# Assessing Community Health Status: Establishing Geographic Areas for Small Area Analysis in Utah

by
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### *Abstract*

*This article describes the process used to establish geographic areas in Utah for purposes of analyzing health status information at the community level. The process, commonly referred to as small area analysis, has a long history in public health. Producing public health information for "small areas" in Utah provides community planners and others with information that is specific to the population living in that community. Small area analysis also allows an investigator to explore ecologic relationships between health status, lifestyles, the environment and the health system.*

*ZIP codes were used individually or combined to create 61 geographic areas with an average 1997 population size of 33,500 persons (range 15,000 to 62,500). Criteria for combining areas included population size, local health district and county boundaries, similarity of ZIP code area income levels, and community political boundaries. Input from local community representatives was used to refine area designations. Information on motor vehicle deaths, prenatal care, health insurance, and cigarette smoking are presented by small area. Many issues are discussed, including the availability and accuracy of data for small areas, methods for analysis of small area data, geocoding health information, and the strengths and limitations of small area analysis.*

## Introduction

Small area analysis has a long history in public health. The first well-documented use of the methodology was by Glover (1938, as cited in Goodman & Green, 1996), who found substantial variation in the rates of tonsillectomy among different school districts in England. Glover demonstrated that the rates were not associated with incidence of disease, poverty, or medical services, and suggested that differences in the medical practice preferences of the attending physicians were largely responsible for the variation in rates. More recently, several authors (Paul-Shaheen, Clark, & Williams, 1987; Wennberg, 1987; Wennberg & Gittelsohn, 1973; Wilson & Tedeschi, 1984) have used small area analysis to characterize health care services within specific geographic areas, and to explore the effects of supply factors versus population need on the distribution of health services. For instance, Wennberg (1987) reported that hospitalization rates were more clearly related to the supply of hospital beds than to the morbidity of the population, especially for medical conditions where hospitalization was not standard practice. Small area analysis has also been used to demonstrate that the socio-economic status of residential areas was associated with mortality (Waitzman & Smith, 1998; Gould, Davey and LeRoy, 1989) and with primary cesarean section rates (Gould, Davey & Stafford, 1989). Other applications of small area analysis in public health have included the examination of patterns of disease in relation to environmental conditions (Lang & Polansky, 1994), the production of synthetic estimates of disease or risk factor prevalence (Lafata, Koch & Weissert, 1994; Spasoff, Strike, Nair et al., 1996), and identification of areas with excess morbidity or mortality in order to target preventive or curative services at population groups with special needs (Andrews, Kerner, Zauber et al., 1994; Kleinman, 1977).

Public health, as is true of public policy in general, has increasingly emphasized local, or community health, assessment and planning (American Public Health Association, 1991; APEXPH Steering Committee, 1991). Those efforts are often inhibited by a paucity of relevant and meaningful information about the current status and needs of local populations. Although the information needs of community planners cannot all be met by the results of small area analysis, understanding community health status can only improve community public health planning.

Information from different datasets can be combined using small area analysis so that previously unexplored relationships can be examined. Although this is sometimes possible with individual-level data, matching individuals across datasets is typically not possible because the same individuals are seldom represented in multiple datasets. Matching small areas across datasets, on the other hand, is often easily accomplished. For instance, economic data from the U.S. Census can be combined with vital statistics data, such as infant mortality; disease data can be compared to information on environmental exposures; survey data on risk factors can be compared to information on hospitalizations, and so forth.

In this paper, methods to specify small areas in Utah are described and discussed. The small areas that are specified by these methods are then used to examine health status in Utah. Four health measures were selected as examples because they represented variables from a variety of data sources that yielded geographic differences: Motor vehicle crash death rates, percentages of persons without health insurance, percentages of women giving birth who did not have early prenatal care, and percentages of adults who smoked cigarettes. Several issues surrounding the design and use of small areas are also discussed.

## Methods

A variety of methods exist for aggregating persons into discrete geographic units below the state level. Public administrators often use counties, or groups of counties such as local health districts. Although county-level data are often available, such analyses do not provide sufficient geographic detail in urban counties with large population sizes. Perhaps the smallest widely-used geographic units are the U.S. Bureau of the Census' block groups, areas of only a few blocks used by the Census Bureau to enumerate the population. Census block groups are aggregated into census tracts which are designed to contain relatively homogenous populations of similar sizes. Neither block groups nor census tracts can be used in Utah because health data such as vital records, hospital data, and health surveys are not identified by census block group or tract. ZIP code areas were used to define small areas in the current study because they are the smallest commonly-used geographic units that are also identified in most health data sources. ZIP code areas are discrete geographic areas used by the U.S. Postal Service in mail delivery that often roughly follow political boundaries. In some sparsely populated areas, counties were used as the geographic unit of interest.

Population size criteria for designing the small areas in this study were determined based on health event incidence rates. Smaller areas may be more meaningful to communities, but rates based on small numerators are unstable (Buescher, 1997) and confidence intervals for such rates are large, rendering the comparisons uninterpretable for most practical purposes. Using such small areas with small numbers of events may also pose privacy problems for more sensitive events, such as suicide or AIDS. The population size criteria were determined by examining the three- and five-year incidences of selected events, such as infant mortality and lung cancer, for which small area estimates were desired. A numerator of 20 or greater produces relatively stable estimates, and also approximates a normal distribution of the Poisson parameter ($\mu$), which simplifies computation of confidence intervals (Ahlbom, 1993). It was determined that areas with 40,000 to 60,000 persons would produce incidence counts of 20 or more for a wide range of health events. Increasing the population sizes sufficiently to produce reliable estimates for rare events (e.g., homicide or AIDS) would increase area size beyond that which would allow meaningful community level analyses. Where possible, areas with 40,000 to 60,000 persons were established, but areas with population sizes of approximately 20,000 were created when low population density, community identity, or others factors suggested that it was appropriate. ZIP codes and counties were used individually or combined to create 61 geographic areas.

Because the local health district is the primary seat of community public health decision-making in Utah, areas were geographically constrained so that their boundaries would not cross local health district boundaries. Most multi-county Utah health districts contain more than one small area. In all but two cases, only contiguous ZIP codes were combined. With only one exception, sub-county small areas were wholly contained within individual counties and were not combined with ZIP code areas in neighboring counties. Whenever possible, the areas were designed to conform to established political boundaries of cities and towns. We examined the median per capita annual income levels of each ZIP code area to guard against combining ZIP code areas with extremely divergent socio-economic status. After addressing the criteria listed above, there still remained areas whose boundaries had not been set. For those areas (primarily the urban counties that were subdivided into many small areas), ZIP codes were combined based on the authors' and their colleagues' perceptions of the similarity of the populations. The resulting draft small area design was then submitted to local representatives, primarily in areas where subjective criteria had been used to combine ZIP code areas. The local representatives (10 of the 12 Utah local health officers, and 26 city officials selected from the directory of the Utah League of Cities and Towns) were provided a map of their locality showing the proposed small area boundaries and asked to consider whether the combined ZIP code areas were similar in terms of lifestyle and demographic characteristics. Several changes were made based on their recommendations.

Data on population size, median age, and median income were purchased for current Utah ZIP codes from a commercial vendor, CACI Marketing Systems. CACI constructed population estimates at the ZIP code level by using the most recent decennial census data and additional information, such as sub-county estimates of change from the U.S. Census Bureau, special censuses, local sources of information about change, and changes in residential delivery statistics from the U.S. Postal Service. Estimates included 1997 population totals and population by sex and age group for each ZIP code, allowing for age standardization. The CACI file also included estimates for the average annual rate of population change for each ZIP code area, which allowed for the derivation of 1994 through 1996 population estimates required for the analyses.

The 61 small areas were used to examine several health measures. Four health measures were selected because they represented variables from a variety of health data sources that yielded geographic differences: motor vehicle death rates, percentages of mothers giving birth who had no prenatal care in the first trimester, percentages of persons who were without health insurance, and percentages of persons who smoked cigarettes.

When comparing across geographic areas, some method of age-adjusting is typically used to control for area-to-area differences in health events that can be explained by differing ages of the area populations. For example, an area that has an older population will have higher crude (not age-adjusted) rates for cancer, even though its exposure levels and cancer rates for specific age groups are the same as those of other areas. One might incorrectly attribute the high cancer rates to some characteristic of the area other than age. Age-adjusted rates control for age effects, allowing better comparability of rates across areas. Direct standardization adjusts the age-specific rates observed in the small area to the age distribution of a standard population (Lilienfeld & Stolley, 1994). This method can present problems when age-group-specific rates for small areas are unstable. In such cases, indirect standardization of rates may be used. Indirect standardization adjusts the overall standard population rate to the age distribution of the small area (Lilienfeld & Stolley, 1994). It is technically appropriate to compare indirectly standardized rates only with the rate in the standard population, not with each other. In some cases, the investigator will not want to age-adjust. For instance, he or she may be interested in the actual cancer rates in an area for the purposes of targeting a screening program. Age-adjusting is not necessary when only age-specific rates are used, or when the population of study has a narrow age range. For purposes of comparing overall rates of disease across areas, age-adjusting was performed for three of the four variables in this study. Age-adjusting procedures are indicated below for each of the four variables.

Motor vehicle crash deaths information was derived from a computer file of all deaths in Utah from 1980 to 1996, obtained from the Utah Department of Health Bureau of Vital Records, which excluded information that would identify individuals. Cases consisted of deaths of Utah residents occurring in the five year period from 1992 through 1996 in which motor vehicle crash was recorded on the death certificate as the underlying cause of death (International Classification of Diseases, Version 9, codes E810 to E825), and were assigned to an area according to the residence of the decedent. The motor vehicle death data were age-adjusted because factors other than age were of primary interest. The indirect method of age-adjustment was used because there were small numbers of deaths in individual age strata. Confidence intervals were calculated using a method recommended for indirectly standardized rates (Kahn & Sempos, 1989). For the motor vehicle data, 90% confidence intervals were used.

