	25.4	22.2	8.2	8.9	10.2	25.4*	25.3*	25.5
Eastern NC	30.1	30.4	25.4	26.5	26.1	24.1	9.0	9.5	9.6	33.1	32.6	27.6
Chi-square	33.8*			25.1*			35.7*			36.6*		
NC Rate	25.7	25.8		22.9	22.7		9.7	10.0		26.4	26.3	
95% CI**	24.0-27.5	24.1-27.6		21.2-24.6	21.1-24.5		8.7-11.0	8.9-11.3		24.8-28.1	24.6-28.0	
Range (NC)	18.2-30.7	18.9-31.6	25.4-28.0	16.9-26.5	17.6-26.4	21.0-24.3	6.0-16.7	6.9-16.2	9.6-14.0	18.8-33.1	19.6-32.6	23.6-27.7
Range (US)#	13.4-30.9			14.9-26.5			6.8-25.6			16.5-35.6		
	No Health Insurance Coverage			**Cost as Barrier for Health Care Access**			**No Usual Place of Care**			**No Dental Insurance**		
Buncombe	17.1	18.0	12.8	13.6	14.1	10.3	22.2	23.0	20.8	49.9	49.8	47.0
Cumberland	17.1	15.4	16.1	12.4	10.6	12.6	17.3*	17.9	24.0	39.2*	41.2*	42.6
Durham	12.5*	11.4*	15.9	9.8*	9.3*	12.7	19.9	18.3	23.2	36.8*	37.5*	43.2
Forsyth	8.4*	9.1*	14.1	8.3*	8.2*	11.5	13.6*	14.2*	21.7	34.2*	32.7*	45.4
Gaston	13.4*	14.1	13.6	17.5	17.7	10.8	20.7	20.7	21.5	46.6	44.9	45.7
Guilford	11.4*	12.0*	14.6	7.6*	7.9*	11.9	20.0	20.4	22.1	38.3*	37.8*	44.8
Mecklenburg	8.7*	8.3*	15.4	8.6*	8.3*	12.1	21.0	20.1	23.1	32.4*	34.4*	43.1
New Hanover	11.3*	10.5*	13.8	12.4	12.0	11.1	28.3	27.4	21.7	46.2	47.2	45.4
Onslow	18.6	15.8	16.4	8.3*	7.6*	11.7	19.8	18.6	25.5	33.3*	36.2*	41.9
Wake	14.1	12.6*	15.3	6.9*	6.2*	11.8	25.9	23.5	23.2	36.9*	40.7*	42.6
Western NC	16.1	18.1	12.4	11.9	13.3	9.9	18.2	18.8	20.6	53.7	50.1	47.8
Piedmont NC	12.2*	12.8*	13.7	9.9*	9.9*	10.9	22.7	23.7	21.5	45.7*	45.2*	45.8
Eastern NC	18.7	18.7	14.3	16.3	16.5	11.8	23.7	24.0	21.7	53.3	52.7	45.5
Chi-square	32.6*			40.7*			27.1*			94.9*		
NC Rate	14.2	14.4		11.4	11.5		21.9	22.1		45.3	45.3	
95% CI**	12.8-15.8	13.0-16.0		10.2-12.8	10.3-12.9		20.2-23.6	20.4-23.9		43.3-47.3	43.3-47.2	
Range (NC)	8.4-18.7	8.3-18.7	12.4-16.4	6.9-17.5	6.2-17.7	9.9-12.7	13.6-28.3	14.2-27.4	21.5-25.5	32.4-53.7	32.7-52.7	41.9-47.8
Range (US)#	5.5-22.9											

*Indicates differences between this rate and the Eastern region is statistically significant at the 0.05 probability level (based on t-tests) and also indicates that chi-square values are statistically significant at the 0.05 probability level.

**CI=Confidence Interval

Ranges are given for 48 contiguous states and the District of Columbia when 2001 data were available.

Results

The North Carolina 2000 census population and the 2001 BRFSS samples for the ten counties and three regions are shown in Table 1. A comparison of unweighted sample percentages with the adult population percentages show that the eight counties were oversampled, with ratios ranging from approximately 4 to 1 in Onslow County to 1.3 to 1 in Guilford County. The two largest counties, Mecklenburg and Wake, and the Western region were slightly under-sampled, while the Eastern and Piedmont regions were under-sampled by approximately 50%. The weighted percentages are very close to the distribution of the census population.

