Using Cartograms to Illustrate Disparities in Oral Health in Kentucky

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Introduction

Oral health problems in Appalachia are considered severe, with Kentuckians having some of the worst oral health outcome indicators in the nation across all age groups. Kentucky ranks second in the number of completely edentulous older adults, third in adults with any permanent teeth extracted, and sixth in the prevalence of individuals not visiting a dentist or dental clinic within the past year for any reason (1). Though Kentucky has a high rate of water fluoridation (2), teeth cleanings and dental sealants comparable to the nation's, it still has a higher rate of caries experience and untreated caries among children. Parents in rural Kentucky report that their children are less likely to have teeth in excellent condition and to have dental insurance than their urban counterparts. These indicators point to a spatially-based disparity between rural and Appalachian Kentucky and the rest of Kentucky. Unfortunately, tabular presentations (alone) of oral health data to policymakers can fail to convey both the relative magnitude and location of disparities. To clearly illustrate these geographic differences in oral health outcomes, we propose the use of a cartographic construction technique called the contiguous bivariate areal cartogram.

We believe that these cartograms provide an immediate visual impact and ease of assessment of spatially-based disparities, and are capable of being readily interpreted by policymakers. The objective of this paper is to illustrate this using data on oral health disparities in Kentucky.

Methods

We created cartograms using ArcGIS v9.2 (ESRI, Redlands, CA) that visualize 2006 population estimates, dental manpower (2007), and an oral health outcome across Kentucky by counties. We calculated dental manpower by county, defined as dentists per 10,000 population, by geocoding the physical addresses of dentists in Kentucky and calculating the rate via a point-in-polygon count divided by the respective county population. County areas were then transformed to adjust for population and dental manpower using the Gastner-Newman diffusion algorithm along with a shaded depiction (choropleth) of an oral health outcome: in our case, the percentage of adults 18 or older with six or more permanent teeth removed because of tooth decay or gum disease. This health outcome was collected from the 2007 Kentucky Institute of Medicine Report which compiled data from the Kentucky Behavioral Risk Factor Surveillance System over four years (1997, 1999, 2002, & 2004).
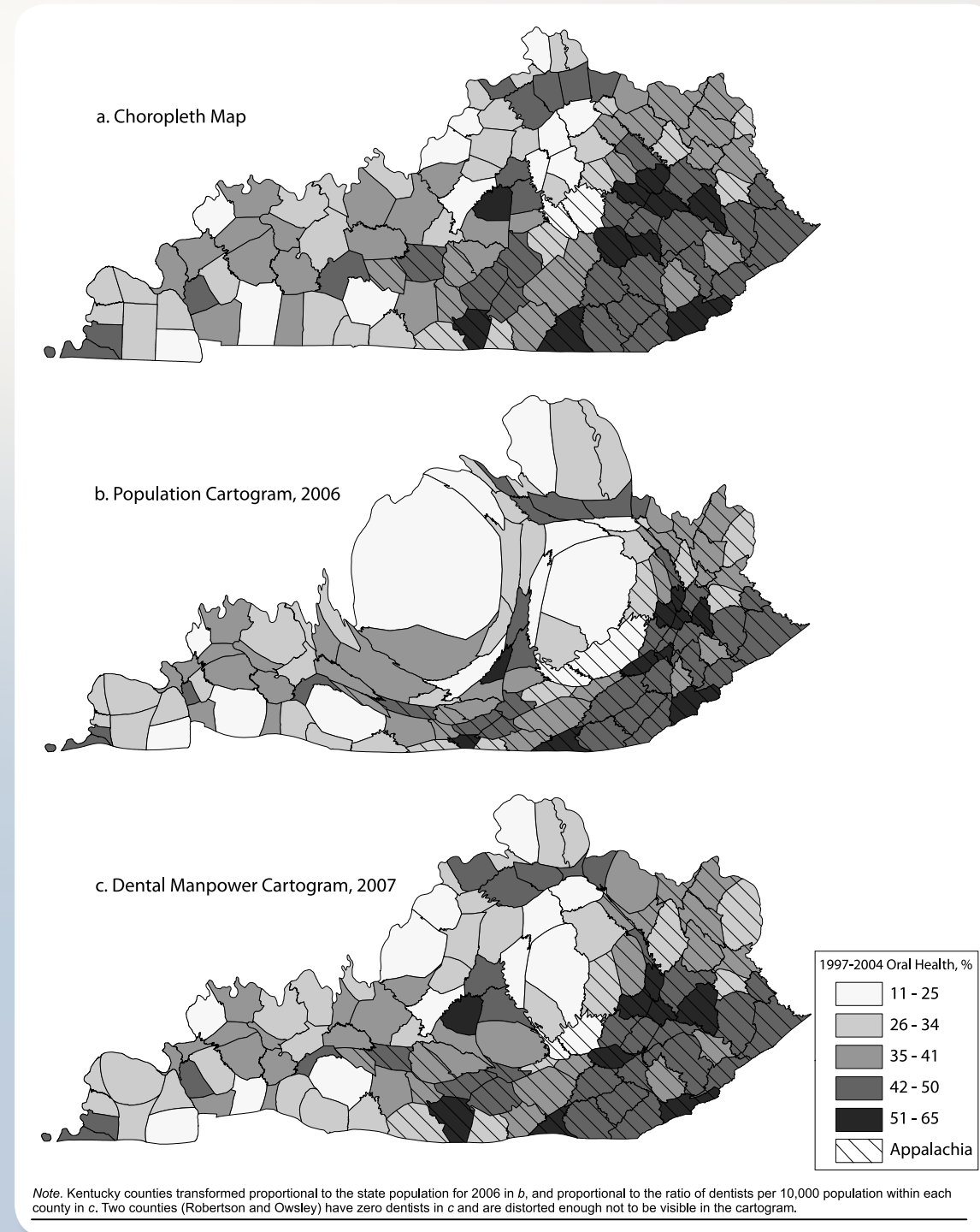
Results

