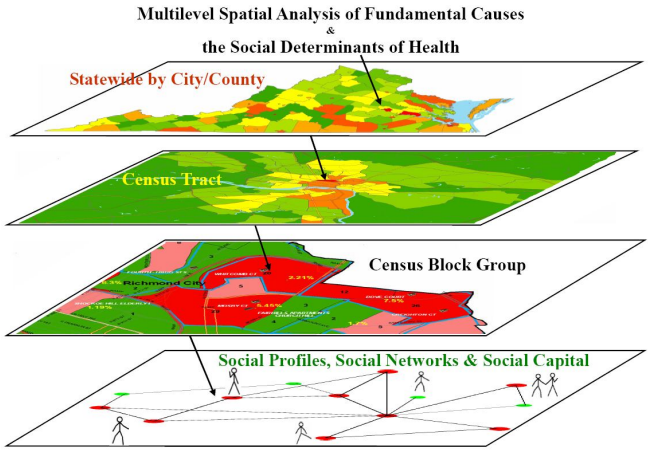
VANGHR

Changing the view on public health

Multilevel Analysis

Preliminary investigations by VaNGHR partners suggest that multilevel analysis can itself be seen from many perspectives; among others, as a statistical method, as part of a policy framing tool, and as a directive for intervention strategies. As a method, Harvard social epidemiologist, Nancy Krieger has defined multilevel analysis as:

> Analyses that conceptualize and analyze associations at multiple levels, e.g., employ individual- and area-based data in relation to a specified outcome. These analyses typically entail the use of variance components models to partition the variance at multiple levels, and to examine the contribution of factors measured at these different levels to the overall variation in the outcome. (http://www.hsph.harvard.edu/thegeocodingproject/webpage/monograph/glossary.htm)



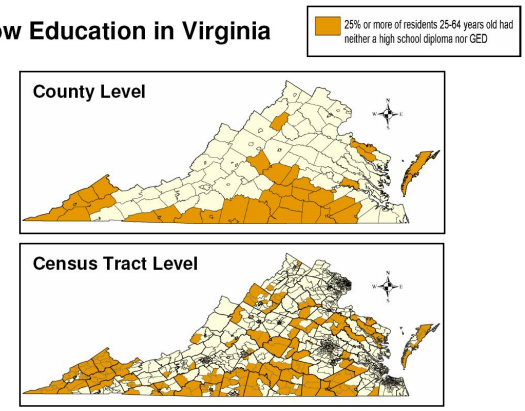
From this perspective, the level of spatial aggregation becomes particularly relevant when high levels of variance are discovered at lower sub-levels of spatial analysis. Especially when increased variance is found at spatially disaggregated levels, the question immediately becomes, how much of the variance is attributable to individual characteristics of residents and how much is attributable to the area-based contextual characteristics. In short, the methodological issue immediately shifts to how different population groups (defined by age, race, ethnicity, poverty, etc,) can be analyzed to explain how they systematically vary in relationship to area-based (social-ecological-demographic) characteristics.

Epidemiology has always been aware of these contextual effects, e.g. the presence of asthma triggers in association with particular industrial sites. But with the advent of geospatial analysis an increasing number of derivative spatial characteristics can be associated with adverse public health outcomes at the lowest levels of spatial aggregation.

In addition, ecological and aggregation related:

(1) ***spatial characteristics*** can now be evaluated that were previously difficult or impossible to calculate. Particularly noteworthy is:

Low Education in Virginia



Source: United States Department of Agriculture: Economic Research Service, 2004 County Typologies; Census 2000, SF3-PCT25.

(a) ***spatial adjacency*** at the lowest levels, e.g., Census Block Groups. This has allowed the development of numerous clustering models (e.g., hotspot, Kernel Density, and Kriging—see below) which evaluate concentrations within sub-jurisdictional areas to determine their unique spatial distributional characteristics.

(b) ***distance*** itself has been used as a variable (e.g., stroke or cancer mortality in relationship to distance from stroke and cancer treatment centers and infant mortality in relationship to distance from OB services) to associate with sub-jurisdictional outcome data. VaNGHR partners have proposed a research study of drive times for every women giving birth in the Commonwealth since 1990. Once the distance and drive times are computed with ArcGIS (Network Analysis) they could be summarized for any boundary desired-- from jurisdictions to census tracts--by race, payer source (Medicaid, Private Insurance, Uninsured) and by other criteria deemed of importance. Geospatial referenced data allows for this flexible and robust research agenda that was previously not possible.

(c) ***directional movement*** over space can be also be used as a variable. It is known, for instance, that Richmond, Virginia has approximately 800,000 individuals within its boundaries at noon, but only 200,000 at midnight. Using (i) mobility (stochastic) modeling techniques the movement of populations of working aged individuals can be traced, (ii) the age specific primary health care utilization rates for each jurisdiction can be calculated (see NAMCS), and (iii) estimates of real demand for primary care services, taking directional employment mobility of populations into account, can be calculated.

