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Designating Places and Populations as Medically Underserved: A Proposal for a New Approach

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Abstract: This article describes the development of a theory-based, data-driven replacement for the Health Professional Shortage Area (HPSA) and Medically Underserved Area (MUA) designation systems. Data describing utilization of primary medical care and the distribution of practitioners were used to develop estimates of the effects of demographic and community characteristics on use of primary medical care. A scoring system was developed that estimates each community's effective access to primary care. This approach was reviewed and contributed to by stakeholder groups. The proposed formula would designate over 90% of current geographic and low-income population HPSA designations. The scalability of the method allows for adjustment for local variations in need and was considered acceptable by stakeholder groups. A data-driven, theory-based metric to calculate relative need for geographic areas and geographically-bounded special populations can be developed and used. Its use, however, requires careful explanation to and support from affected groups.

Key words: Access, primary care, underservice, Health Professional Shortage Area, Medically Underserved Area, resource allocation.

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Background

The search for an optimal method to prioritize the allocation of health care resources among areas and populations has been a long and often frustrating process. This paper briefly reviews that history in the United States and describes an alternative to current methods for designating and prioritizing areas and populations eligible for health care assistance from the U.S. federal government. This alternative measure of medical underservice and provider shortage was designed using guiding principles agreed upon by various stakeholders, theory from the academic literature, and methods drawn from econometrics and general statistical analysis. The development of this replacement measure was supported in part by the Health Resources and Services Administration; a proposed regulation incorporating its use is under consideration by the U.S. Department of Health and Human Services.

Attempts to identify medically underserved places date back to the 1930s[1] and the discussion of indicators of need was a part of the broader discussion of standards for medical care planning.[2] In 1970, the Emergency Health Personnel Act established the National Health Service Corps to serve "Critical Health Manpower Shortage Areas" (HMSAs). The regulations implementing the law set a criterion of one full-time-equivalent (FTE) primary care physician per 4,000 people as the threshold for designation of such areas. This ratio was applied to *rational service areas*, which were meant to approximate the catchment areas for primary care practices. Initially, these were primarily whole counties, but part-county and multi-county areas were later considered and designated. The Health Professions Education Act of 1976 then created Section 332 of the Public Health Service Act, which defined a review process for the designation of HMSAs and required that criteria be developed for designation of areas, population groups, and facilities with such shortages. These criteria were issued in 1978 and, for primary care physician shortages, involved lower ratios of 1:3,500 for geographic areas and 1:3,000 for population groups. (Criteria were also defined for Dental, Mental Health and other types of shortage areas.)

The 1973 Health Maintenance Organization Act, P.L. 93-222, took an even broader view of community need and called for the identification of Medically Underserved Areas (MUAs). An Index of Medical Underservice (IMU) was developed using a nominal process where a group of experts reviewed the statistical characteristics of a large number of areas considered well- or under-served and proposed a summary measure. The IMU included four factors: the primary care physician-to-population ratio; the infant mortality rate; percentage of people age 65 and over; and percentage of population with incomes below the federal poverty level.

The two systems were criticized early in their implementation. The IMU was described as lacking a conceptual core and unable to differentiate underservice from access or health status[3,4] and as being unable to identify truly needy areas adequately.[5] An evaluation of the health manpower shortage criteria concluded that the "HMSA criteria cannot successfully delineate areas in a way that meets multiple and inconsistent objectives. The inconsistent objectives are the requirement that areas be capable of developing the support needed for a viable practice, and the requirement that need for care be

addressed without regard to manpower availability" (p. 304).[6] They recommended that ". . . greater consideration be given to indicators of effective demand" (p. 305).[6]

Beginning in 1975, the MUA designation was required to qualify areas as eligible for Community Health Center (CHC) grants. The adaptation of the MUA to the CHC program started a general trend of using these designation systems to qualify applicants for programs that formed what came to be called the federal health care safety net. By the mid-1990s, the MUA and the HMSA (by this time renamed Health Professional Shortage Areas (HPSAs)) were being used to determine eligibility for over 30 different federal assistance programs.

In the early 1990s, the Bureau of Primary Health Care started work on revisions to the HPSA and MUA systems (now expanded to include a Medically Underserved Population (MUP) definition, often combined with MUAs as MUA/Ps). In 1995, the U.S. General Accounting Office (GAO) published a report titled, *Health Care Shortage Areas: Designations Not a Useful Tool for Directing Resources to the Underserved*.[7] The report found a number of flaws in the HPSA and MUA designation systems for identifying shortage areas and their use for targeting funding to the underserved. The report also found that the designation systems were neither timely nor consistently accurate and suggested they did not necessarily merit renewal or updating. The report recommended that the HPSA and MUA/P designation systems be replaced with more specific designation criteria created for each of the different federal assistance programs that were using them. The GAO observations were echoed in the field as stakeholders expressed the view that the system had become unwieldy and arbitrary.[8] During the same period, there were apparent shifts in how policymakers viewed the distribution of primary care resources in the nation. A previously recognized national shortage of primary care professionals had been replaced by a perceived potential surplus of physicians coexisting with continuing inequity in geographic distribution.[9] At the same time, more federal programs were linked to the HPSA and MUA/P designations.[10] These factors contributed to a growing perception, beyond the Congress and including the implementing agency and stakeholders, that the existing HPSA and MUA/P designations were not adequate for the identification of underserved communities.