The information on prenatal care was derived from a computer file of all births in Utah from 1980 to 1996 obtained from the Utah Department of Health Bureau of Vital Records, which excluded information that would identify individuals. Information regarding the month of pregnancy that prenatal care began originated from either a medical record or a parent's self-report, and is recorded on the birth certificate at the time of the infant's birth. Cases consisted of mothers giving live birth during the three year period from 1994 through 1996, and were assigned to the area of residence of the mother. Prenatal care data were not age-adjusted because the population has a relatively narrow age range and because information on prenatal care is traditionally used to target interventions, rather than to explain between-area differences. The 95% confidence intervals for these data were calculated using a method suggested by Fleiss (1981) for proportions that are close to zero or one (less than or equal to 0.3 or greater than 0.7).

Health insurance coverage and cigarette smoking data came from the 1996 Utah Health Status Survey (Bureau of Surveillance and Analysis, 1998). Health insurance was defined as "... private and employer plans, prepaid plans such as HMOs, and government plans, such as Medicare." A randomly-selected adult respondent reported information on each household member , including health insurance coverage, cigarette smoking, and ZIP code of residence. The data were age-adjusted because factors related to health insurance and smoking other than age were of primary interest. Age-adjustment and calculation of 95% confidence intervals were accomplished using SUDAAN (Shah, Barnwell & Bieler, 1997), which takes into account the design effects inherent in complex survey data (Lee, Forthoger & Lorimor, 1989).

The data were then mapped using various geographic perspectives (mapping the entire state versus a close-up of a particular area) and mapping strategies (mapping rate categories of the measure, versus mapping whether a rate was significantly different from that for Utah overall). Due to space limitations, only one view was included here for each variable.

## Results

Sixty-one small areas with an average 1997 population size of 33,500 persons (range 15,000 to 62,500 persons) were identified in Utah (see Table 1). Seventeen areas had population sizes of 40,000 or more, while in 38 areas the population sizes ranged between 20,000 to 40,000 persons. Due to local health district boundaries or input from local area residents population sizes were close to, but under 20,000 for six areas. Areas varied widely in surface area, with the smallest area consisting of a few square miles in an urban county, and the largest area encompassing four large frontier counties. In four cases, a small area encompassed an entire local health district. The largest urban health district, Salt Lake City/County Health District, included 23 small areas. A complete list of area definitions (ZIP codes and county combinations that were used to create each area) may be found in Table 2.

### *Motor Vehicle Deaths*

During the five-year period from 1992 through 1996, the average annual motor vehicle death rate for Utah was 15.8 deaths per 100,000 persons. Rates in the small areas in Utah ranged from 3.9 deaths per 100,000 persons in the Foothill/U of U area (#19) to 49.3 in Grand/San Juan County (#57). The rates were mapped according to whether each was significantly different from (higher than, same as, or lower than) the overall state rate, based on whether its confidence interval included the overall Utah rate.

The geographic pattern of results (Figure 1) indicated that motor vehicle death rates were higher for residents of more sparsely-populated areas. One might expect to find that pattern if residents of rural areas tend to drive longer distances at higher speeds in their day-to-day lives, but other explanations are possible. Note that five small areas (#1, 2, 18, 21, & 41) that had relatively small population sizes (Table 1) had death rates over 20 per 100,000, but were not considered "different" from the state rate because the confidence intervals for those rates were so large that they included the state rate.

### *Prenatal Care*

Of all Utah mothers of live-born infants during the five year period from 1992 through 1996, 15.4% had not received prenatal care in the first trimester of pregnancy. The rates in small areas ranged from 8% in Farmington/Centerville (#14) to 35.7% in Glendale (#21) (Figure 2). To demonstrate a different approach to mapping health information, the prenatal care rates for small areas were ranked and assigned to five categories (quintiles). Of the 13 areas in the highest rate quintile (percentages of 19.4% or greater), six were in Salt Lake County. In five areas, over 25% of women had not received first trimester care; these included Downtown Ogden (#7), Rose Park (#17), Glendale (#21), South Salt Lake (#25), and Grand/San Juan County (#57). A scatter showing prenatal care rates and median per capita annual income of the 61 Utah small areas suggested that women were less likely to receive early prenatal care in areas with lower income levels (Pearsons's $\underline{r} = -.31$, $\underline{p} \leq .05$) (Figure 3).

### *Health Insurance*

At the time of the 1996 Utah Health Status Survey, 9.5% of Utahns were without health insurance. The small area with the highest percentage of uninsured persons, 24.3%, was Other Southwest District (#61). The lowest rate, 0%, was in the Avenues district in Salt Lake County (# 18) (Figure 4). That estimate is certain to be an artifact of the small Health Status Survey sample size in the Avenues area (n=77); the confidence interval in this case ranges from 0% to about 4%. The geographic pattern of results was striking, with primarily frontier areas in the central and southern portions of the state having the highest percentages of uninsured persons, and urban and northern areas having the lowest percentages. Over 90% of Utah households obtained insurance coverage through an employer or union (Bureau of Surveillance and Analysis) suggesting that differences in the types of jobs and industries predominant in a given area may be an important cause of the observed pattern.

### *Cigarette Smoking*

The overall adult cigarette smoking rate reported by the 1996 Utah Health Status Survey was 12.3%. Smoking rates ranged from 0.1% in South Jordan (#35) to 34.8% in Magna (#20) (Figure 5). The association in the 1996 Utah Health Status Survey data between smoking rates and LDS religion among the 61 small areas in Utah $\underline{r} = -.61$, $\underline{p} \leq .001$) suggests that smoking behavior is strongly influenced by the LDS religion in Utah. However, membership in the LDS religion accounts for only 36% of the variance in cigarette smoking in Utah, suggesting that other correlates of cigarette smoking, such as education level or local cultural factors, are also important.

## Discussion

The four health measures described in this paper offer examples of how small area analysis can be a useful tool for examining, describing, and exploring relationships among health variables in small areas. Three issues that warrant further discussion are 1) the method used to specify small area boundaries, 2) the use and interpretation of statistical techniques, and 3) the process of mapping itself.

### *Difficulties with Designating Small Area Boundaries*

Using Existing Administrative Boundaries. One of the ongoing challenges to meaningful mapping of health information is that administrative boundaries designed for a particular purpose do not typically match boundaries that would be ideal for planning purposes (Kirby, 1996). Ideally, other boundaries should have been incorporated into this small area design, such as city boundaries, school district boundaries, and boundaries that signify neighborhood identities. Because ZIP code areas are arbitrary areas designed for the convenience of postal carriers, they often do not correspond to other, more meaningful boundaries, such as those of cities or towns, school districts, or political voting districts. They may also be heterogeneous with respect to relevant characteristics, such as socio-economic status. However, ZIP codes are found on most public health data records (e.g., birth, death, hospital discharge, etc.), they are routinely gathered or can easily be incorporated in survey and other data collection efforts, and population denominators and other demographic characteristics are often available for ZIP code areas.

Regardless of how well small area boundaries match relevant community boundaries, they may not match boundaries of a particular health event. In such cases, the zone where the event (e.g., a disease or exposure) occurred will be divided between two or more small areas, diluting the observed rates and perhaps resulting in the pattern being missed altogether. However, there is a scientific argument for deriving a priori the small area boundaries independent of the geographic patterns of health events.

Stability of Administrative Boundaries. An investigator who uses them does so with the understanding that they may change at any time, without regard for the investigator's needs. Areas such as U.S. Census Bureau block groups and ZIP code areas are subdivided as the populations within them increase. Although it is possible for an investigator to stay current with prospective changes to administrative boundaries, particular problems are encountered in retrospective application of a small area design. Small area boundaries may align with ZIP codes in the present, but a given ZIP code essentially either grows bigger or disappears as one goes back in time. An investigator must decide how methodologically to deal with ZIP code areas whose former boundaries spanned more than one current small area.

Availability of Data for Administrative Areas. Area boundaries must also take into account the availability of data, such as population estimates. Valid population estimates are needed to calculate disease and mortality rates, and are not always easily obtained.

Establishing Area Size. For some health measures, such as prenatal care, where rates are based on the almost 40,000 births each year in Utah, rates were precise enough that the areas could have been subdivided further into more geographic detail. That would satisfy the needs of those for whom areas, such as the large, multi-county areas, cover too much territory to provide meaningful local information. For other measures based on relatively rare events, such as lung cancer deaths, the small areas defined here were already too small, yielding imprecise estimates (that is, with large confidence intervals) and few statistically significant differences across areas. It would be possible to aggregate areas for rarer events and subdivide them for more common events. That approach might solve some of the inflexibility imposed by a "one-size-fits-all" solution, but would add complexity both to analysis and to interpretation of results presented in variable ways.

Standardization of Small Area Definitions. Although flexibility is desirable, standardization also has clear and important benefits. By using standard definitions for area boundaries across the various applications of small area analysis in the state, information on the small areas may be accumulated in a repository, data from different data sets and from published accounts may be integrated, and comparisons may be made that were previously not possible or feasible. The area boundaries that were designated in this study used rather general criteria such as population size, income level, and community identity. This was done with the assumption that other investigators would want to take advantage of the groundwork that has been laid here.