(d) geocoding of health related data ***stabilizes data analysis of geographic units over time*** and provides tremendous elasticity in the units studied—as latitude and longitude remain unchanged for events and can be joined with all potential boundaries. This allows:

1. Longitudinal analysis over long time periods at any desired level of aggregation without respect to traditional boundaries such as jurisdictions, census tracts or census block groups. Since any arbitrarily drawn boundary or geographic attribute, such as a lake or a GIS derived hotspot, can be buffered at any distance and georeferenced point data can be placed within these boundaries, epidemiological research has been elevated to a new level of sensitivity to spatial distributions and is no longer limited to distributions within populations at high levels of aggregation.
2. The fact that data from the 1970, 1980, 1990, and 2000 decennial census has been normalized to the Census 2000 census tract boundaries [see, Neighborhood Change Database (NCDB), http://www.geolytics.com/] suggests the importance of understanding contextual variables within both a geospatial and a temporal dimension. VaNGHR partners will be using these data to more efficiently construct at the census tract level standard indicators of persistent poverty (usually defined as more than 20% of the population under FPL for at least 3 decennial census periods), persistent low education areas (over 20% of the population without high school diplomas or GEDs).

3. It is the stabilizing of point data and boundaries at the most disaggregated levels that permit re-aggregation to levels that have not previously been possible with traditional epidemiological methods. The following table shows how VaNGHR partners have prepared numerous health inequity tables illustrating how Black infant mortality is higher than the infant mortality of all other race/ethnicity groups at all levels of census tract poverty, demonstrating the interaction of race and census tract poverty on poor birth outcomes. Likewise, Black infant mortality could be aggregated to compare those born with 5, 10 and 20 mile distances from hospitals delivering OB services or any other boundary matrix.

Distribution of Infant Deaths, by Race/Ethnicity* and Census Tract (CT) Poverty, 1996-2005

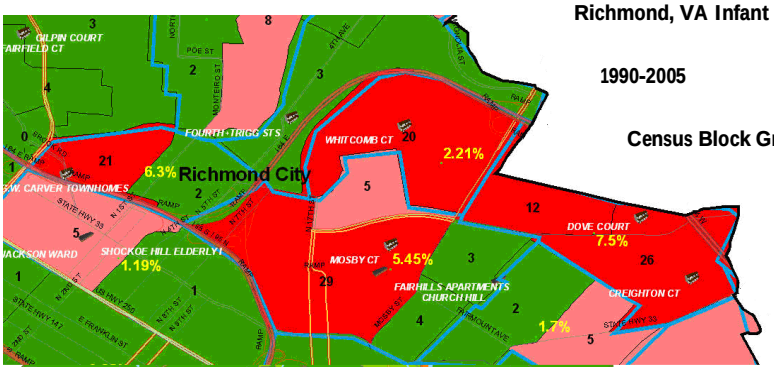
				% Distribution by CT Poverty Level											
	Total			0.0-4.9%			5.0-9.9%			10.0-19.9%			≥ 20.0%		
	Births (n)	Deaths (n)	IMR	births (n)	deaths (n)	IMR	births (n)	deaths (n)	IMR	Births (n)	deaths (n)	IMR	births (n)	deaths (n)	IMR
Total	870,558	5,217	6.0	321,464	1333	4.1	252,239	1,395	5.5	211,169	1,496	7.1	85,686	993	11.6
White	541,796	2,442	4.5	233,427	823	3.5	164,142	772	4.7	119,704	675	5.6	24,523	172	7.0
Black	194,544	2,190	11.3	32,517	306	9.4	46,859	432	9.2	59,437	668	11.2	55,731	784	14.1
Hispanic	78,124	354	4.5	25,620	104	4.1	25,615	118	4.6	23,188	110	4.7	3,701	22	5.9
Other	56,094	231	4.1	29,900	100	3.3	15,623	73	4.7	8,840	43	4.9	1,731	15	8.7

* White and Black classifications are for non-Hispanic only. Rate calculations are based on birth and death data that geocoded correctly, 90%. Data consists of only singleton births and mothers aged 15-44 years.

Heuristic Modeling and Ecological Effects

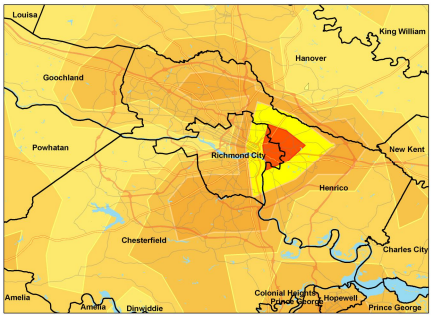
A heuristic model is designed to be of assistance in furthering understanding, discovery and problem solving without necessarily presenting a theory of causation. It is as much a teaching and learning device as an analytical tool. The reason that multilevel analysis should be considered a "heuristic device" is that it is not always clear how the levels should be related and how they should inform one another. If a city is found to have statistically significant high infant mortality rates, and if this can be explained by race and poverty, the multilevel strategy says, that's true, but are there spatially significant distributions of these mortality events that warrant explanation? And once distributed, could it be that explanations other than race and poverty arise? From the multilevel approach many of the traditional epidemiological studies represent high flying

reconnaissance missions which could be used heuristically to point to the need for lower level explanations before the area is targeted for policy intervention.



The example of infant deaths is instructive because the common explanatory variables (race and poverty) are well known as one does a "low fly over" at the census tract level. But in many of Virginia's older cities, infant deaths concentrate within census block groups, and is the case with Richmond City, these block groups are dominated by HUD housing. (see above) The area residents are by policy poor and most often black. Additionally, these areas often manifest other eco-social conditions that may pose health risks to expecting mothers, such as exceedingly high homicide rates. (in yellow)

Richmond VA Infant Deaths, 1990-2005
Predictive Kriging Analysis



It has been found that such small area presentations are seldom met with astonishment; they are usually perceived as obvious. The map image is transformative and persuasive in and of itself. The solution to infant mortality is no longer simply educational brochures in grocery stores that are outside of the transportation networks of HUD housing. At the disaggregated level the potential social and policy realities become more visible (obvious) and at this level one can plausibly entertain the possibility that what has been traditionally seen as a "fact" may in reality be the result of earlier policy decisions. Could HUD policy have an unintended consequence of exacerbating infant mortality? Is there a self-referential circularity in the argument? Could poverty policies at the macro level have consequences that when measured at a disaggregated level provide the basis for suggesting that race and poverty are the major explanatory variables?