In response to the GAO Report and other stakeholder concerns, the Bureau of Primary Health Care (BPHC) developed an alternative designation process, making use of an enlarged set of variables and a series of weights to qualify areas and populations for assistance. The Bureau issued a Notice of Proposed Rulemaking (NPRM) in the September 1998 *Federal Register*[11] (referred to in this paper as NPRM-1) which proposed combining the two designation processes into one new method. The BPHC invited comments on the proposed rule and received an unusually large number (800), most of them from stakeholder groups objecting to some specific element of the proposed formula that would create more "losers" (undesignated places) than "winners" among their constituents. External analysts modeled the effects of the proposed system of designation and found that up to half of all previously designated areas would lose their designation if the new formula were applied to current data for the communities and populations.[12] As a result, HRSA withdrew its proposal, but committed to developing a new one based on analysis of the public comments received and with input from

analysts who had modeled the impact of the previous proposal. Ultimately, the agency entered into a cooperative agreement with the University of North Carolina to create a revised method. This article describes the results of that work, which forms the basis for a revision of the designation rules. The proposed rule changes were approved by the Secretary of Health and Human Services on March 26, 2007 and a "notice of proposed rulemaking" will appear in the Federal Register sometime in 2007. After a 6-month comment and review period, which may result in modifications to the proposal, the final rule is scheduled for publication in early 2008.

Guidelines Constraining the New Scheme

Among the criticisms of the revision proposed by HRSA in 1998 (NPRM-1) was that its development did not make use of the most current data, and that it did not develop out of a general theory of access and underservice. The 1998 proposal was based on the extant literature, but the working group did not conduct original data analysis to develop weights or link the process to a formal generalized theory of access. The HRSA team did conduct an impact analysis of the effects of the proposal but the analysis used 1994 or earlier data, resulting in an underestimate of the number of places that would lose designation.

To assist the study group in defining the scope of the problem, five key elements were specified as highly desirable in a future method for designation. These were developed with contributions from key stakeholders, including federal agency staff, state organizations that supported safety net providers, and the safety net organizations themselves. Those elements were:

1. *Simplicity*: The new underservice measure must be understandable and usable by those who seek designation. The use of reference tables to convert raw data to scores (similar to those currently used in the calculation of the MUA/P) was particularly desirable. Furthermore, the number of factors included in the calculation should be limited. The process should be simple enough that, given the data, the score could be computed in about 5–10 minutes.

2. *Science-based*: The new underservice measure must be based on scientifically recognized methods and be replicable. For example, the current Index of Medical Underservice comprises four variables, each of which contributes approximately a quarter to the maximum score. There is no empirical justification for the percentage of the population below the poverty line having a weight equal to the infant mortality rate. The contribution of each variable to an overall measure should be based on some verifiable statistical relationship.

3. *Face validity*: The new underservice measure must be intuitive and have face validity. For example, factors that reflect progressively worse access should result in proportionately increasing scores. Stakeholders in the process should contribute to the selection of indicators.

4. *Retention of designations for places with safety net providers*: The new underservice measure should not dramatically affect the overall number of designations for places with safety net providers. Most places that currently have safety net resources and that are serving a substantial number of uninsured, low-income people, or people who

would otherwise not have ready access to primary care, should retain their associated designations. Secondly, the new measure should designate approximately the same overall total population included in currently designated areas and populations, but better focus the designations to more needy areas and populations.

5. *Acceptable performance*: The new system must perform better than alternative proposals and better than the current designation criteria using updated data. *Better* is vaguely defined, since multiple criteria will likely be used to judge whether the new system is an improvement over current rules. The new rule should be seen as an improvement by the multiple key stakeholder groups.

The guiding principles received roughly equal weight in the construction of the new method and its application. When two principles were in conflict and the advantages from choosing one over the other were roughly equal, the principle listed first on the list was given priority. Thus, if the use of a more complex set of tables and calculations on the part of applicants would bring only minimal improvement of the accuracy of the estimate of underservice, then the priority would be given to the simpler option.

The Population Denominator

To integrate the HPSA and MUA/P designation processes logically and scientifically required some common theoretical basis for the two. This was drawn from frameworks and theories that defined or described the concept of *access* to health care. This is consistent with the goals of the programs that make use of the HPSA and MUA systems, which are to improve access to care for underserved populations. In HPSAs, by definition, access is restricted because there are few or no primary care health professionals who will take care of certain patients. The remedy for this is to supplement the professional supply with practitioners who will see all patients, in order to bring the numbers of professionals more into line with a level of supply generally considered adequate. For MUA/Ps, the primary reasons for designation relate to barriers to accessing existing primary care services (e.g., financial) or the combination of higher needs and lower availability. The central task in combining these two systems was to find a common metric that was sensitive to both of these characteristics of underservice.

The prominence of population-to-practitioner ratios in the two existing measurements of underservice was recognized. Discussions with the federal agencies and stakeholder groups during the development of the revised approach revealed a preference for using that metric as the basis for a revised method. Practical reasons for the use of this ratio as a starting point for the construction of an index included the fact that such ratios are well-recognized and understood by the program participants and would provide some continuity between a new proposal and the older methods that included the ratios in the calculations. However, there was no consensus on the right threshold for a ratio that would trigger designation and there was pressure to create an abstract, multifactorial index, or score, that did not refer statistically or lexically to the population-practitioner-ratios. Following the guiding principles agreed upon at the outset of the project, the team elected to attempt to create an index that was related in scale and form to a ratio but was derived from a weighted, multifactorial process. The index was conceived to reflect the logic that meeting community needs could be

expressed in ratios of appropriate use to optimal service productivity. The use rate would be expressed in population counts and the service productivity in practitioner counts. The goal was to reflect the level of a population's need for office-based primary care visits in terms of an adjusted population count that took into consideration the age-gender structure as well as characteristics that would affect use of services.