*Statistical Techniques*

Although the use of formal applications of statistical tests for hypothesis testing may often be unnecessary, most agree that there must be some empirical method for identifying rates that are either higher or lower than usual (Diehr, Cain, & Abdul-Salam, 1993; Diehr, Cain, & Connell, 1990; Thompson, 1998). How different must a rate be before it becomes a cause for concern or action? Rates calculated from few events or in a small population can be unreliable in the sense that a few events can create a large deviation on a trend line. Statistical tests are one method of using an independent criterion to develop professional agreement on differences that are likely to be real, versus those that may be due to sampling error. Two statistical approaches for detecting significant differences among small areas are discussed here: Confidence intervals and Bayesian smoothing techniques. Ecological fallacy and synthetic estimation are also briefly described.

Confidence Intervals. Confidence intervals are calculated to describe the precision of an estimate, that is, a range within which the true value of the measure (e.g., a rate, percentage, average, etc.) is expected to occur, taking into account the variance of the measure, the sample-size, and the sampling method that was used to generate the estimate when sampling from a population [1]. In general, small areas yield rates with poor precision, that is, wide confidence intervals, whereas large areas yield rates with better precision. While their primary purpose is to provide information on the precision of an estimate, they can be useful in separating out true differences from sampling variation. An area may be judged as "not different" from a base rate whose estimate falls in the range of values defined by the confidence interval.

One limitation with using confidence intervals to identify whether an area is significantly different from an overall state rate is the lack of independence of the area and state rates. The state includes the small area, and it is not technically appropriate to compare one area with the one that encompasses it because the two are not independent samples (Colton, 1974). Another issue is that the state rate also has a confidence interval that should be taken into consideration.

Issues around the use of multiple comparisons should also be considered. A 95% confidence interval describes the range for a true value in 95% of a large number of hypothetical samples. This means that the confidence interval will not include the true value 5% of the time. If one measures rates and calculates confidence intervals for some time period in 50 small areas, none of which are truly different from the state rate, a small number will appear different by chance alone. There is currently some debate about the need to adjust for multiple comparisons (Goodman, 1998; Rothman, 1990; Savitz & Olshan, 1998; Thompson, $1998_1$, $1998_2$).

Despite their limitations, confidence internals are relatively easy to compute, and can serve as reasonably good guides for comparing small area estimates. They are thus helpful in determining if differences are important enough to warrant attention or are likely to be chance aberrations. For information on calculating confidence intervals for various types of data, consult Colton (1974) or Levy and Lemeshow (1991).

Bayesian Smoothing Techniques. A problem with most analyses of small areas is the instability of estimates from small samples. Estimates for small samples can be stabilized using empirical Bayes (EB) statistical estimation procedures (Devine, Annest, & Kirk, et al.). An EB method developed by Manton et al. (1989, as cited in Devine, Annest, & Kirk, et al.) develops a stabilized age-specific rate for each area that is a weighted average of two components: the age-specific rate observed in the area, and the age-specific rate estimated for that area on the basis of the observed rates of all areas ("prior probabilities"). In areas with large populations, the stabilized EB rate gives more weight to the observed rate for that area. For areas with smaller population sizes, the weight on the observed rate tends to decrease, and the modified EB rate moves closer to the rate estimated from the other areas, thus smoothing, but not flattening, the dramatic peaks and valleys that are evident on trend lines for small areas.

Bayesian smoothing, itself, does not identify statistically significant differences in the data. In fact, the Bayes-adjusted data tend to underestimate the true variance that is found in the observed population rates (Martuzzi and Elliott, 1996). Specialized methods are required for calculation of confidence or "credibility" intervals and other statistics on EB stabilized data (Greenland & Robins, 1991). Although the result of this method, "smoothing" of improbable extreme values, is appealing, the method itself requires more statistical expertise than the methods previously discussed, and may not be practical for those desiring a quick solution.

Ecological Fallacy. A well-documented problem with the interpretation of data from small area analyses, commonly referred to as "ecological fallacy", is that of using aggregate (i.e., small area) data to represent associations at an individual level (International Epidemiological Association, 1995). Associations found between variables at the small area level will sometimes disappear or even reverse when recomputed with data at the individual level. In addition, associations may change depending on the spatial boundaries used. Statistical techniques have been developed to attempt to adjust for the bias resulting from the ecological fallacy problem, allowing inferences to be made about individual associations (King, 1998). As with other types of data, care must be taken when interpreting associations to avoid making inappropriate inferences.

Synthetic Estimation. Another analytic technique that is relevant to the analysis of small area information is synthetic estimation, used to estimate the value of some rate or measure in a small area where it has not been directly measured. In synthetic estimation, the observed relationships between predictor variables, typically demographic characteristics such as age, sex, race, and an outcome variable in a standard population, such as a state or U.S. population, are applied to known demographic characteristics in the small area to produce an estimate of the outcome variable in the small area (Lafata, Koch and Wiessert, 1994). Synthetic estimates can be useful for small area planning in the absence of direct local estimates; however, one must be willing to accept the untestable assumption that the relationships between predictor and outcome variables found in the standard population will hold true in the small area. Even if the relationships between variables generalize to other populations, synthetic estimation can only account for whatever variation in health variables is attributable to variation in the sociodemographic variables used in the analysis (Spasoff et al., 1996).

### *Mapping*

Deciding Which Characteristics to Map. A decision must be made regarding which aspect of the health event to display spatially: the place of residence of the individual, the place of the incident, the place of the exposure, or the place where the health service was rendered. Although this is an important consideration from the standpoint of the research question, it is often a moot point because data are usually only available according to one of the above schemes. However, persons who are creating new data reporting systems, or making refinements to existing systems should consider geocoding the data in more than one way to allow for more flexibility in the use of the data.

Deciding How to Display the Information. Maps can be a powerful communication tool, communicating the size and shape of an area, its location and neighbors on a single page. Several issues confront the investigator in this process. Information may be presented by shading blocks of areas (chloropleth map), such as a map of the U.S. with states in varying shades of some hue or density of gray to signify differences on some variable. Information may also be presented by plotting points (isopleth map), for instance, plotting each individual case of a communicable disease according to the residence of each victim (Kirby, 1996). If blocks are to be used, will the shading variations of the blocks represent ranges of values assumed by the variable of interest, ranges of percentiles on the variable of interest, or the results of some test for statistically significant differences? If points are used, how will overlapping points be represented? Should the maps be printed in color? The inclusion of physical features, such as highway systems, bodies of water, or other landscape features can serve as landmarks to orient the viewer. In addition to orienting the viewer, roads communicate population density. These are just a few examples of display decisions involved in mapping. For a more detailed discussion of the presentation of maps, refer to Tufte (1983, 1990), and Steinberg (1995).

## Conclusions

Small area analysis has many applications to public health. It can be used to express variation in health services utilization, to identify populations most at need as an aid in targeting health promotions and interventions, and to examine health events and health status in small areas to identify problems. Potential determinants of community health status may be suggested by comparing health status and health events to demographic, environmental and health system attributes.

One limitation that can be dealt with but never solved is that small areas are, by definition, small, yielding small population sizes and small numbers of health events. This causes problems for statisticians and decision-makers alike because small numbers produce unstable estimates, which are a poor basis for decisions. However, appropriate statistical methods can help deal with the issue of small numbers. A limitation that is not in the investigator’s control is the accuracy of existing data. Small area analysis relies on the accuracy of event and population data. Even U.S. Census Bureau population estimates, commonly assumed by many to be “truth,” have error margins and under enumerate certain populations (U.S. Bureau of the Census, 1995), which can be problematic when estimates are applied to small areas. Accuracy issues also apply to vital records, hospital, and survey data.

Another complication arising from the size of the populations in small areas is that of individual privacy. Providing information about the health of a black, 24-year-old female who lives somewhere in the U.S. is not intrusive on that individual’s privacy, whereas providing that same information on the same person is definitely an intrusion on her privacy if it is disclosed that she lives in Snowville, UT. Whenever the possibility exists of identifying an individual, important ethical concerns about the potential public costs and benefits of storing, using, and reporting information must be addressed.

Use of ZIP codes or other area blocks to geocode population sizes and health events is an imperfect approach. ZIP code areas are not based on geographic homogeneity. Using a ZIP code characteristic, such as income, as a proxy for a person's household income introduces misclassification bias, leading to underestimates of statistical relationships (Gould, Davey & LeRoy, 1989). Identifying the exact geographic coordinates of persons and health events would be superior, but this information can be difficult to obtain. Cross references that code street names and addresses into Cartesian coordinates exist, but in growing areas, they quickly become out-of-date. Using these systems also requires that the address data be rigidly standardized, so that "300 South Street" is always written exactly the same way, and not as "3rd So." or any number of other variants. Small area analysis would benefit not only from better geocoding, but also from adopting standard forms for the geocoding of information. These standards would need to be applied not only to health data, but also to demographic, survey, and other data that could be examined with small area analysis.

The demand for information at the community level is great and will probably continue to be so. Public health planning at the community level would benefit greatly from having more proximal and detailed information about the health of their communities. In addition, as we accumulate information on small areas, we can examine community health status trends over time. Although there are challenges to performing small area analysis, many of them may be overcome, and when analyzed correctly and presented appropriately the information these techniques provides can be quite valuable.

## References

Ahlbom, A. (1993) Biostatistics for Epidemioligists. Boca Raton: Lewis Publishers.

Andrews, H. F., Kerner, J. F., Zauber, A. G., Mandelblatt, J., Pittman, J., & Struening, E. (1994). Using Census and Mortality Data to Target Small Areas for Breast, Colorectal, and Cervical Cancer Screening. American Journal of Public Health, 84, 56-61.