Table 2 shows the county- and region-specific crude, age-adjusted, and synthetic rates; chi square test results for the crude rates; North Carolina statewide estimates; and ranges for the 48 contiguous states and the District of Columbia for the 12 selected indicators from the three health domains. Based on chi square tests, crude rates differed significantly across the ten counties and three regions for all but two health outcomes, diabetes and current asthma. Half or more of all 78 possible comparisons between each of the ten counties and three regions showed significant differences for the crude rates for doctor-diagnosed arthritis and no dental insurance (Table 3).

Table 3. Number of statistically significant differences for each health indicator among the ten North Carolina counties and three regions for crude and age-adjusted rates (out of all 78 possible county/region comparisons).

Health Indicators	Crude Rates	Age-Adjusted Rates
Disability	21	5
Arthritis	43	34
Diabetes	6	5
Current Asthma	0	1
Smoking	21	23
Obesity	18	15
Binge Drinking	20	8
No Leisure-Time Physical Activity	22	16
No Health Insurance coverage	14	21
Cost as Barrier for Health Care Access	22	26
No Usual Place of Care	11	10
No Dental Insurance	39	34

The Eastern region had either the highest rate, or a rate not significantly different from the highest rate, for disability, arthritis, diabetes, current asthma, smoking, obesity, no leisure-time physical activity, and reporting cost as a barrier to health care. The Eastern region also had the highest rates of having no health insurance and no dental insurance. Gaston County and the Eastern region had the worst levels of health conditions and behaviors; out of the 12 indicators only the crude rate for no health insurance differed significantly between the two areas. In contrast, Durham, Guilford, Mecklenburg, and Wake counties had significantly better rates for at least seven of the 12 indicators, compared to the Eastern region. Guilford, Mecklenburg, and Wake counties had also significantly better rates for at least five of the 12 indicators compared to the statewide estimates, based on t-tests.

The ranges of crude rates for the ten counties and three regions were wider than the confidence intervals (CI) of the North Carolina statewide estimates for all health indicators, and ten of the 12 indicators had at least one crude rate that differed significantly from the state estimate. For example, the range for the smoking rate was between 18.2% and 30.7%, compared to the CI of 24.0% - 27.5% for the statewide smoking rate of 25.7%. Durham, Guilford, and Mecklenburg counties had significantly lower smoking rates and Onslow County had a significantly higher smoking rate than the state rate. For a number of health indicators, the ranges of prevalence estimates were such that the upper values were more than twice the size of the lower values. For example, the prevalence of arthritis was the lowest in Wake County, with a rate of 11.5%, compared to the highest rate of 30.3% in the Western region. Likewise, the rate of cost being a barrier for health care access was only 6.9% in Wake County compared to 17.5% in Gaston County.

For eight of the 12 health indicators, crude rates were available for the 48 contiguous states and the District of Columbia. The variation in North Carolina for these eight indicators was comparable to the variation across the 48 states and the District of Columbia. For most of these indicators, only one or two states had rates either higher or lower than those observed in the ten North Carolina counties and three regions. For example, only Utah and California had lower smoking rates than Durham County, and only Kentucky had a higher smoking rate than Onslow County. Likewise, only Massachusetts and Colorado had lower obesity prevalence than

New Hanover County. Moreover, the range for prevalence of arthritis across the North Carolina geographical areas exceeded that of the 48 states and District of Columbia.

Age adjustment tended to reduce the number of significant inter-county or region differences (Table 3). There were fewer significant age-adjusted rate differences for disability, arthritis, obesity, binge-drinking, no leisure time physical activity, and no dental insurance compared to the crude rate differences for the same indicators. In contrast, there was an increase in the number of significant differences in age-adjusted rates for current smoking, having no health insurance, and cost being a barrier to health care.

Age-adjusted rates also differed significantly between the Eastern region and at least one of the ten counties and two other regions for all health indicators except current asthma rates. Again, the prevalence of doctor-diagnosed arthritis and no dental insurance varied the most. As expected, the ranges in age-adjusted rates were generally slightly smaller than the ranges for the crude rates, but they were wider than the confidence intervals for the statewide age-adjusted rates. For example, disability crude rates ranged from 16.9% to 29.2% among the ten counties and three regions, compared to a range of age-adjusted rates of 19.6% to 28.3% and the confidence interval of 23.3% - 26.6% for the statewide age-adjusted disability prevalence.

The relative position of the Eastern region did not change much after age-adjustment. The Eastern region still had among the worst levels of these 12 health indicators compared to the ten counties and the other two regions. Although the age-adjusted rates for Gaston County were slightly better than the Eastern region in general, Gaston was the only county for which none of the age-adjusted rates differed significantly from the Eastern region. Compared to statewide rates, the Eastern region had higher rates for all of these health indicators except binge drinking. The Eastern region's age-adjusted rates for three of the four health care access indicators (no health insurance, no dental insurance, cost as a barrier for health care access, and no usual place of care) were *significantly* higher than the state rates.