The assumption was made that, for groups without significant barriers to care, primary care utilization rates would cluster around the most appropriate level. Office-based primary care visits were considered the most appropriate metric of use since they corresponded to the central "product" of safety net programs. The initial analysis examined survey data on the use of services drawn from the 1996 Medical Expenditure Panel Survey (MEPS). In the MEPS, use rates vary by age and sex but also by characteristics that can be related to community level rates (e.g., unemployment, income, race, and geographic location). These variables, when aggregated, have been commonly used to describe restrictions on realized access for populations and have been used to estimate need for services and underservice. Recent work by Krieger and colleagues has supported the utility of linking areal socioeconomic data with individual measures of health status.[13] The project goal was then to estimate the degree of shortage or underservice faced by a population based on the aggregate characteristics of the population and the relationship between those characteristics and the available supply of primary care services.

Use of services is considered an outcome of a health care system. The lower use rates of minority, unemployed, low-income, and certain rural and inner city populations who do not have an established or acute illness are reflected in lower primary care office visits reported in the MEPS. The association of a characteristic of an individual, such as being unemployed, on access can be expressed for populations in the relationship between a related aggregated factor (% unemployed) and population access. These aggregated factors that create barriers to care are often also associated with lower numbers of primary care practitioners in communities. These correlations raise the question of whether the use rates are depressed due to lack of practitioner supply or to the restricting effects of individual and aggregate characteristics on demand for practitioners. Some researchers have observed a relationship between the supply of primary care practitioners and health outcomes measured as preventable hospitalizations.[14,15] This potentially creates a paradox since low access results in subsequent illness that may require hospitalization which, due to the entry of the patient into a structured care system, may actually induce subsequently higher rates of use of primary care services incident to the hospitalization or due to raised familiarity with the system. This paradox is likely to affect overall use rates in low-access areas in such a way as to increase use rates. We accepted that these positive and negative factors would be simultaneously operating and sought ways to estimate their individual effects in terms of both reduced and increased visits. The net, overall need for services can be reflected in a combination of visits precluded with visits induced.

Absolute number of reduced visits caused by access barriers	+	Absolute number of increased visits caused by delayed care or greater morbidity	=	Total visits to be provided by accessible providers

The Numerator in an Underservice Index: Practitioners

The programs that rely on a shortage designation are structured to provide solutions that do not allow for small incremental additions to capacity. Clinics and professionals, when placed into communities require sufficient demand to justify the expense of their support. Thus, a measure that is used to trigger assignment of a practitioner or the decision to fund a clinic should reflect a threshold level of need for, at least, an additional, potentially autonomous, practitioner. This measure has been expressed as a population-to-primary care physician ratio; the identification of the optimal ratio has been the subject of contention for decades. Goodman and colleagues suggested benchmark ratios to compare relative supply; their preferred ratios bracketed 1,500:1.[16] That ratio as a gold standard for reasonable access is supported by data from the National Ambulatory Medical Care Survey (NAMCS). The NAMCS annually estimates the number of physician office visits per person per year.[17,18] The visit rate to primary care physicians in 1998 was 1.94 per person. This translates into a ratio of 2,132 persons per full-time-equivalent (FTE) primary care if all primary care visits and only primary care visits are allocated to primary care practitioners. However, it is reasonable to assume that a portion of visits to specialists are for primary care reasons and, in creating an optimal rate for programs that place or support only primary care services, the potential need or demand for those visits should be included in the calculation of a community's level of underservice. The NAMCS data indicate that 20% of visits to non-surgical specialists were primary care visits; this produces a ratio of 1:1,909. However in a community made up of a mix of generalist practitioners (family medicine, pediatrics, obstetrics/gynecology, internal medicine), it is reasonable to expect practitioners to be able to see 90% of the total office visit demand (effectively, 2.763 visits per person); the national mean ratio would then be 1:1,498. Based on this overall mean ratio, we posited a preferred ratio of 1,500 people per full-time primary care physician as a central-tendency standard of adequate access. Setting a ratio of 1:3,000 as a trigger for designation would then be a conservative approach to identifying a threshold since it reflects the productivity of an additional FTE physician. We chose to accept that level as guidance for a score or index of underservice both because it reflected the logic of adequate demand for services as well as because it was in agreement with prior policies that used similar ratios in federal designation systems.[6,19]

Combining Numerator and Denominator to Calculate an Index of Underservice

The project team sought to create a measure of underservice that was based on recognizable concepts of supply of services and population-based need. Need for services would be expressed as a population adjusted to reflect community and individual barriers to access as well as induced need. That adjusted population was included in a ratio to FTE primary care practitioners. The population to FTE ratio was then further adjusted to account for community or service area factors that are thought to increase need further (above the population adjustments already made) to create what we have called an Underservice Index.

Underservice Index	=	Adjusted population-to-practitioner ratio	+	Total score from demographic, economic, and health status factors

This new measure is intended to resemble the current MUA/P method in that it creates a score or index of underservice. The implementation is also similar to the current MUA/P and HPSA methods in its use of a population-to-primary care provider ratio and the accommodation of other high need variables; these two components are key pieces of the new underservice measure. The following section describes the process used to calculate the Underservice Index, starting first with the development of an adjusted population component, which is then modified to consider service area variables.

The Population-to-Provider Ratio

The ratio numerator. The ratio includes a denominator, which is termed the "barrier-free, use adjusted population." Unlike previous underservice measures' use of an actual population in a ratio, the proposed system's ratio is based on an adjusted population that is meant to represent an *effective* or *apparent* population and its primary health care needs. Pursuant to the theory presented earlier, the population used for the ratio is adjusted to reflect age and sex-specific primary care rates in an access barrier-free (or minimal barrier) population. That is, if the population of a community were able to use primary care services at the same rate as a population with no constraints due to poverty, race, or ethnicity, what would the use rate be for each age-sex group and for the entire population? The reason for the restriction to a barrier-free population is that income or racial barriers may have effects that vary by age and sex, distorting age and sex-related differences in primary care use rates.