GIS as a policy framing tool fulfills a significant heuristic function—it can tell one where to look, it can stimulate discussion, it presents data in a way that is persuasive and requires a response, it is perceived as objective and suggests where intervention strategies need to be developed without constraining approaches. Strategies become unthinkable without the full spectrum of multilevel perspectives.

High Priority Target Areas

A clear impetus for the spatial analysis program in VDH is the need to identify well defined sub-jurisdictional areas which are in health and/or healthcare distress. The *concern is with the development of a proactive surveillance system which can identify specific neighborhoods and communities that could benefit from public health and public policy interventions.* The use of multilevel analysis in this case concentrates on the complex nexus of social and policy interactions with health outcomes at the community level. It has been noted that communities that request support and interventions are not always the neediest communities but criteria were lacking historically for defining "neediest." High Priority Target Area (HPTA) analysis is therefore designed to provide both the criteria and methodology needed to identify areas that are often overlooked.

The VaNGHR approach to HPTA has been shaped by a number of considerations:

(1) the increasing view that epidemiology must take into consideration social and ecological contexts to adequately understand adverse health and health care situations,

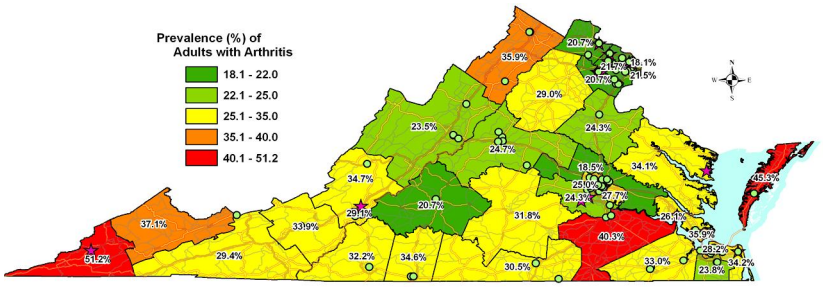
(2) the increasing need for public health to cost-effectively address these adverse conditions with the pin-point accuracy allowed by the currently available spatially referenced data,

(3) the ability to entertain new explanations for adverse conditions that may entail non-traditional causal explanations of these events,

(4) the need to develop Health Impact Assessments for all policies that have the potential to adversely affect specific populations and lead to social and health inequities,

(5) the belief that public health responsibilities cannot wait until all the social and ecological determinants of adverse conditions are eliminated before they act,

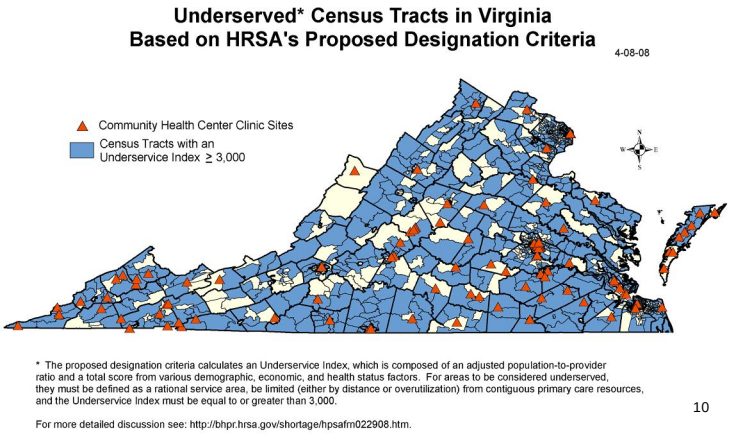
Prevalence of Arthritis (BRFSS, 2005) in Adults 18 & Over in Virginia's Local Health Districts



Practice Sites of Board Certified Rheumatologists are Noted with Stars Representing those Speaking Spanish

(6) the research model should inform community action within a framework of Community Based Participatory Research (CBPR), and

(7) the research model should be able to stimulate health and healthcare analysis at the most disaggregated level (e.g.., chart and fetal infant mortality review, key informant interviews, and focus groups) without being reduced to a bio-medical explanation.



On the one hand, as the above enumeration suggests, the HPTA model was designed to interface with *decision models* that are relevant to public health policy. Adverse health outcomes had to be placed in a spatial context that not only broadly framed the public health issues (e.g., low birth weight infants) but also revealed a decision framework for both understanding the existing policy matrix within a community and capable of assessing any proposed policy's (directed and indirect) effects on the community. On the other hand, the HPTA model was to be more than an indicator mode that predicted consequences without suggesting the causal factors driving the system, but it was never intended to tell the whole story. HPTA would always remain in some sense a heuristic model. As in the case of HRSA's proposed indicators of medical underservice (see Rickets, et al., Designating Places and Populations as Medically Underserved: A Proposal for a New Approach, 2007), important leading variables are used, but not *all* relevant variables are required to point to an area of need. HPTA as a proactive surveillance system is designed to inform public health decision makers where to look but there may be more to observe than what the model contains.

Because of State, Federal, and private foundation interest the very definition as HPTA can precipitate a series of direct interventions.