American Public Health Association (1991) Healthy Communities 2000: Model Standards. Guidelines for Community Attainment of the Year 2000 National Health Objectives. (3rd Ed.) Washington DC: American Public Health Association.

APEXPH Steering Committee (1991) APEXPH: Assessment Protocol for Excellence in Public Health. Washington DC: National Association of County Health Officials.

Buescher, P. A. (1997) Problems with rates based on small numbers. Statistical Premier, 12: 1-6. North Carolina: North Carolina Department of Environment, Health, and Natural Resources.

Bureau of Surveillance and Analysis (1997) Health Insurance Coverage. (1996 Utah Health Status Survey Report). Salt Lake City, UT: Utah Department of Health.

Bureau of Surveillance and Analysis (1998) Overview of the 1996 Health Status Survey. (1996 Utah Health Status Survey Report). Salt Lake City, UT: Utah Department of Health.

Colton, T. (1974). Statistics in Medicine. Boston: Little, Brown and Company.

Diehr, P., Cain, K., and Connell, F. (1990) What is Too Much Variation? The Null Hypothesis in Small-Area Analysis. Health Services Research, 24, 741-771.

Diehr, P., Cain, K., and Abdul-Salam, F. (1993) Small Area Variation Analysis. Methods for Comparing Several Diagnosis-Related Groups. Medical Care, 31, YS45-YS53.

Devine, O. J., Annest, J. L., Kirk, M. L., Holmgreen, P., & Emrich, S. S. Injury Mortality Atlas of the United States, 1979-1987. Atlanta, GA: U.S. Department of Health and Human Services.

Fleiss, J. L. (1981) Statistical Methods for Rates and Proportions. (Second Ed.) New York: John Wiley & Sons.

Goodman, D. C., & Green, G. R. (1996). Assessment Tools: Small Area Analysis. American Journal of Medical Quality, 11(1), S12-S14.

Goodman, S. N. (1998). Multiple Comparisons, Explained. American Journal of Epidemiology, 147, 807-812.

Greenland, S., & Robins, J. M. (1991). Empirical-Bayes Adjustments for Multiple Comparisons Are Sometimes Useful. Epidemiology, 2, 244-251.

Gould, J.B., Davey, J.B., & LeRoy, S. (1989). Socioeconomic Differentials and Neonatal Mortality: Racial Comparison of California Singletons. Pediatrics, 83 (2), 181-186.

Gould, J.B., Davey, J.B., & Stafford, R.S. (1989). Socioeconomic Differences in Rates of Cesarean Section. New England Journal of Medicine, 321 (4), 233-239.

International Epidemiology Association. (1995). A Dictionary of Epidemiology, 3rd Ed. John M. Last (Ed.). New York: Oxford University Press.

Kahn, H. A., & Sempos, C. T. (1989) Statistical Methods in Epidemiology. New York: Oxford University Press.

King, G. (July, 1998). A Solution to the Ecological Inference Problem: Reconstructing Individual Behavior from Aggregate Data [computer program]. Available from: URL: http://gking.harvard.edu/comp/node1.hmtl

Kirby, R. S. (1996). Toward Congruence Between Theory and Practice in Small Area Analysis and Local Public Health Data. Statistics in Medicine, 15, 1859-1866.

Kleinman, J. C. (1977). Age-Adjusted Mortality Indexes for Small Areas: Applications to Health Planning. American Journal of Public Health, 67, 834-840.

Lafata, J. E., Koch, G. G., & Weissert, W. G. (1994). Estimating Activity Limitation in the Noninstitutionalized Population: A Method for Small Areas. American Journal of Public Health, 84, 1813-1817.

Lang, D. M., & Polansky, M. (1994). Patterns of Asthma Mortality in Philadelphia From 1969 to 1991. The New England Journal of Medicine, 331, 1542-1546.

Lee, E.S., Forthofer, R. N., & Lorimer, R. J. (1989) Analyzing Complex Survey Data. Newbury Park, CA: Sage Publications, Inc.

Levy, P.S.; and Lemeshow, S. (1991) Sampling of Populations: Methods and Applications. New York: John Wiley & Sons.

Lilienfeld, D. E., & Stolley, P. D. (1994). Foundations of Epidemiology (3rd ed.). New York: Oxford University Press.

Martuzzi, M., & Elliott, P. (1996). Empirical Bayes Estimation of Small Area Prevalence of Non-Rare Conditions. Statistics of Medicine, 15, 1867-1873.

Paul-Shaheen, P., Clark, J. D., & Williams, D. (1987). Small Area Analysis: A Review and Analysis of the North American Literature. Journal of Health Politics, Policy and Law, 12, 741-809.

Rothman, K. J. (1990) No Adjustments Are Needed for Multiple Comparisons. Epidemiology, 1, 43-46.

Savitz, D. A., & Olshan, A. F. Describing Data Requires No Adjustment for Multiple Comparisons: A Reply from Savitz and Olshan. American Journal of Epidemiology, 147, 813-814.

Shah, B. V., Barnwell, B. G., & Bieler, G. S. (1997) SUDAAN User's Manual, Release 7.5. Research Triangle Park, NC: Research Triangle Institute.

Spasoff, R. A., Strike, C. J., Nair, R. C., Dunkley, G. C., & Boulet, J. R. (1996). Small Group Estimation for Public Health. Canadian Journal of Public Health, 87(2), 130-134.

Steinberg, J. A. (1995). Making Better Maps, Part II. Business Geographics, 3(1), 34-36.

Thompson, J. R. (1998). A Response to "Describing Data Requires No Adjustment for Multiple Comparisons". American Journal of Epidemiology, 147, 815.

Thompson, J. R. (1998). Invited Commentary: Re: "Multiple Comparisons and Related Issues in the Interpretation of Epidemiologic Data". American Journal of Epidemiology, 147, 801-806.

Tufte, E. R. (1983). The Visual Display of Quantitative Information. Connecticut: Graphics Press.

Tufte, E. R. (1990). Envisioning Information. Connecticut: Graphics Press.

U.S. Bureau of the Census. (1995). Population Profile of the United States: 1995. Current Population Reports, Series P23-189. Washington, DC: U.S. Government Printing Office.

Waitzman, N. J., & Smith, K. R. (1998). Phantom of the Area: Poverty Area Residence and Mortality in the United States. American Journal of Public Health, 88(5), 1-4.

Wennberg, J. E. (1987). Population Illness Rates Do Not Explain Population Hospitalization Rates. Medical Care, 25, 354-359.

Wennberg, J., & Gittelsohn, A. (1973). Small Area Variations in Health Care Delivery. Science, 182, 1102-1108.

Wilson, P., & Tedeschi, P. (1984). Community Correlates of Hospital Use. Health Services Research, 19, 333-355.

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## Table 1. Selected Demographic and Health Measures by Utah Small Areas