The standard for utilization is based on the estimated primary care office visit rate for the national population segment considered to have the fewest or no access barriers. The Medical Expenditure Panel Survey (MEPS) sponsored by the U.S. Agency for Healthcare Research and Quality (AHRQ) periodically fields a national survey of the population to estimate overall utilization of health care services. We operationalized this desired visit rate as the overall primary care office visit rate for the population that is (1) White, (2) non-Hispanic, and (3) non-poor, estimated using the 1996 MEPS. Employment status, although included in the MEPS survey and a significant correlate of use of service, was also intercorrelated with the other variables and was not included in the final visit calculation. These rates were estimated for six age groups each for males and females. Table 1 shows the utilization rates for the White, non-Hispanic, non-poor, by age and sex.

This target visit rate can be calculated for any area for which we have population data broken down into these 12 age-sex classifications; population data at this level are available for all counties and all sub-county census areas. Using a community's age and sex distribution, these rates were used to calculate a visit requirement for each community {i.e., 4.046 * (# Females 0–4) + 2.256 * (# Females 5–17) + ... + 8.056 * (# Males 75 and over)}. Dividing this visit requirement by the average number of visits reported in MEPS in a barrier-free population, 3.741 visits per person per year, gave an area's barrier-free use adjusted population. For example, a county with a total population of 12,000 people with 1,000 in each of the 12 cells would have an optimal

Table 1.

VISIT WEIGHTS FOR AGE-SEX ADJUSTMENT (1996 MEPS)

	0–4 years	5–17 years	18–44 years	45–64 years	65–74 years	75 years and over
Female	4.406	2.256	5.007	5.480	6.710	8.160
Male	5.164	2.499	2.867	4.410	6.052	8.056

MEPS = Medical Expenditure Panel Survey

use rate of 61,067 visits, the sum of each of the visit rates times 1,000. The effects of the adjustment effectively increase county populations by a mean of 16.3% (range = 6.7% to 40.3%).

The ratio denominator. Following current federal practice, the providers included in the ratio include primary care doctors of medicine (MDs), including interns and residents, and primary care doctors of osteopathy (DOs), including interns and residents; nurse practitioners (NPs) and physicians assistants (PAs) who are associated with a primary care physician; and all certified nurse-midwives (CNMs). Eligible providers must be non-federal providers of direct patient care. Primary care physicians (MDs and DOs) are practicing principally in general practice, family practice, general internal medicine, pediatrics, or obstetrics and gynecology. Primary care NPs, PAs, and CNMs are similarly defined.

All practitioners are measured in full-time equivalency (FTE) units weighted for relative productivity and scope of practice. The proposal matches current practice in allowing applicants to adjust the FTE numbers to agree with the actual availability of practitioners to the general population; this is done via local or statewide surveys. The relative weights for the practitioners were determined externally to the process by consensus among the stakeholders and the federal agency. That weighting process is under further review at the federal level and may be modified prior to inclusion in a final rule. At the time this article was written, the productivity/scope of practice weights were 1.0 for physicians (MDs and DOs, not including interns and residents), 0.5 for NPs, PAs, and CNMs, and 0.1 for MD and DO interns and residents. The assignment of relative weights to primary care practitioners has been controversial and was subject to much debate in the development of the process. However, there was no consensus among the stakeholders on how to provide more accuracy or specificity to the weighting so the criteria were set at levels that had been suggested in the past.

Need variables. The goal of the programs that are linked to designation is to improve access, thereby improving health. This consideration drove the design of the analysis to develop weights for *need for services* in areas and for populations. We followed the conceptualization of access proposed by Andersen and colleagues, who posit that there are predisposing and enabling characteristics that can represent need.[20–22] There is no consensus set of community-level indicators that reflect need within their framework.

Given the emphasis on the placement of primary care practitioners and their staffing of the clinics and primary care centers that were linked to designation, the project chose to use primary care population-to-practitioner ratios as a proxy indicator of relevant need and to examine how those ratios varied with socio-demographic indicators at an appropriate geographic level, in this case the rational service area as defined by the agency. Geographic adjustments to the supply of practitioners were not used in the analysis because it was felt by the funding agency that these methods had not gained wide acceptance in the field. There are several methods available to account for cross-boundary use of primary care services using GIS systems including floating catchment areas,[23] smoothing algorithms,[24] raster-assisted weighting,[25] and geographically-weighted regression techniques.[26] These methods are gaining wider acceptance and will likely be used in future revisions of regulatory mechanisms intended to identify populations in need.

Candidate indicators were drawn from earlier analytical work[27] and from contributions by a working group of State Primary Care Associations (PCAs) and Primary Care Offices (PCOs) convened by the Division of Shortage Designation (DSD) to gather state-level input. The staff and leadership of the DSD also contributed extensively to the design. More than 60 discrete variables were suggested during the process and the stakeholder group proposed a listing of 18 general variables with multiple specific indicators, ranging from specific health status or use indicators, such as ambulatory care sensitive condition admission rates, to census-derived linguistic isolation, to general morbidity rates for common diseases such as diabetes and more rare diseases such as cancer. Behavior-linked variables were also suggested, including obesity and smoking rates along with utilization of existing safety net providers. Some promising candidate variables could not be used, despite being highly correlated with primary care practitioner-to-population ratios and despite representing health outcomes that safety net programs were to address (e.g., the number of uninsured persons). This was mostly due to their lack of consistent availability at the small area level appropriate for designation. The final choice of variables and the priority for inclusion in the analysis were based on the degree to which the variables reflected underlying components of access as qualitatively assessed by the UNC-CH team, the PCA/PCO group, and staff of the Bureau of Primary Health Care (BPHC) as well as their stability and regular availability at the county level or the level of smaller areas. The final measures included the demographic, economic, and health status indicators summarized in Box 1.