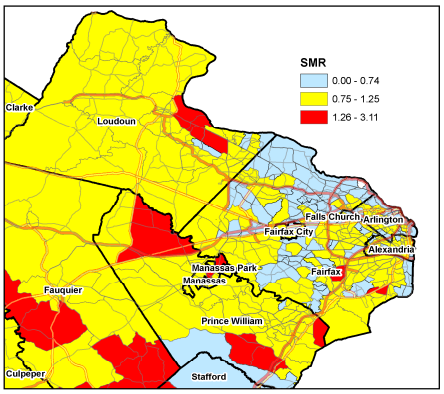
- Because the areas have been selected with criteria similar to those required by federal and state agencies, they are most often designatable as geographical or population Health Professional Shortage Areas (HPSA) or Medically Underserved Area/Population (MUA/P), and score higher than larger designated service areas.
- Because of their high needs they are more likely to receive grant funding by federal and state agencies and by private foundations.
- Because of their high needs they often qualify for preferential reimbursement from Medicaid, for both health professional providers but for outreach workers.
- Because HPTA can be given a continuous score, special programs such as scholarships and loan repayment programs supporting health professionals can be targeted to the highest needs areas.
- HPTA guide public health policy efforts at the local level to allocate their resources to target the neediest areas.

HPTA Methodology. All methodology can carry with it hidden arguments regarding policy (see Tesh, 1990). If the researchers use infant mortality as a sentinel measure, then it is tempting to think that this is the

major problem to be addressed; if low educational attainment is used to identify HPTA then it is tempting to surmise that low literacy educational materials targeted at changing individual behavior is required.

The jurisdictional level data often provides a clue, e.g., Norfolk and Richmond do have exceptionally high infant mortality rates, but the multilevel spatial analysis requires focusing techniques that clarify contexts, potential causes and suggest intervention strategies. These micro areas of concern are what we have labeled High Priority Target Areas (HPTA). The data used to identify such areas approximate those used by federally defined medically underserved area designations and public and private funding entities for identifying viable healthcare service areas. Among others these variables include educational levels, elderly, Hispanic populations, hospital discharge data, housing conditions, infant mortality, linguistic isolation, low birth weight, mortality, non-white populations, population density, poverty, health provider and professional data, underemployment and unemployment, and ambulatory sensitive conditions.

Standardized Mortality Ratio (SMR) by Census Tract, 2001-2005



Source: Observed death data were obtained from VDH Vital Statistics, (2001-2005, geocoding error rate= 10%); Expected death data were calculated from Census 2000 data (SF1, P12) and 2005 age-specific death rates (CDC- National Center for Health Statistics). SMR = actual/expected death rate.

Except as included within hospital discharge, birth and mortality data, specific disease outcomes, such as diabetes or asthma prevalence, are seldom used for identifying the HPTA because the data collection process, mostly surveys, was not designed to provide spatially referenced data. Except for the development of thematic maps, survey data, such as the Centers for Disease Control and Prevention (CDC), the Behavioral Risk Factor Surveillance System (BRFSS), is difficult to focus on specific spatial distributions. Such data is collected to partition variance across characteristics of individuals within populations—race, poverty, educational attainment—and is therefore difficult to partition variance across geographically defined social characteristics with the exception of broadly defined jurisdictions. In the case of BRFSS, as found in this Arthritis map, the data due to the size of the sampling frame, is usually not significant in Virginia below the multi-jurisdictional health district level.

Distribution of Infant Deaths, by Race / Ethnicity* and Census Tract (CT) Poverty, 1996-2005

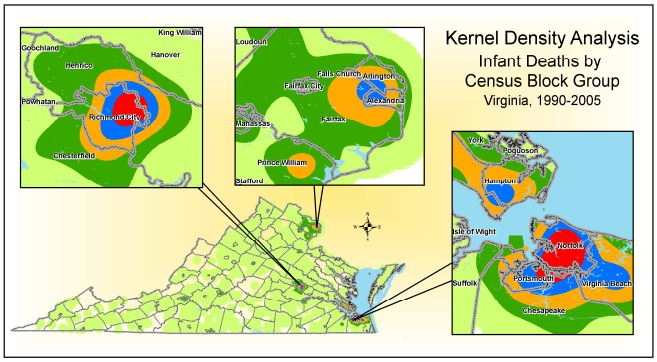
		Infant Mortality Rate (per 1,000) by CT Federal Poverty Level (FPL)			
	total	**0.0-4.9%**	**5.0-9.9%**	**10.0-19.9%**	**≥ 20.0%**
Total	6.0	4.1	5.5	7.1	11.6
White	4.5	3.5	4.7	5.6	7.0
Black	11.3	9.4	9.2	11.2	14.1
Hispanic	4.5	4.1	4.6	4.7	5.9
Other	4.1	3.3	4.7	4.9	8.7

* White and Black classifications are non-Hispanic. Rate calculations are based on birth and death data that geocoded correctly, 90%.

The georeferenced infant mortality data, the longitudinal data can be joined to normalized census tract boundaries (and even lower level census block groups and blocks), with known characteristics, such as Census 2000 poverty rates. It is only when data is so lined geospatially

that it is readily observed that the Black infant mortality rate (IMR) is higher than for Whites or Hispanics for all poverty levels and for census tracts with over 20% of the population below FPL,

Blacks have the highest IMR but Hispanics the lowest IMR in the state. The so-called "Hispanic Paradox" can be observed with macro-level data but the fairly stable distribution across all geographically defined poverty areas is instructive. The HPTA for Hispanics is more associated with linguistic isolation characteristics within census tracts than it is with their IMR at any poverty level. Looking at geocoded primary care provider data within these same Census Tracts clearly displays the statewide difficulty to attract providers to areas with multiple adverse health conditions and socially and economically compromised populations.