The third set of estimates examined was synthetic estimates. As expected, the synthetic estimates based on gender, two race groups, and three age groups were closer to the state rates and had narrower ranges compared to both crude and age-adjusted rates for the 12 health indicators across the ten counties and three regions. Synthetic estimates rarely fell outside the state confidence intervals for either the crude or age-adjusted rates. For example, only one area estimate (out of 13) for current smoking, obesity, and no leisure-time physical activity was outside the state confidence intervals. For current asthma and binge-drinking, all synthetic rates were within the state confidence intervals for both crude and age-adjusted rates.

The synthetic estimates differed substantially from both the crude and age-adjusted rates in Table 2. The health indicators that had the largest differences between synthetic estimates and crude or age-adjusted direct estimates were those with the most variation across the ten counties and three regions: no dental health insurance, cost being barrier to health care access, no health insurance coverage, current smoking, and doctor-diagnosed arthritis.

A comparison of the synthetic estimates with the crude and age-adjusted rates for each county and region revealed that the synthetic estimates were over-estimates in counties with direct survey estimates that were significantly lower than the state rate, and were under-estimates in counties with direct survey estimates that were significantly higher than the state rate. For example, Mecklenburg County had a very low prevalence of no health insurance, based on both the crude and age-adjusted rates; however, the synthetic estimate for Mecklenburg County was approximately twice as high as the crude and age-adjusted rates for no health insurance. In contrast, many of the synthetic estimates for the Eastern region were much lower than the direct survey estimates and were nearly always within the confidence intervals of the crude and age-adjusted rates for the state.

Discussion

The first objective was to compare crude and age-adjusted rates for 12 important health indicators among ten counties and three regions in North Carolina based on the 2001 BRFSS survey results. These comparisons revealed that the health indicators varied significantly across North Carolina. A county should use crude rates for their own public health planning purposes. However, if the interest is to compare the counties and regions on the relative level of health risks, then it is

better to use the age-adjusted rates. Our results suggest that age-adjustment produces the largest differences from the crude rates for two chronic conditions, arthritis and disability; has only a marginal effect on the rates for high risk behaviors; and has little effect on the rates for health care access.

This study shows that health care access indicators varied significantly across North Carolina counties and regions. An underlying factor contributing to the geographical health disparities in North Carolina seems to be access to health care, which is in turn highly associated with economic conditions. The most impoverished area, Eastern North Carolina, clearly had the worst health outcomes on most of the 12 indicators. In contrast, the four wealthiest counties had consistently better health outcomes than both the Eastern region and the state as a whole.

Our study provides strong evidence for the importance of direct local-level sampling to detect sub-state geographical variation in health indicators. The use of synthetic estimates does not capture the variation across counties in health risks and behaviors. In fact, using synthetic estimates can clearly be misleading. Our results show that the synthetic estimates were generally over-estimates in counties where rates were significantly lower than the state rate and under-estimates in counties where rates were significantly higher than the state rate. However, more complex statistical modeling procedures may have the potential to produce better sub-state estimates, reducing the need for extensive local-level sampling.

Our study also provides evidence for the importance of ensuring an adequate sample size for detecting significant variation for health indicators with low prevalence rates. The prevalence estimates for diabetes and asthma were the lowest among the 12 indicators in our study, and we found very few significant differences across the ten counties and three regions, likely due to lack of power. With a sample size of 400, we expect the 95% confidence interval to be within plus or minus 5% for indicators with a prevalence of 50% (a relative error of 10%). For health indicators with low prevalence rates such as diabetes and current asthma (around 6%), a sample size of 400 would result in a confidence interval plus or minus 2.3% (a relative error of 38%!), indicating the need for a further increase in sample size.

There are several limitations to the data presented here. The BRFSS survey does not cover persons who live in households without a telephone and does not cover persons who live in institutions. Also, in a phone survey all data are self-reported and thus subject to biases due to recall and social acceptability of responses. Finally, the 2001 North Carolina BRFSS survey was conducted in English only, thus excluding Spanish-speaking Hispanics and others who do not speak English.

Public health implications from the observed large county variations in health indicators are: 1) where possible, counties should use county-level baseline data to monitor health behaviors and track progress toward their objectives, such as Healthy People 2010; and 2) state programs should be aware of these large geographical differences in health indicators when making decisions, planning programs, and allocating resources. We recommend that those counties that were not sampled separately in the BRFSS use the data from their own region (Western, Piedmont, Eastern) for planning and tracking purposes.

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