Demographic characteristics. Population characteristics, especially racial and ethnic characteristics, have been consistently shown to affect access to primary care.[28–30] Measures of the proportion of the population that is non-White, non-Hispanic and proportion of the population that is Hispanic were used to adjust the ratio further. The proportion of the population older than 65 years was also included because communities with higher proportions of elderly residents have unique community characteristics not captured in the initial population adjustment. This could be due to the relative lack of younger people to provide supportive care and the fact that communities with declining economies, especially rural communities, have older age profiles that combine with other factors to create overall worse access.

Economic characteristics. Income and employment are very strong indicators of ability

Box 1.

VARIABLES USED IN CREATING PROPOSED METHOD

Demographic Population density	Economic	Health status
☐ Percent non-White	• Percent population <200% FPL	◊ Actual/expected death rate (adjusted)
☐ Percent Hispanic	• Unemployment rate	◊ Low birth weight rate
☐ Percent population >65 years		◊ Infant mortality rate

to access primary health care and to afford health insurance.[31–33] The unemployment rate and the proportion of the population below 200% of the federal poverty level were used to further adjust the ratio.

Health status characteristics. Certain populations and communities have higher than average need for health care services, based primarily on their health status independent of other factors. Therefore, health status measures used to adjust the ratio include the standardized mortality ratio (SMR),[34] and the infant mortality rate or the low birthweight rate.[35,36] These special epidemiological conditions that increase need are not fully represented in the age-sex adjustment.

Unit of Analysis to Derive Weights

The goal of this step was to weight the relative effects of local population characteristics on practitioner supply appropriately and to include that in the calculation of need. The assumption was that a place or population might have attracted more or fewer practitioners than would be expected based on a summary regression model. The general approach was to take population-level variables characteristic of beneficiaries of the federal programs that used the HPSA/MUA methods and then determine the relationship of those variables to the adjusted population-to-practitioner ratio described above, using regression analysis. From this analysis, the relative influence of those variables on the ratio would be derived and, from those parameters, scores could be estimated to adjust the overall index.

To approximate normal market geography, a sample of counties and county equivalents that serve as proxies for a health care market were selected to derive the area characteristic weights. This step was carried out in order to identify places that functioned as primary care service areas and that reported stable, reliable, usable data. Many U.S. counties meet these general qualifications, and the process selected a range of counties that met certain further criteria: populations less than 125,000; area less than 900 square miles; and unadjusted population-to-practitioner ratio less than 4,250 to one. This yielded 1,643 counties of the total of 3,040. Variations in the criteria were used and tested, altering population between 80,000 and 150,000; area between

700 and 1200 sq. miles; and the ratio between 3,000 and 4,250. The estimates derived from the models were not substantially different among the different samples. In effect, the criteria eliminated very small and very large counties and counties with unusual distributions of health practitioners.

Counties were chosen because they are well-defined and are not endogenous to the current system. Using currently designated areas would lead to biased conclusions due to the fact the subcounty areas are carefully and deliberately constructed for purposes of designation. Furthermore, dividing a county into subcounty-designated and subcounty-undesignated areas would generate an extremely large number of possible observations in the analysis since the county could be divided in many different ways and into many subsets of county parts. Finally, since most available health resource and health status data are calculated and reported on a county level, measurement error is minimized by using counties. Using other units of analysis requires interpolating values for subcounty and multicounty areas based on the constituent geographic units.

The Dependent Variable: Adjusted Population-to-Private Supply Provider Ratio

The dependent variable in the regression model is the age-sex adjusted population-to-primary care provider ratio. While the practitioner count follows the general guidelines described earlier (non-federal, direct patient care MDs, DOs, NPs, PAs, and CNMs), an additional restriction is imposed. The analysis included only those practitioners practicing in the community without federal support or without incentives to practice in state- or federally-operated facilities. Practitioners in the National Health Services Corps (NHSC) and State Loan Repayment Programs (SLRP) and J-1 visa physicians are not included in the ratio for the regression model.

Independent Variables as Percentile Scores

The value for each need variable was assigned a percentile rank based on the distribution of actual values of all U.S. counties. This was done to allow for future changes in the scaling of the scores when there are changes in the distribution of values. The use of percentiles will allow policymakers a choice of how often (or whether) to update the values without having to change the overall approach to developing component scores.

For all variables, except population density, the theoretically worst actual value corresponded to the 99th percentile (e.g., the higher the unemployment rate in an area, the higher the percentile). Population density was the only need variable lacking a natural theoretically worse value. Both very low density and very high density areas would be expected to have greater health service needs and problems with primary care access than moderately dense areas. Since we found that other indicators of need increased consistently with higher density, we set the lowest population density at the 99th percentile.

Due to a skewed distribution across the areas, we modified the definition for the percentage of non-White population so that only the top (most non-White) 60% of areas could be included in the weighting for the non-White variable. Areas with non-White populations lower than the 40th percentile were assigned to the zero percentile;

the actual value at the 40th percentile is 2.6% non-White. Following existing agency practice, the analysis also combined low birth weight and infant mortality into one measure, taking the higher of the two as the percentile value for adverse birth outcomes for a given area.

The associated percentile values for all need variables were subsequently transformed to a logarithmic scale so that the highest derivative corresponded to the theoretically worst end of the scale. For example, the independent variable corresponding to poverty was defined such that the fastest acceleration in the poverty component score occurred at high levels of poverty rather than at low levels. The model thus allowed a greater relative weight difference between the 95th and the 96th percentile than between the 5th and 6th percentile.