| | | | | Average Annual Motor Vehicle Death Rate, 1992-1996[2] | | % of Births With No Prenatal Care in 1st Trimester, 1994-1996[4] | | % of Persons Without Health Insurance, 1996[3] | | % of Adults Who Smoked Cigarettes, 1996[5] | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Area | Population Size[1] | Per Capita Income[1] | Median Age[1] | Rate | Confidence Interval (90%) | Percentage | Confidence Interval (95%) | Percentage | Confidence Interval (95%) | Percentage | Confidence Interval (95%) |
| 0 State of Utah | 2,042,003 | $14,045 | 28 | 15.8 | *15.1 - 16.4* | 15.4% | *15.2% - 15.6%* | 9.5% | *8.5% - 10.6%* | 12.3% | *11.4% - 13.1%* |
| 1 Brigham City | 18,915 | $14,867 | 30 | 20.3 | *13.3 - 29.8* | 14.7% | *12.6% - 17.0%* | 9.6% | *5.7% - 13.5%* | 9.7% | *5.2% - 14.1%* |
| 2 Other Box Elder Co. | 20,712 | $13,231 | 27 | 21.3 | *13.7 - 29.0* | 17.1% | *14.9% - 19.5%* | 3.8% | *1.7% - 5.9%* | 13.0% | *8.0% - 18.1%* |
| 3 Logan | 60,515 | $13,006 | 24 | 7.7 | *5.1 - 10.3* | 8.6% | *7.7% - 9.6%* | 9.2% | *7.1% - 11.3%* | 4.8% | *2.8% - 6.8%* |
| 4 Other Cache/Rich Co. | 26,325 | $11,769 | 26 | 25.0 | *17.6 - 32.4* | 10.6% | *9.3% - 12.1%* | 6.2% | *4.0% - 8.4%* | 7.2% | *4.0% - 10.3%* |
| 5 Ben Lomond | 39,592 | $13,151 | 30 | 18.2 | *13.2 - 23.2* | 16.2% | *14.7% - 17.8%* | 12.1% | *8.2% - 15.9%* | 18.7% | *12.9% - 24.4%* |
| 6 Morgan/East Weber Co. | 32,686 | $14,757 | 28 | 9.4 | *5.7 - 14.7* | 11.0% | *9.4% - 12.9%* | 5.6% | *2.7% - 8.5%* | 9.6% | *4.9% - 14.4%* |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 Downtown Ogden | 24,663 | $12,484 | 31 | 16.8 | *11.1 - 22.6* | 28.4% | *26.4% - 30.4%* | 19.6% | *13.6% - 25.7%* | 28.2% | *20.7% - 35.7%* |
| 8 South Ogden | 30,696 | $18,185 | 33 | 11.9 | *7.9 - 17.3* | 16.7% | *15.1% - 18.4%* | 7.2% | *3.6% - 10.8%* | 9.4% | *5.1% - 13.7%* |
| 9 Roy/Hooper | 36,276 | $14,404 | 28 | 17.2 | *11.9 - 22.4* | 11.2% | *9.9% - 12.7%* | 9.3% | *5.8% - 12.8%* | 16.4% | *10.8% - 22.0%* |
| 10 Riverdale | 23,783 | $15,443 | 31 | 13.0 | *8.2 - 19.8* | 13.2% | *11.4% - 15.2%* | 1.2% | *0.0% - 2.8%* | 12.4% | *6.0% - 18.8%* |
| 11 Clearfield/Hill AFB | 45,593 | $11,592 | 24 | 11.2 | *7.5 - 14.9* | 15.4% | *14.0% - 16.8%* | 6.1% | *3.5% - 8.7%* | 15.5% | *10.3% - 20.8%* |
| 12 Layton | 53,648 | $14,465 | 26 | 15.9 | *11.7 - 20.0* | 14.5% | *13.3% - 15.7%* | 4.9% | *2.6% - 7.2%* | 14.0% | *9.2% - 18.7%* |
| 13 Syracuse/Kaysville | 29,312 | $14,029 | 25 | 13.7 | *8.9 - 20.4* | 13.3% | *11.7% - 15.1%* | 3.2% | *1.0% - 5.4%* | 8.5% | *4.3% - 12.8%* |
| 14 Farmington/Centerville | 24,991 | $14,948 | 24 | 6.2 | *2.9 - 11.6* | 8.0% | *6.6% - 9.7%* | 3.4% | *0.9% - 5.8%* | 2.9% | *0.1% - 5.7%* |
| 15 Woods Cross/No SL | 17,596 | $13,972 | 25 | 18.5 | *11.4 - 28.5* | 11.0% | *9.2% - 13.2%* | 6.1% | *1.8% - 10.5%* | 8.3% | *2.2% - 14.4%* |
| 16 Bountiful | 44,309 | $17,141 | 30 | 9.1 | *5.9 - 12.4* | 9.4% | *8.3% - 10.7%* | 5.1% | *2.6% - 7.6%* | 8.8% | *4.5% - 13.0%* |
| 17 Rose Park | 26,083 | $12,871 | 30 | 22.1 | *15.3 - 28.8* | 31.2% | *29.1% - 33.3%* | 19.3% | *10.6% - 28.0%* | 23.6% | *11.0% - 36.2%* |
| 18 Avenues | 23,277 | $23,110 | 35 | 11.1 | *6.8 - 17.0* | 19.3% | *17.1% - 21.8%* | 0.0% | *0.0% - 0.0%* | 6.3% | *0.0% - 12.9%* |
| 19 Foothill/U of U | 22,917 | $23,761 | 35 | 3.9 | *1.5 - 8.2* | 9.7% | *8.2% - 11.4%* | 2.8% | *0.0% - 5.8%* | 6.1% | *0.3% - 11.9%* |
| 20 Magna | 20,128 | $11,315 | 25 | 10.9 | *5.9 - 18.4* | 18.8% | *16.7% - 21.0%* | 6.7% | *0.4% - 13.0%* | 34.8% | *21.6% - 48.1%* |
| 21 Glendale | 20,579 | $11,133 | 32 | 22.2 | *14.8 - 29.7* | 35.7% | *33.4% - 38.0%* | 20.0% | *11.0% - 29.0%* | 22.3% | *11.1% - 33.5%* |
| 22 West Valley West | 58,179 | $11,989 | 25 | 14.4 | *10.6 - 18.3* | 19.3% | *18.0% - 20.6%* | 8.2% | *4.3% - 12.1%* | 21.9% | *14.7% - 29.0%* |
| 23 West Valley East | 40,174 | $12,773 | 27 | 16.9 | *12.2 - 21.7* | 19.8% | *18.3% - 21.4%* | 20.7% | *12.9% - 28.5%* | 21.3% | *12.3% - 30.2%* |
| 24 Downtown Salt Lake | 48,215 | $16,691 | 33 | 16.3 | *12.4 - 20.2* | 20.7% | *19.2% - 22.2%* | 18.0% | *11.5% - 24.5%* | 19.0% | *12.6% - 25.4%* |
| 25 South Salt Lake | 22,416 | $12,582 | 31 | 24.5 | *17.2 - 31.7* | 25.9% | *23.9% - 28.0%* | 17.2% | *8.3% - 26.1%* | 34.0% | *19.4% - 48.7%* |
| 26 Millcreek | 55,943 | $18,385 | 36 | 12.7 | *9.4 - 16.1* | 13.0% | *11.9% - 14.3%* | 4.7% | *1.3% - 8.0%* | 9.9% | *3.8% - 16.0%* |
| 27 Holladay | 46,584 | $21,967 | 37 | 11.3 | *7.8 - 14.8* | 12.0% | *10.7% - 13.6%* | 5.0% | *1.5% - 8.4%* | 8.4% | *3.2% - 13.5%* |
| 28 Cottonwood | 45,933 | $20,675 | 33 | 13.8 | *9.7 - 17.9* | 11.4% | *9.9% - 13.0%* | 7.4% | *2.5% - 12.3%* | 7.6% | *2.3% - 12.9%* |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 Kearns | 62,462 | $12,057 | 25 | 17.1 | *13.0 - 21.2* | 18.0% | *16.8% - 19.2%* | 8.4% | *4.7% - 12.1%* | 20.6% | *13.5% - 27.8%* |
| 30 Taylorsville | 33,294 | $15,877 | 29 | 14.7 | *9.8 - 19.7* | 16.3% | *14.7% - 18.1%* | 12.8% | *7.0% - 18.6%* | 14.5% | *5.2% - 23.8%* |
| 31 Murray | 30,139 | $17,764 | 33 | 11.9 | *7.8 - 17.5* | 15.3% | *13.7% - 17.1%* | 14.8% | *7.6% - 22.0%* | 18.5% | *8.5% - 28.5%* |
| 32 Midvale | 27,154 | $14,959 | 29 | 9.4 | *5.5 - 14.9* | 20.1% | *18.2% - 22.0%* | 4.3% | *0.0% - 9.0%* | 12.6% | *3.6% - 21.6%* |
| 33 West Jordan No. | 44,308 | $12,100 | 22 | 11.9 | *7.7 - 16.1* | 13.1% | *11.9% - 14.5%* | 16.2% | *11.3% - 21.1%* | 11.9% | *5.3% - 18.5%* |

# Table 1. Selected Demographic and Health Measures by Utah Small Areas

(continued from previous page)