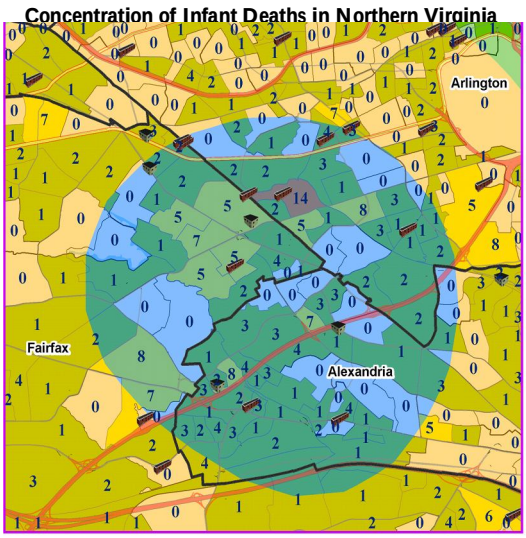


Cluster Analysis Tools. Using spatially referenced data at a more disaggregated Census Block Group level has allowed VaNGHR and VDH to surmount the artificial jurisdictional boundaries that often dominate traditional epidemiological geographical analysis. Using ArcGIS Kernel Density

analysis, it can be clearly seen how areas of high infant mortality are not respecters of county and city boundaries. Such "spill-over" effects point to the importance of ecological and social effects that are often spatially more continuous than can be observed in traditional graphic presentations.

VaNGHR partners are currently using the Index of Medical Underservice scoring methods used by the HRSA Shortage Designation Branch, to determine underserved areas at the Census Tract level, to determine which areas of the Commonwealth are in need of designation. Using these geographically constructed indicators, VaNGHR partners have been able within one year time to increase the number of designated census tracts with more than 20% of their population below FPL from 50% to 80%. Within these identified HPTA, six areas have been designated with over one million of federal PHS 330 funds being requested to develop clinic sites within these areas. The HPTA methodology has allowed VDH to become proactive rather than reactive regarding clinic site placement. The methodology has also raised the underservice scoring of these areas which also increases the chances of funding. One site, in fact, has been noted by a U.S. Senator, as worthy of special federal funding to address the infant mortality rate within a complex of HUD housing developments.

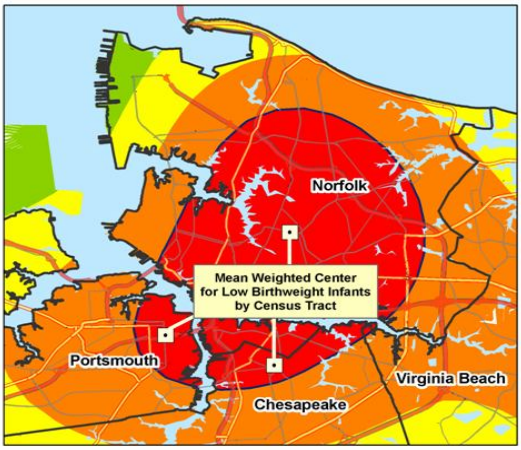
1990-2005 Block Group Infant Mortality Kernel Density Analysis



Source: VDH Vital Statistics, 1990-2005.

Likewise, with the new proposed regulations for federal underservice designations, VDH has been able to estimate the impact of the new rules and regulations on the ability of the Commonwealth to maintain designation of previously designated areas. With the ability to analyze all of the composite indicators except unemployment, at the census tract level, the impact of the new procedures have been evaluated for their potential impact.

Kernel Density Analysis of Infant Mortality in Virginia (Analysis based on Census Tract Data—1991-2005) With Optimum Locations for Clinics

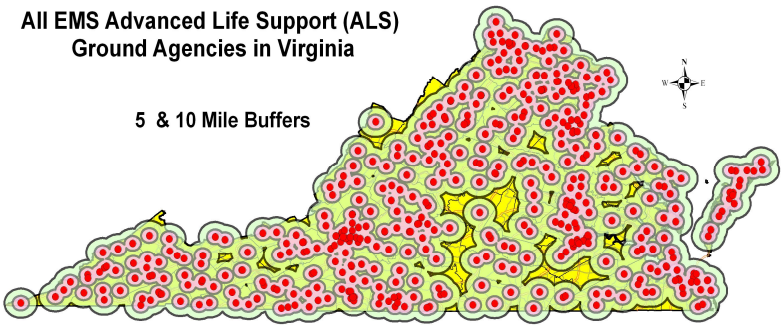


In addition to the HPTA analysis impact on identification and designation of health and healthcare compromised areas, the technique identifies specific neighborhoods—often even specific public housing developments—which require more immediate interventions. Complex and multi-faceted issues can be framed by GIS presentations and can

offer potential interventions in ways that words, with their associations and often political overtones, can not effectively express. The reframing of public health policy issues at the census tract and census block group levels, has become an effective argument for, among other approaches, the Community Based Participatory Research (CBPR) model. Focusing on outcomes, needs and public health concerns has been used to transition from models with few alterable policy variables to a plethora of actionable social variables.