Controls for Multicollinearity

Because many of the need measures were moderately inter-correlated, we performed a principal components factor analysis to create uncorrelated factor scores for the selected variables to use in the regression modeling. To further ensure unbiased estimators, the regression model was structured as a weighted least squares regression using county total populations as weights. Parameter estimates from the regression were further adjusted for their statistical significance by weighting the parameter contributions to the need component scores using transformed standard errors.* A set of scores that could be added to the adjusted population portion of the ratio were derived for every combination of assigned percentile values for all the variables. However, the scores, at this stage, did not represent the full range of association between the variables and the ratios. The scores were derived using county-level data, where the maximum ratio was restricted to 4,250:1. If the scores were to estimate ratios larger than this maximum accurately, the dimension of the scores would have to be changed to allow for those higher values. In reality, 10% of all U.S. counties have ratios greater than 4,250. A second consideration was that the ratios themselves were constructed with the assumption that the numbers of primary care practitioners reported in national data sets overstate the actual numbers providing care in the counties and areas designated as HPSAs.[37] Applicants for HPSA designation are currently encouraged to adjust for this by surveying locally to estimate the actual FTE supply in their rational service areas; this is done by most applicants and the actual FTEs are reported by the agency in its summary of HPSAs. This adjustment yields a reduction of FTEs of approximately 20%. To compensate for the overcount of practitioners and the exclusion of the high ratio

*The process involved four steps: (1) Obtain the variance-covariance matrix V of the parameter estimates from the regression. (2) Compute the weighting matrix W defined as the inverse of the Cholesky transformation of a zero matrix except for the diagonal, which consists of the diagonal of V. (This is identical to a zero matrix with diagonal elements equal to the reciprocal of the standard errors of the parameter estimates.) (3) Transform the vector of parameter estimates (omitting the constant) b by $b^* = b * W *$ number of factors/trace (W). The trace portion of the expression ensures the weights sum to the number of factors. (4) Compute $F = S\ b^*$ as above. An alternative treatment would be to discard any statistically insignificant estimates. We have strong conceptual biases against employing such stepwise procedures.

counties, the scores were adjusted to levels that would predict the full range of actual ratios, were they translated back into parameter weights in a regression. This adjustment to the scores is in a sense arbitrary but necessary to make use of the intuitive appeal of the 3,000 cut-off point. This decision was supported by the impact analysis described below. The distribution of the final scores is depicted in Figure 1.

Application of the Proposed Method

The goal of the regression process was to derive weights that could be used to adjust the population to practitioner ratio to reflect the relative effect of aggregate population and area-level characteristics on demand and use of services. The weights are in the same metric and can be interpreted as population-equivalent additions that are added to the demand facing each FTE. The scores were then added to the adjusted population total to create a "total score" that resembled a further adjusted population. Figure 2 provides a summary of the steps involved in combining the adjusted population ratio with the scores for demographic, economic, and health status factors derived from the regressions. Table 2 presents the calculations for data from a random set of U.S counties ranging from very urban to very rural. The designation status as of 1999 is also indicated. *Whole* means the entire county was designated; *part* means that part of the county was designated; and *lowinc* means that the low-income population in the county was designated.

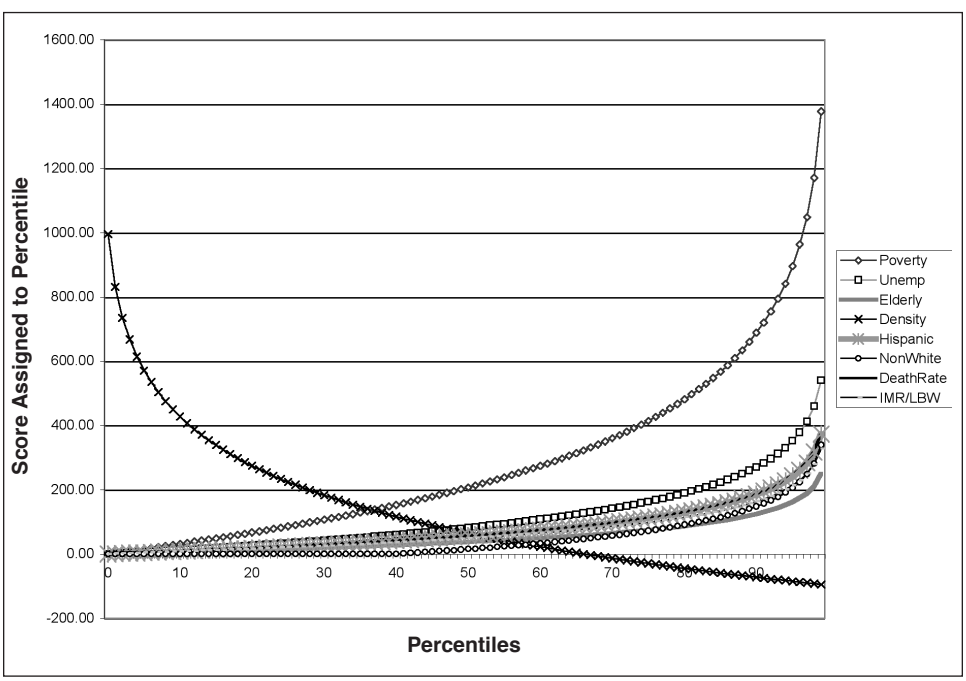

Figure 1. Summary of weights for barrier factors.