| | | | | Average Annual Motor Vehicle Death Rate, 1992-1996[2] | | % of Births With No Prenatal Care in 1st Trimester, 1994-1996[4] | | % of Persons Without Health Insurance, 1996[3] | | % of Adults Who Smoked Cigarettes, 1996[5] | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Area | Population Size[1] | Per Capita Income[1] | Median Age[1] | Rate | Confidence Interval (90%) | Percentage | Confidence Interval (95%) | Percentage | Confidence Interval (95%) | Percentage | Confidence Interval (95%) |
| 34 W. Jordan, Copperton | 28,860 | $12,170 | 24 | 12.5 | *7.7 - 19.2* | 13.4% | *12.0% - 15.0%* | 7.3% | *2.3% - 12.4%* | 13.4% | *4.2% - 22.5%* |
| 35 South Jordan | 32,401 | $13,936 | 24 | 8.3 | *3.9 - 15.5* | 11.0% | *9.1% - 13.2%* | 8.1% | *1.5% - 14.6%* | 0.1% | *0.0% - 0.2%* |
| 36 Sandy Center | 52,784 | $14,260 | 27 | 12.7 | *8.9 - 16.4* | 12.7% | *11.5% - 13.9%* | 20.0% | *14.1% - 25.8%* | 6.1% | *0.8% - 11.4%* |
| 37 Sandy, NE | 28,948 | $19,615 | 28 | 9.9 | *5.8 - 15.7* | 8.6% | *7.0% - 10.5%* | 6.6% | *0.0% - 14.0%* | 5.2% | *0.0% - 10.8%* |
| 38 Sandy, SE | 34,139 | $19,391 | 25 | 11.1 | *7.0 - 16.9* | 10.4% | *8.7% - 12.2%* | 5.9% | *2.2% - 9.6%* | 7.1% | *0.8% - 13.3%* |
| 39 Riverton/Draper | 37,651 | $12,542 | 27 | 16.4 | *11.1 - 21.7* | 13.1% | *11.7% - 14.6%* | 8.1% | *1.4% - 14.7%* | 1.5% | *0.0% - 4.3%* |
| 40 Tooele Co. | 30,371 | $11,953 | 30 | 29.7 | *22.4 - 37.0* | 19.4% | *17.5% - 21.4%* | 8.5% | *7.1% - 10.0%* | 22.2% | *19.7% - 24.7%* |
| 41 Lehi/Cedar Valley | 14,951 | $11,875 | 25 | 20.5 | *12.4 - 32.1* | 10.7% | *9.0% - 12.6%* | 14.2% | *7.2% - 21.1%* | 16.7% | *6.9% - 26.5%* |
| 42 American Fork/Alpine | 34,378 | $12,285 | 24 | 12.1 | *7.9 - 17.8* | 12.2% | *10.8% - 13.7%* | 3.5% | *0.6% - 6.4%* | 0.8% | *0.0% - 1.9%* |
| 43 Pleasant Grove/Lindon | 26,294 | $11,827 | 23 | 17.2 | *11.4 - 25.0* | 12.9% | *11.4% - 14.5%* | 7.8% | *2.7% - 13.0%* | 5.8% | *1.0% - 10.6%* |
| 44 North Orem | 35,107 | $12,406 | 23 | 25.1 | *18.1 - 32.1* | 11.8% | *10.8% - 13.0%* | 10.2% | *6.3% - 14.1%* | 6.0% | *1.0% - 11.0%* |
| 45 West Orem | 27,114 | $12,735 | 23 | 17.8 | *11.4 - 24.2* | 11.7% | *10.5% - 13.0%* | 7.5% | *3.5% - 11.5%* | 5.5% | *0.5% - 10.4%* |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 46 East Orem | 30,579 | $13,712 | 24 | *** | *** - *** | *** | *** - *** | 2.0% | 0.0% - 5.6% | 3.7% | 0.0% - 8.5% |
| 47 Provo/BYU | 47,328 | $12,581 | 22 | 7.1 | 4.6 - 9.7 | 10.0% | 8.9% - 11.1% | 9.8% | 5.3% - 14.3% | 3.2% | 0.0% - 6.6% |
| 48 Provo South | 47,650 | $9,795 | 24 | 10.7 | 7.5 - 13.9 | 11.2% | 10.3% - 12.1% | 8.6% | 4.8% - 12.3% | 7.4% | 2.4% - 12.4% |
| 49 Springville/Spanish Fork | 44,774 | $12,283 | 25 | 20.8 | 15.6 - 25.9 | 9.0% | 8.1% - 10.1% | 11.1% | 7.0% - 15.2% | 9.5% | 4.5% - 14.4% |
| 50 Utah Co. South | 19,920 | $10,539 | 24 | 14.0 | 8.3 - 22.2 | 11.1% | 9.4% - 12.9% | 10.1% | 5.2% - 15.0% | 11.5% | 4.1% - 18.9% |
| 51 Summit Co. | 25,301 | $21,809 | 33 | 23.7 | 15.9 - 31.5 | 13.2% | 11.2% - 15.4% | 6.7% | 5.5% - 7.8% | 7.6% | 6.0% - 9.2% |
| 52 Wasatch Co. | 12,441 | $13,616 | 29 | 25.7 | 15.8 - 39.5 | 13.5% | 11.1% - 16.4% | 13.1% | 11.8% - 14.4% | 11.8% | 10.2% - 13.4% |
| 53 Tri-county LHD | 39,334 | $10,055 | 27 | 36.7 | 29.4 - 44.0 | 18.7% | 17.0% - 20.5% | 16.7% | 14.8% - 18.5% | 18.4% | 16.0% - 20.8% |
| 54 Juab/Millard/Sanpete Co. | 39,473 | $9,144 | 29 | 18.1 | 13.1 - 23.1 | 19.1% | 17.4% - 20.9% | 13.9% | 11.8% - 15.9% | 11.9% | 9.4% - 14.4% |
| 55 Sevier/Piute/Wayne Co. | 21,373 | $10,126 | 32 | 14.9 | 9.3 - 22.6 | 21.6% | 19.2% - 24.3% | 15.5% | 12.4% - 18.6% | 15.3% | 11.4% - 19.2% |
| 56 Carbon/Emery Co. | 31,108 | $11,257 | 31 | 25.5 | 18.9 - 32.0 | 19.1% | 17.1% - 21.3% | 9.8% | 8.0% - 11.5% | 21.2% | 18.1% - 24.3% |
| 57 Grand/San Juan Co. | 21,083 | $9,333 | 29 | 49.3 | 38.0 - 60.7 | 29.7% | 27.1% - 32.4% | 16.5% | 13.2% - 19.8% | 13.6% | 9.8% - 17.4% |
| 58 St. George | 51,395 | $13,574 | 30 | 10.6 | 7.2 - 14.0 | 21.8% | 20.1% - 23.5% | 13.2% | 10.0% - 16.3% | 9.2% | 5.8% - 12.5% |
| 59 Other Washington Co. | 26,263 | $10,123 | 29 | 26.9 | 19.2 - 34.6 | 19.7% | 17.9% - 21.7% | 14.9% | 11.3% - 18.5% | 16.0% | 11.3% - 20.7% |
| 60 Cedar City | 24,424 | $11,485 | 25 | 17.9 | 11.5 - 24.3 | 11.0% | 9.5% - 12.7% | 12.7% | 9.0% - 16.4% | 5.4% | 2.2% - 8.5% |
| 61 Other Southwest Dist. | 19,162 | $10,571 | 34 | 33.7 | 24.1 - 43.4 | 22.6% | 20.1% - 25.4% | 24.3% | 19.3% - 29.2% | 19.2% | 13.4% - 25.0% |

1. 1997 population estimates. Age and per capita income figures are means, weighted by population count, of the ZIP code median values. Source: CACI Marketing Systems, Inc. La Jolla, CA.
2. Rate per 100,000 persons. Age-adjusted using the indirect method. Source: Utah Department of Health, Bureau of Vital Records.
3. Age-adjusted using the direct method. Source: Utah Department of Health, 1996 Utah Health Status Survey
4. Percentage of mothers delivering live births with no prenatal care in 1st trimester. Source: Utah Department of Health, Bureau of Vital Records
5. Percentage of adults (age 18+) who smoked cigarettes at the time of the survey. Age-adjusted, direct method. Source: Utah Dept. of Health, 1996 Utah Health Status Survey

*** Sample size insufficient to produce population estimates.

## Table 2. Small Area Boundary Designations

| Area | Boundary Designation |
|---|---|
| 1 Brigham City | ZIP code 84302 |

| | |
|---|---|
| 2 Other Box Elder Co. | Box Elder County other than ZIP code 84302 |
| 3 Logan | ZIP codes 84321, 84322, 84341, 84332 |
| 4 Other Cache/Rich Co. | Cache & Rich Counties other than ZIP codes 84321, 84322, 84341, 84332 |
| 5 Ben Lomond | ZIP codes 84404, 84407, 84412 |
| 6 Morgan/East Weber Co. | ZIP codes 84310, 84317, 84414, 84050 or Morgan County |
| 7 Downtown Ogden | ZIP codes 84401, 84402 |
| 8 South Ogden | ZIP code 84403 |
| 9 Roy/Hooper | ZIP codes 84067, 84315 |
| 10 Riverdale | ZIP codes 84405, 84409 |
| 11 Clearfield/Hill AFB | ZIP codes 84015, 84016, 84056 |
| 12 Layton | ZIP codes 84040, 84041 |
| 13 Syracuse/Kaysville | ZIP codes 84037, 84075 |
| 14 Farmington/Centerville | ZIP codes 84025, 84014 |
| 15 Woods Cross/No SL | ZIP codes 84087, 84054 |
| 16 Bountiful | ZIP codes 84010, 84011 |
| 17 Rose Park | ZIP code 84116 |
| 18 Avenues | ZIP codes 84103, 84114 |
| 19 Foothill/U of U | ZIP codes 84108, 84112, 84113 |
| 20 Magna | ZIP code 84044 |
| 21 Glendale | ZIP codes 84104, 84101, 84110, 84152 |
| 22 West Valley West | ZIP codes 84128, 84120, 84170 |
| 23 West Valley East | ZIP codes 84119, 84199 |
| 24 Downtown Salt Lake | ZIP codes 84111, 84102, 84105 |
| 25 South Salt Lake | ZIP codes 84115, 84165 |

| | |
|---|---|
| 26 Millcreek | ZIP codes 84106, 84151, 84109 |
| 27 Holladay | ZIP codes 84124, 84117 |
| 28 Cottonwood | ZIP code 84121 |
| 29 Kearns | ZIP code 84118 |
| 30 Taylorsville | ZIP code 84123 |
| 31 Murray | ZIP codes 84107, 84157 |
| 32 Midvale | ZIP code 84047 |
| 33 West Jordan No. | ZIP code 84084 |
| 34 W. Jordan, Copperton | ZIP codes 84088, 84006 |
| 35 South Jordan | ZIP code 84095 |
| 36 Sandy Center | ZIP codes 84070, 84091, 84094 |
| 37 Sandy, NE | ZIP codes 84093, 94090 |
| 38 Sandy, SE | ZIP code 84092 |
| 39 Riverton/Draper | ZIP codes 84065, 84020 |
| 40 Tooele Co. | Tooele County |
| 41 Lehi/Cedar Valley | ZIP codes 84043, 84013 |
| 42 American Fork/Alpine | ZIP codes 84004, 84003 |
| 43 Pleasant Grove/Lindon | ZIP codes 84062, 84042 |
| 44 North Orem | ZIP codes 84057, 84059 |
| 45 West Orem | ZIP code 84058 |
| 46 East Orem | ZIP code 84097 |
| 47 Provo/BYU | ZIP codes 84602, 84604 |
| 48 Provo South | ZIP codes 84601, 84603, 84605, 84606 |
| 49 Springville/Spanish Fork | ZIP codes 84660, 84663, 84664, 84653 |

| | |
|---|---|
| 50 Utah Co. South | ZIP codes 84651, 84655, 84626, 84633 |
| 51 Summit Co. | Summit County |
| 52 Wasatch Co. | Wasatch County |
| 53 Tri-county LHD | Daggett, Duchesne and Uintah Counties |
| 54 Juab/Millard/Sanpete Co. | Juab, Millard, and Sanpete Counties |
| 55 Sevier/Piute/Wayne Co. | Piute, Sevier, and Wayne Counties |
| 56 Carbon/Emery Co. | Carbon and Emery Counties |
| 57 Grand/San Juan Co. | Grand and San Juan Counties |
| 58 St. George | ZIP codes 84770, 84771, 84790 |
| 59 Other Washington Co. | Washington County other than ZIP codes 84770, 84771, 84790 |
| 60 Cedar City | ZIP code 84720 |
| 61 Other Southwest Dist. | Beaver, Garfield, Iron, and Kane Counties other than ZIP code 84720 |

**Figure 1. Average Motor Vehicle Crash Death Rates per 100,000 Persons According to Residence of Decedent. Utah Small Areas, 1992-96.**

Age-adjusted to the 1990 Utah population using the indirect method.
Numbers on map refer to area labels (see Table 1).
Data Source: Utah Department of Health, Bureau of Vital Records.