Infant Mortality and Site Selection. In addition to designation, funding and intervention strategies, geospatially referenced data has allowed VaNGHR to engage in location analysis suggesting the need for services in specific areas of the Commonwealth and the evaluation of specific policy changes with reference to specific health care needs. With the assistance of Kernel Density analysis in locating significant concentrations of infant mortality at the Census Tract level, VaNGHR partners has further analyzed the data to provide suggestions to local safety net providers of optimum clinic development sites given various assumptions concerning the population to be served. Interestingly in the Portsmouth site analysis there already exists a Community Health Center, and in the Chesapeake site a current health department clinic exists that in process of applying for a PHS 330 grant. The Norfolk site location represents a new site but the area identified can be used to inform decisions as to the optimum placement parameters.

Emergency Medical Services: A related question concerning spatial distribution of providers can be seen in two analyses, one concerning the spatial coverage of Advanced Life Support (ALS) Emergency Service across the Commonwealth the other concern is with the lack of obstetrical services in isolated rural areas

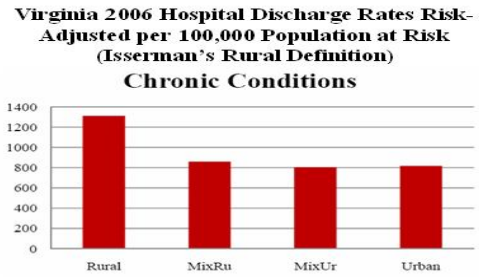


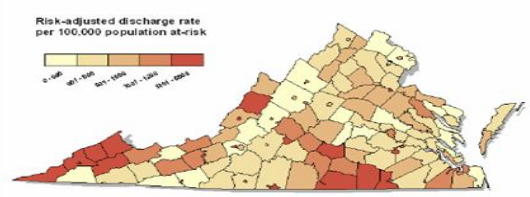
With a georeferenced database of all EMS services in the State, it was possible to locate the services and develop a buffer analysis to estimate the percentages of Virginia's population within five and ten miles distance from an emergency service. From the mapping it is immediately apparent that in the rural south central area of Virginia there would appear to be fewer EMS-ALS services than in the more urbanized northern-central-eastern corridor. It is predominantly in the south tier I rural regions of the state where the fourteen (14) percent of

Virginia Population, Households and House Units Served by Advanced Life Support EMS

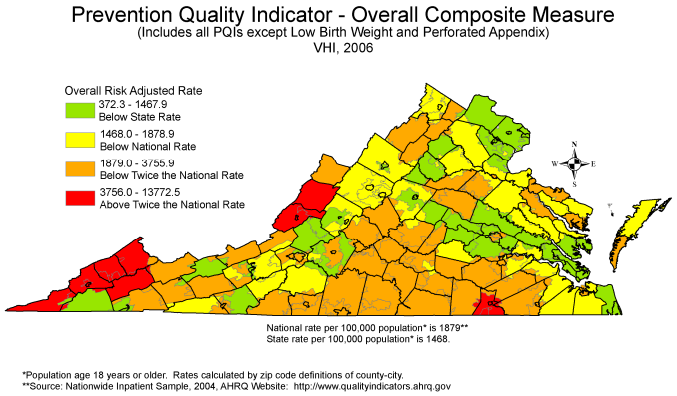
	Population	% Population	Households	% Households	House Units	% House Units
Virginia	7,078,515	100.0	2,699,173	100.0	2,904,192	100.0
10 Mile Buffer	7,027,030	99.3	2,679,964	99.3	2,880,274	99.2
5 Mile Buffer	6,065,495	85.7	2,319,543	85.9	2,480,667	85.4

the population (or 1,013,020 residents) live outside of the five mile buffer zone. And yet as can be seen from the tabular analysis made possible by the GIS analysis, over ninety-nine percent of Virginia's population is within ten (10) miles of ALS services. This analysis is currently suggestive of where some expansions could occur but further analysis based on age specific utilization rates of emergency services and the number of ALS teams at each site need to be analyzed to determine adequacy of coverage.



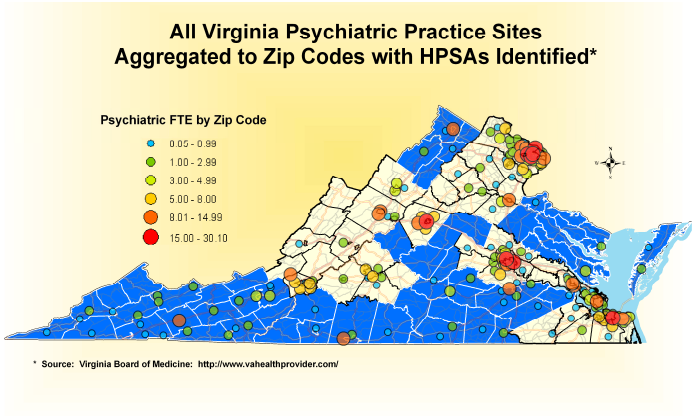


Since the inception of the Virginia Office of Rural Health in 1991, focus groups and stakeholder surveys have emphasized travel time and distance as the major access barrier to health care services for rural residents. The Governor's 2004 study of access to obstetrical services noted several rural areas in the Commonwealth that required women to travel over two hours to deliver their babies. Since this study was completed birthing center models have been supported legislatively and two model programs have been awarded grants to implement this model. In addition, (non nurse) Licensed Midwives have been approved for practice. The question at issue is therefore two fold, namely, (1) where are the areas that the birthing center model should be developed, and (2) are Licensed Midwives one of the answers for supplementing traditional obstetrical services in these areas.