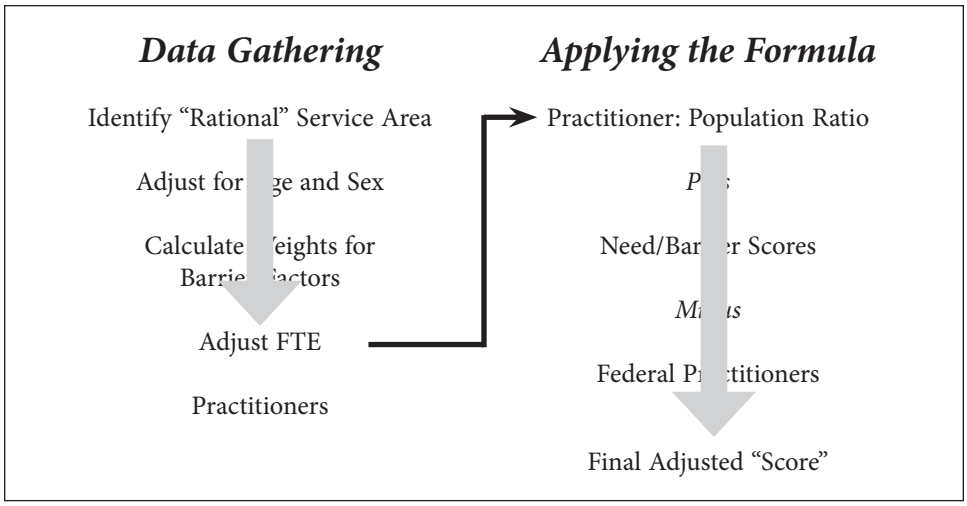

Figure 2. The proposed designation process.

Table 2 also shows the application of the scores to the ratios of population to practitioners; this is presented in two ways, before and after accounting for federal practitioners who may be placed in the area by some program that depends on a designation. The scores from the weights change the ratios into a designation score and, without the removal of the practitioners placed in areas by federal programs, three of the counties have scores above 3,000, the designation threshold (Score1 in bold). The initial total score, Score1, includes all primary care providers regardless of the reason for practicing in the community. The federal government recognized, however, that including safety net providers in a designation measure could result in a yo-yo cycle whereby the safety net providers provide enough capacity for an area to lose its designation status. Thus, the final total score, Score2 in Table 3, takes out those practitioners; in the example, an additional county reaches the threshold ratio as a result. The practical application of the system would make use of Score1 for an initial determination and, if the applicant falls below the threshold, the FTE adjustment to create Score2 would be carried out. This step would make use of national data sets that identified practitioners placed by federal programs or, where possible, local surveys to count the FTEs of primary care practitioners accurately to adjust supply.

Although the proposed scoring system is expressed in terms that appear to be population counts, it is a far more complex metric and actually represents the integration of a number of ecological and individual characteristics of any group or place and not a population *per se*.

Effects of the Proposed Underservice Index

The agency and stakeholder groups were very interested in the effects of any revised designation formula and part of the contracted work included impact testing on all designated areas. The revised scoring method was designed for so-called *geographic*

Table 2.

EXAMPLE SCORES AND RATIOS

County Name	HPSA designation 1999	MUA/P designation 1999	Total population 1999	Age-gender adjusted population	Total FTE primary	Adjusted population FTE ratio	Score from weights[a]	Score1	Ratio w/o Fed. FTE	Score2
Coconino, AZ	part	part	116,977	127,492	91.7	1,389.6	1,161.4	2,550.9	1,444.7	2606.1
St. Lucie, FL	low-inc.	whole	180,937	222,417	105.1	2,116.5	918.3	**3,034.8**	2,314.7	**3233.0**
E. Baton Rouge, LA	part	part	395,635	447,680	379.5	1,179.7	640.2	1,819.8	1,185.9	1826.1
Dunklin, MO	none	whole	33,006	40,146	22.8	1,764.6	1,469.4	**3,234.1**	1,764.6	**3234.1**
Bronx, NY	low inc. & part	part	1,185,970	1,366,382	1,210.6	1,128.7	1,665.3	2,793.9	1,199.6	2864.8
Burlington, NJ	none	none	416,853	482,594	411.2	1,173.6	251.6	1,425.3	1,179.4	1431.0
Guernsey, OH	part	part	40,854	48,273	20.2	2,389.8	751.7	**3,141.5**	2,389.8	**3141.5**
Rusk, WI	low-inc.	whole	15,449	18,501	10.8	1,713.0	1,070.5	2,783.6	8,043.7	**9114.2**

[a]This is the score that is calculated by multiplying the regression parameters by the percentiles rank for each area or population for the 9 variables in Table 2. Figure 1 depicts the values for the score components by percentile rank.
Boldface scores reach threshold.
HPSA = Health Professional Shortage Areas
MUA/P – Medically Underserved Area or Medically Underserved Population
Fed. = Federal
FTE = full-time equivalent
low-inc. = low-income

designations, or designations that include the entire population in a *rational service area*, or fixed geographic area. Other designation types are provided for under current rules, including *population* and *facility* designations. Population designations single out a specific population in a geographic area and include low-income, Medicaid, homeless, and migrant farm worker categories (e.g., the low-income population of Madison County or the Medicaid-eligible population of Jones and Smith Counties). Low-income population designations are the most common current population designation. In the data set used for the impact analysis, there were 1,710 geographic and 809 population primary care HPSAs; of the population HPSAs, 592 were low-income population group designations. There also were 3,504 total MUA/Ps, and 46 of these were low-income population designations. After accounting for overlap between HPSAs and MUA/P, there were 3,960 whole or part geographic HPSAs or MUAs and 487 low-income HPSAs or MUPs.