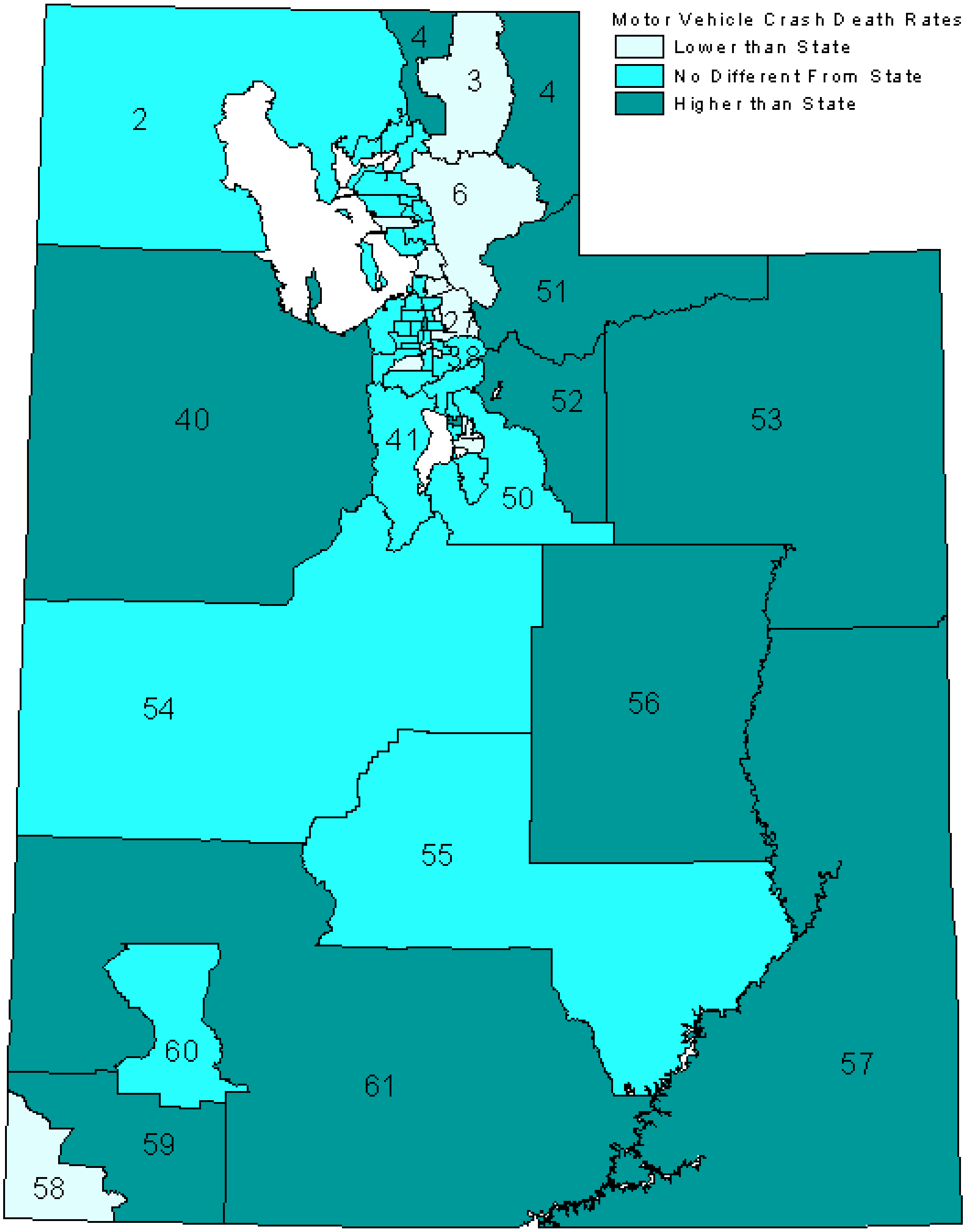

**Figure 2. Percentage of Mothers of Liveborn Infants Who Did Not Receive Prenatal Care in the First Trimester of Pregnancy. Utah Wasatch Front Counties, 1994-96.**

Numbers on map refer to area labels (see Table 1).
Data Source: Utah Department of Health, Bureau of Vital Records.

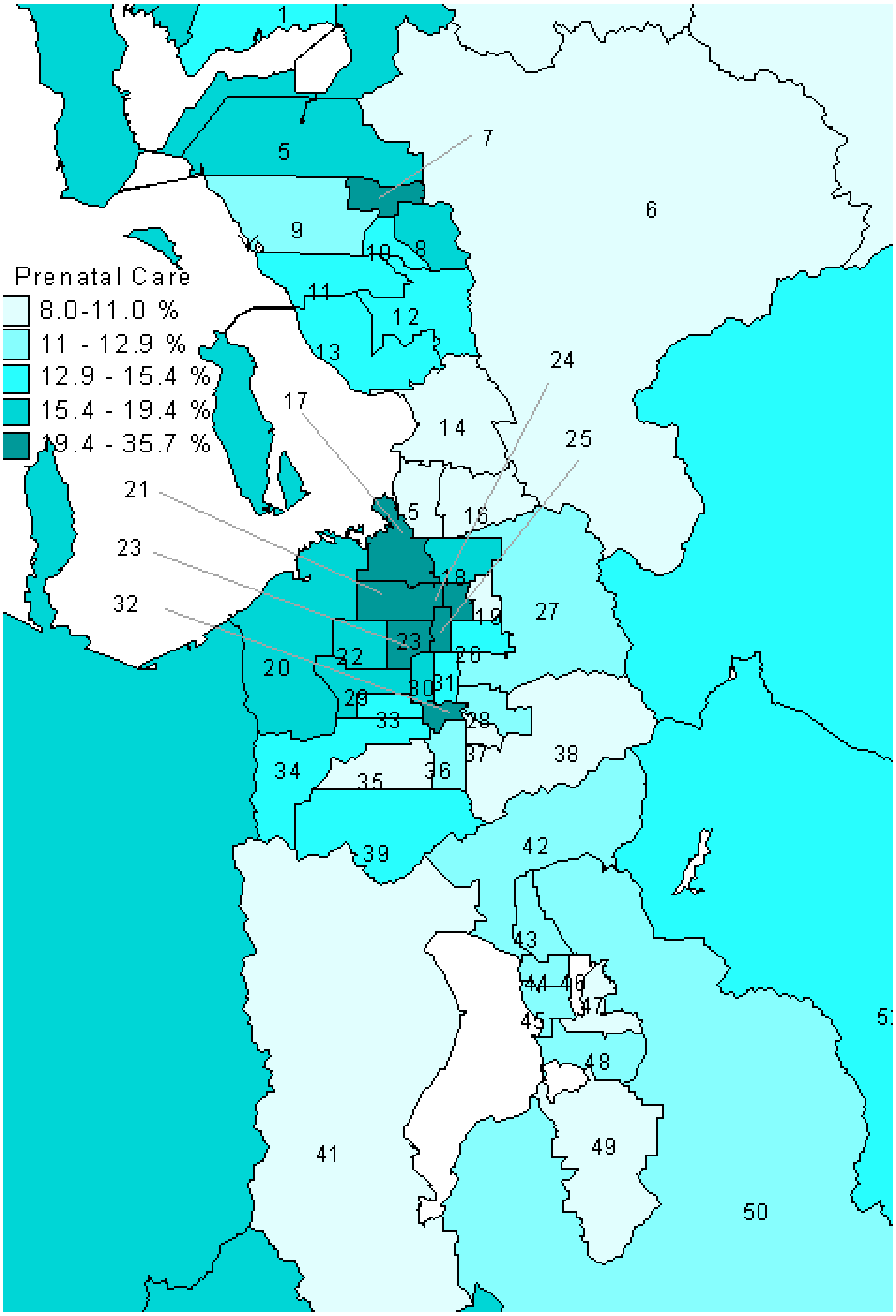

**Figure 3. Percentage of Mothers of Liveborn Infants Who Did Not Receive Prenatal Care in the First Trimester of Pregnancy by Median Per Capita Annual Income. Utah Small Areas, 1992-1996.**