Trends in the created cartograms lead us to conclude that counties with lower populations (i.e., typically Appalachian and more rural counties) tend to have worse oral health as measured by our oral health outcome. Figure 1a shows an untransformed typical choropleth map of Kentucky. Figure 1b depicts counties with the highest populations as also having the largest areas. Figure 1c shows a similar trend as Figure 1b in that counties with the largest areas—i.e., higher ratios of dentists per 10,000 population—also have the lowest percentage of adults with 6 or more removed teeth.

Figure 1 points to an area density distortion favoring counties (i.e., a lower percentage of adults with 6 or more teeth removed) with denser populations and higher ratios of dentists per 10,000 population.

Table 1 enumerates on the results in Figure 1 with mean population and dentists per 10,000 population in Appalachia lower than in non-Appalachia and the state and the percentage of adults with 6 or more teeth removed higher in Appalachia than non-Appalachia and the state.

Table 2 shows that both panels b & c in Figure 1 have higher square areas in the first two classes (11-25% & 26-34%) than panel a and lower square areas in the bottom three classes (35-41%, 42-50%, & 51-65%) than panel a.

Figure 1: Percentag of Adults 18 or Over with Six or More Permanent Teeth Removed Because of Tooth Decay or Gum Disease in Kentucky

a. Choropleth Map

b. Population Cartogram, 2006

c. Dental Manpower Cartogram, 2007

1997-2004 Oral Health, %
11 - 25
26 - 34
35 - 41
42 - 50
51 - 65
Appalachia

Note. Kentucky counties transformed proportional to the state population for 2006 in b, and proportional to the ratio of dentists per 10,000 population within each county in c. Two counties (Robertson and Owsley) have zero dentists in c and are distorted enough not to be visible in the cartogram.

Table 1: Sample Descriptives of Transformation Variables: Kentucky

Variables	Regions		
	Appalachia	Non-Appalachia	State
Mean Population	22,080	45,837	35,146
Mean Dentists per 10,000 Population	3.77	6.42	5.67
Mean Percentage of Adults 18 or older with six or more permanent teeth removed because of tooth decay or gum disease	42.2%	33.2%	37.3%

Table 2: Total Square Area Comparison of the 3 Map Projections among the Five Oral Health Classes

Oral Health Classes	Counties	Total Area of Counties in Square Miles (%)		
		a State	b Population Cartogram	c Dentist:Population
11-25%	14 (12)	5069 (13)	13590 (34)	7165 (18)
26-34%	32 (27)	9064 (22)	9637 (24)	11332 (28)
35-41%	34 (28)	13033 (32)	9095 (23)	10561 (26)
42-50%	30 (25)	10265 (25)	6562 (16)	8985 (22)
51-65%	10 (8)	2974 (7)	1371 (3)	2347 (6)
Total	120 (100)	40405 (100)	40255 (100)	40390 (100)

Note. Oral Health= percentage of adults 18 or older with six or more permanent teeth removed because of tooth decay or gum disease. Percentages do not add up to 100% because of rounding.

Discussion

The depiction of a distorted Kentucky via cartograms offers more of a truthful and intelligible visualization of the state by oral health than regular choropleth maps and tabular presentations and allows policy makers to better understand the spatial component of oral health disparities within the state.

This study provides policy makers with easy-to-follow maps and table and shows evidence of spatially-based oral health disparities and a dental workforce misdistribution (Figure 1c). Mapping health care providers using a GIS has been shown to be a useful tool for assessing provider distribution and availability, and developing programs to attract dentists to underserved areas.

Some limitations of our study include artificially abrupt changes in oral health from county boundary to boundary and the use of county-level choropleth thematic mapping that depicts a synthetic uniformity (ecological fallacy) of the oral health outcome across counties. In addition, the oral health outcome is limited to adults 18 or older with six or more permanent teeth removed because of tooth decay or gum disease. While necessary, this outcome is not sufficient in providing an exhaustive understanding of oral health disparities in Kentucky.

References

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