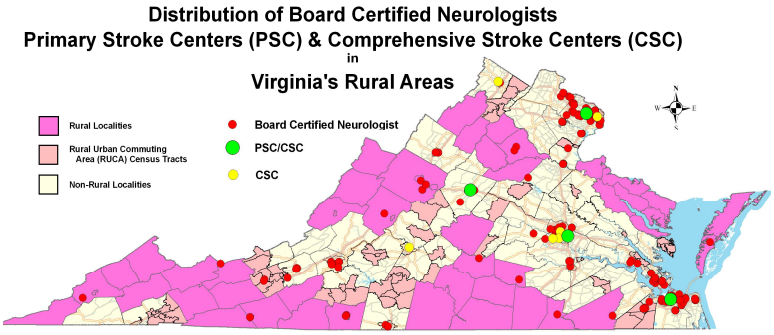
Models of Care

"Orphan" Health Care Services. Obstetrics is representative of a class of health care specialty services where the demand for services is declining within specific regions of the Commonwealth, most often rural areas, and the need has become even more pressing for those who remain and utilize the service. There is, in other words, a class of health care services that have lost their demographic base and the population at risk has become "orphans" within the health care system. One approach with regards to obstetrical care is the development of a pilot birthing centers program. The model not only (1) makes optimum use of midwives and other midlevel providers but it also (2) as a model is cost effective primarily because it circumvents the stringent staffing requirements of a hospital based obstetrical unit. In addition, the model enlarged the provider base by developing a new class of non-nurse licensed midwives. In addition it has stimulated discussion of hospital regulatory procedures with regard to, in particular, rural hospitals. It has become apparent, for instance that rural hospitals certified by CMS as Critical Access Hospitals (CAH) within Virginia are allowed to locate birthing centers within their facilities without requiring a Certificate of Need and without the regulatory requirements of traditional hospital based obstetrical units.



Similarly, we are using the AHRQ ICD-9-CM Code definitions of Ambulatory Care Sensitive Conditions (ACSC) (http://www.ahrq.gov/data/safetynet/billappb.htm) to assess specific hospital discharges requiring additional medical monitoring. In cooperation with the VDH Division of Chronic Disease, we are tracking ACSC for Chronic Diseases [e.g., Chronic obstructive pulmonary disease (ICD-9, 491, 492, 494, 496, 466.0), Asthma (ICD-9, 493), Congestive heart failure (ICD-9, 428, 402.01, 402.11, 402.91, 518.4), Hypertension (ICD-9, 401.0, 401.9, 402.00, 402.10, 402.90), Diabetes "A" (ICD-9, 250.1, 250.2, 250.3), Diabetes "B" (ICD-9, 250.8, 250.9), Diabetes "C" (ICD-9, 250.0)]. The availability of specialists that traditionally treat advanced states of these chronic diseases are notably lacking in most rural areas. Such specialist with their population to provider averages for the Virginia area are: cardiologists (3.44:100,000), pulmonologists (1.82:100,000), nephrologists (.98:100,000), opthamologists (4.52:100,000), psychiatrists (4.45:100,000) which suggest that the market base is simply not available in the sparsely populated rural areas for these specialties [see, "Physician Community Requirements in the 21st Century: The 2003 Physicians to Population Ratios," Solucient (now Thomson Reuters)]. The patients in need of such services are orphaned. Preventive interventions (e.g., diabetes training models for both diabetics and for primary care providers via telecommunication) and specialist support (e.g., through telemedicine consults) are currently being implemented. This will allow cost

effectively targeting of access to care models where chronic disease rates are exceptionally high but the population at risk is not sufficient to support specialists.



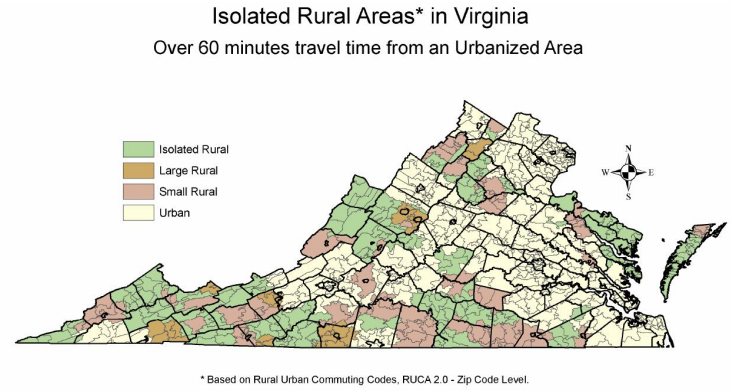
Stroke Care: The immediate impact of such analysis has been felt in the development of emergency stroke stabilization services via telemedicine for isolated rural hospital providers. This telemedicine medical care service allows distant rural hospitals and community health centers to provide immediate remote stroke diagnosis and allows stabilization while en route to the higher level stroke centers. VaNGHR has used GIS to evaluate the areas of need for such services and to successfully obtain grant monies from both the Federal Communications Commission (FCC, $1,200,000) and HRS-Health Information Technology (HIT) program (HRSA-HIT, 50,000).