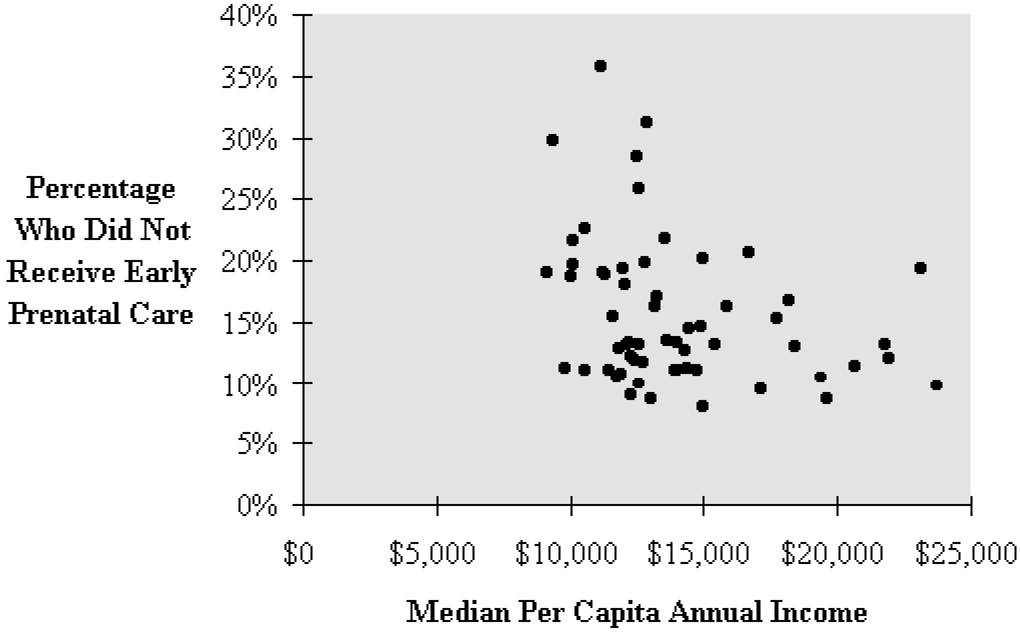

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**Figure 4. Percentage of Persons Who Were Without Health Insurance. Utah, 1996.**

Age-adjusted to the 1996 Utah population using the direct method.
Numbers on map refer to area labels (see Table 1).
Data Source: 1996 Utah Health Status Survey, Utah Department of Health.

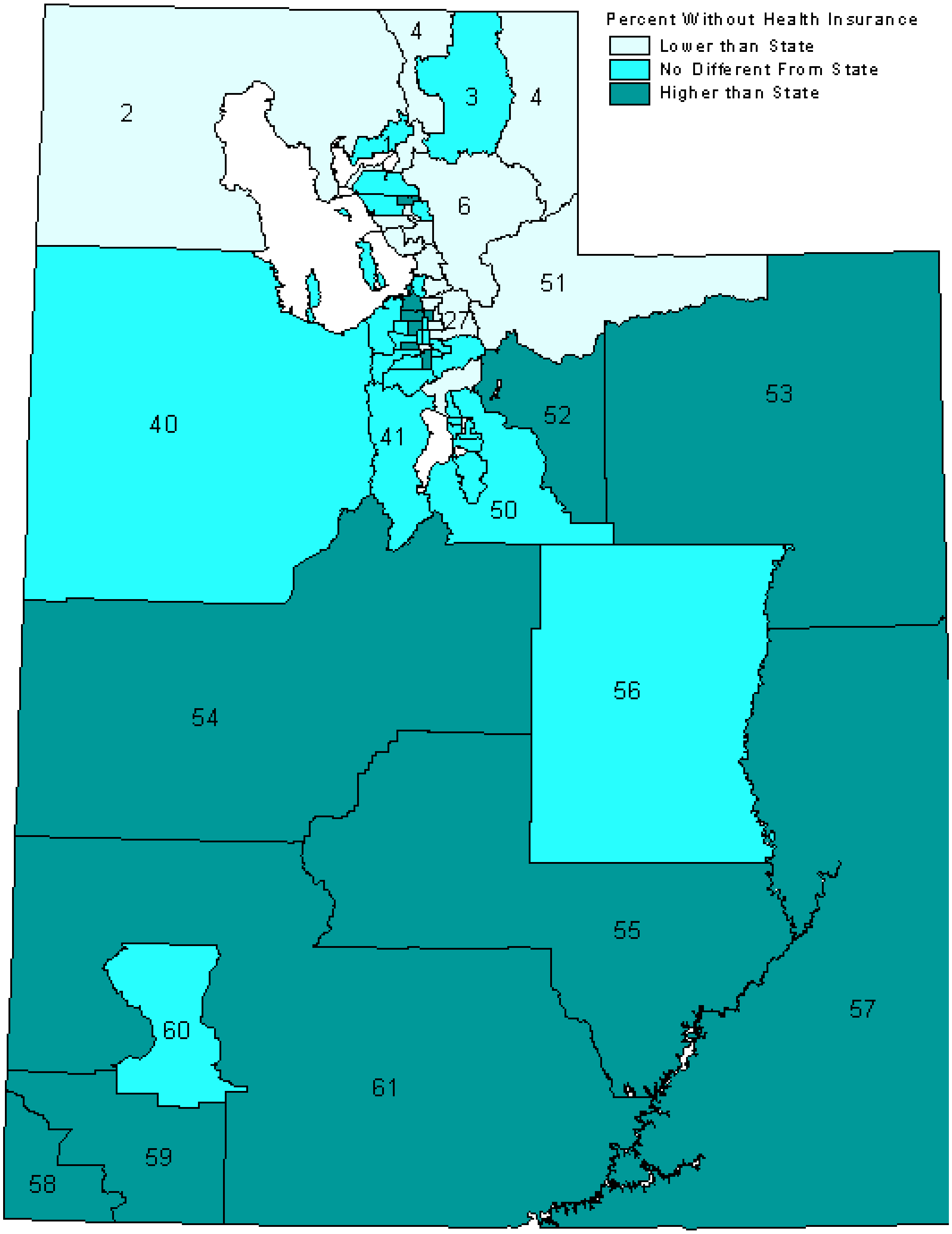
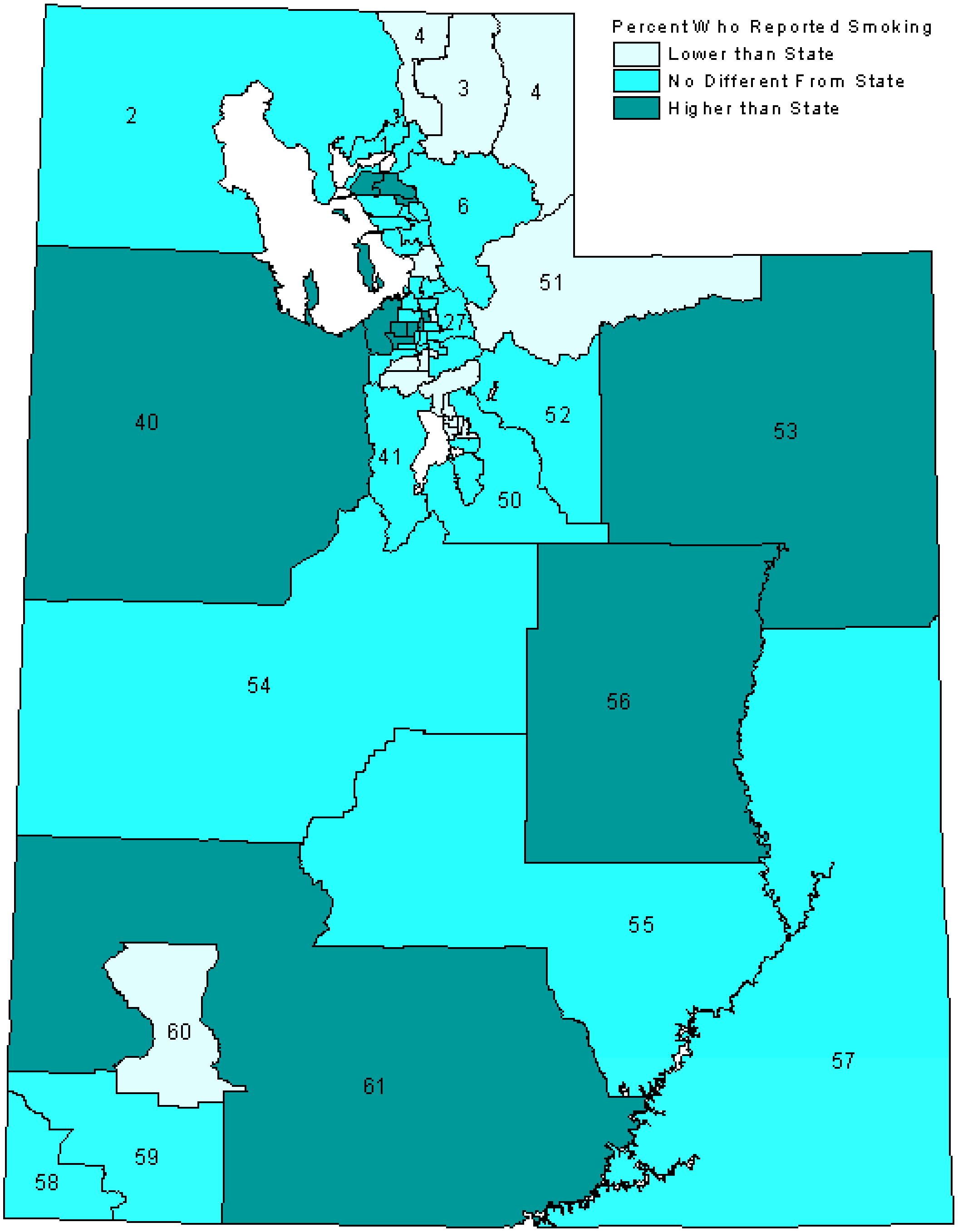


**Figure 5. Percentage of Adults (Age 18+) Who Reported Smoking, Utah, 1996.**

Age-adjusted to 1996 Utah population using the direct method.
Numbers on map refer to area labels (see Table 1).
Data Source: 1996 Utah Health Status Survey, Utah Department of Health.


Percent Who Reported Smoking
Lower than State
No Different From State
Higher than State
4
3
4
2
6
5
51
27
40
52
53
41
50
54
56
55
57
60
61
59
58