WCHF Service Area
Bacterial Pneumonia (PQI 11) Patient Characteristics, VHI 2006

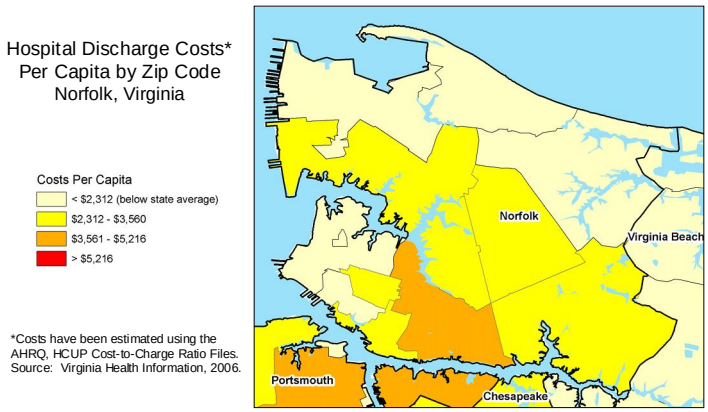
Hospital	Patient Discharges (n)	Race	Mean Age	Mean Total Charges ($)	Mean Distance (miles)
Sentara Williamsburg	3	Other	66.3	25,287	2.0
	35	Black	64.2	14,586	3.0
	165	White	74.5	16,500	3.9
Riverside Walter Reed	7	Black	64.6	22,058	1.3
	63	White	71.7	14,896	47.4

Distance. To continue its evaluation on the adequacy of the stroke stabilization program VDH is developing a continuous monitoring system to track all hospitalizations for Ischemic Stroke (where the primary diagnosis as ICD-9 433-434 and 436) and for Hemorrhagic Stroke (where the primary diagnosis was given as ICD-9 430-432) using the Commonwealth's Virginia Health Information (VHI) patient discharge database. Because the data is compiled by discharge patient zip codes, and not street addresses, we will be using zip code centroids and hospital point location data to estimate "crow fly" distance between these points using a generalized Pythagorean algorithm (i.e., "great circle distance" calculations). Because we have the full complement of hospital data from UB-91, UB-92 and (after March 07) UB-04 allowing analysis of hospital entry point (e.g., emergency room) race, gender, age, comorbidities, payer, etc. with the added spatial and distance variables. Thus analysis using the Agency for Healthcare Research and Quality (AHRQ) Healthcare Cost and Utilization Project (HCUP) algorithms, we will be able to analyze all of AHRQ's quality indicators taking spatial distribution and distance into account at the zip code level. We will be analyzing those stroke cases that entered the hospitals via the emergency room and will be linking these data where possible with EMS data.

Because one of the currently most relevant definitions of rurality for funding and policy is based on rural urban commuting area (RUCA) codes (www.ers.usda.gov/data/ruralurbancommutingareacodes/) These codes classify Census Tracts using measures of population density, urbanization and daily commuting patterns. These criteria utilize the same methodology used by the Office of Management and Budget to define county level metropolitan and micropolitan areas and are therefore consistent with the intent of these "sphere of influence" measures. These codes have been calculated at both the zip code and census tract level and have been used to identify rural pockets with the OMBs metropolitan classification. By using these codes it is possible to identify isolated rural areas of the Commonwealth that are more than 60 minutes drive time from an urbanized area and to calculate mortality rates, low-birth rates and other spatially referenced health outcomes data in terms of a rural urban continuum that is operationalized according to clearly delineated criteria.

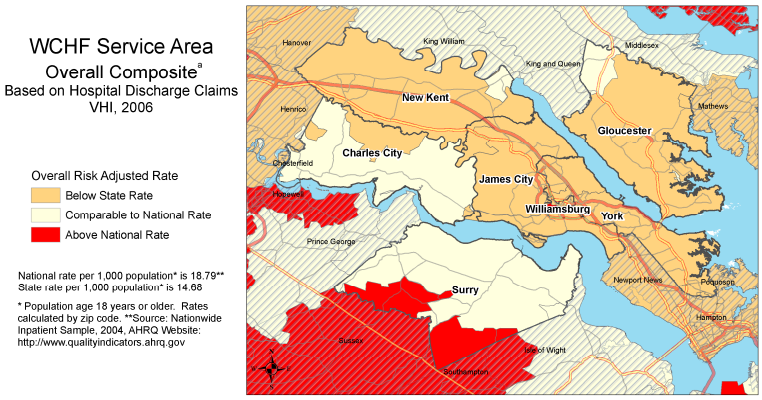


Hospitals, Costs and Care. We have begun a study of Virginia's hospital discharge database using the charge data and the HCUP Cost-to-Charge Ratio Files to estimate the resource cost of inpatient care and its variation across hospitals and conditions and their spatial distribution. Because it was initially discovered that clustering occur for total per capita hospital charges and other sentinel measures as would be anticipated in areas that are some of the poorest residents in the Commonwealth. Because these areas can be easily seen as health care "cost centers" and it is possible to aggregate all of the zip code per capita costs with z-scores more than 2 standard deviations above the mean, to comprehensively analyze the social ecological nature of such areas. We anticipate that Cost Center analysis combined with cost-benefit analysis will allow strategies to estimate the burden of negative health outcomes on the state and local governments. It has been strikingly demonstrated with even cursory observation that the highest per capita costs track closely with the high priority target area analysis.



As early as 1900 it was realized that the cost of low-birth weight infants was staggering.

> The State Perinatal Services Advisory Board has estimated that each year more than $1.6 billion in neonatal special care unit costs could be saved in Virginia just through statewide implementation of aggressive preterm birth prevention efforts (Report of the Virginia Health Planning Board, *Access to Obstetrical Care*, page 1, Senate Document No. 27, 1990)



[a] Overall Composite Measure based on Agency for Healthcare Research and Quality (AHRQ) Prevention Quality Indicators (PQIs). Includes all PQIs except Low Birth Weight and Perforated Appendix.

Because we are now capable of capture the precise spatial dimensions of these cost centers the crisis that was earlier understood can now be addressed with more refined understanding of the social and policy dimensions of low birth infants. What has been proposed for future research is a more detailed analysis of the "Burden of Care" at the local level where the fiscal stress of adverse outcomes often felt.