Low-Income Population Designation Modification

The intention was to create a system that could be applied to all of the potentially designatable populations and groups. Adjusting for the higher needs and lower demand for primary care among low-income populations is difficult because existing data sets based on county boundaries, even census tracts and ZIP code areas, do not always reflect the distribution of people by income or health care need. However, it was possible to create a base ratio for areas that used the percentage of an area's total population that are in low-income categories (e.g., below 200% of the federal poverty level) along with an estimate of the numbers of primary care practitioners who serve those people. In this variation in the application of the scoring formula, termed the *low-income adjustment*, the population and the primary care provider FTEs are adjusted. The low-income population is used for the population portion of the population-to-primary care ratio rather than the total population of the area (the low-income population is assumed to have the same age and sex distribution as the total population for the population adjustment). The number of primary care provider FTEs used in the population-to-primary care ratio is multiplied by 0.21* to adjust for the estimate of the providers available for the low-income population. This revised base ratio becomes the starting ratio for an alternative application that was impact-tested using national data.

Effects on Designated and Undesignated Areas and Populations

The proposed scoring formula was tested using data from all U.S. counties, existing geographic HPSAs and MUAs, and low-income population HPSAs and MUPs designated in 1999. That sensitivity analysis used data relevant to that year. Of the 4,447 unduplicated existing geographic and low-income HPSAs and MUPs, 2,962 (66.6%) met the designation threshold under the original (geographic) proposed formula (Table 3). Fifty-one (51) previously undesignated areas reached the threshold and 177 areas that were designated under low-income population rules reached the threshold

*This number is an average of the FTE adjustment from all low-income designations updated in 1998 and 1999. There were 288 areas that were updated during this time period. The Bureau of Primary Health Care conducted the review and provided these data in November 2001.

Table 3.

IMPACT ANALYSIS OF PROPOSED INDEX

	Number of areas designated			
			Proposed scoring system	
HPSA or MUA/P status	Baseline designations	Current regulation, new data	Geographic	Additionally designated using low-income adjustment
Geographic, 1999	3,960	2,085 (53%)	2,734 (69%)	805 (20%)
Low-income	487	85 (17%)	177 (36%)	166 (34%)
Not designated[a] 1999	—	18	51 (1%)	117 (2.6%)
Total	4,447	2,188	2,962	1,088

[a]Not Designated in this dataset means not designated as either a geographic HPSA or MUA or a low-income population HPSA or MUP. The area may have another type of designation or be undesignated entirely.
HPSA = Health Professional Shortage Areas
MUA/P = Medically Underserved Area or Medically Underserved Population

as geographic areas. The total population meeting the threshold using the proposed formula was 52.9 million people, or 55.5% of the currently designated population. The low-income adjustment to the proposed scoring system qualified an additional 24.5% of existing areas and covered an additional 31.7% of the baseline population. In comparison, applying the current rules resulted in fewer designations (2,188, 49.2% of those designated by the federal government in 1999) and less population coverage (32.7 million people, 34.3% of baseline) than using the proposed formula. State-specific analyses showed that the number and proportions of areas and populations that would be de- or re-designated would vary by state; the majority of states experienced net losses of baseline designations.

We also examined the effects of the proposed formula on areas that included safety net institutions and providers that use the HPSA and MUA/P designation process with the same restrictions on the analysis of population and low-income adjustments; the results are summarized in Table 4. Applying the proposed method to geographically designated areas alone results in a 34.9% decrease in the places that include a federal CHC clinic, a 30.8% decrease in the number of areas with Rural Health Clinics (RHC), and a 44.7% decrease in the number of geographically-designated areas with NHSC placements. The addition of the low-income adjustment to the analysis increases the inclusion of safety net programs by more than 20% but would still result in a 11.2% decrease in the number of areas with CHCs, a 2.5% decrease in the number of RHC areas, and a 13.4% decrease in the number of geographically-designated areas with NHSC placements.

Table 4.

IMPACT ANALYSIS OF PROPOSED INDEX ON SELECTED SAFETY NET PROGRAMS.

		Area designation					
		Current criteria using updated data		Geographic method		Geographic and low-income method	
Safety net program	Sites N	N	%	N	%	N	%
CHC 1999	1,481	639	43.1	964	65	1,315	88.8
RHC 1999	2,842	1,317	46.3	1,967	69	2,771	97.5
NHSC 1999	932	314	33.7	515	55	807	86.6

CHC = Community Health Center
RHC = Rural Health Center
NHSC = National Health Service Corps

Discussion

This designation system has been developed in the context of real world policy. It is an attempt to work from prior theory and research to improve the application of federal safety net policies by better targeting places that are underserved as well as accommodating the on-the-ground realities of existing safety net institutions. The method will be judged against a standard of political and practical acceptability more so than by its theoretical purity. The four years of work that went into its development included substantial discussion of options and alternatives as well as modeling to estimate its effects, and this was open to inspection by all stakeholders.

The proposed method is conceptually and computationally complex, violating one of the original guiding principles for the exercise. However, the system has been developed in a way that allows an applicant to enter their area-specific or population-specific data into an Internet-based query system and have their score returned in real time. This would allow applicants to compare their level of underservice with those of other designated and undesignated areas and populations in an accessible system.

The extrapolation of the relationships between individual characteristics and use of services to aggregate relationships for communities introduces potential weaknesses. For example, Robert and House, in their review of the relative contribution of individual-, community-, and societal-level research on the relationship between socioeconomic factors and health, found that, "Although multilevel studies indicate an independent role of community socioeconomic conditions . . . most of the community level effects have been small in size."[38, p. 122] There, however, remain substantial support and evidence for the contributory role of community characteristics to health status and need for services.[39]

The combination of the scoring formula proposed here with the low-income adjustment addresses many of the concerns of stakeholder groups expressed in comments on the original proposed rules (NPRM-1) of September 1998. It is not anticipated that the methods proposed here will be the only avenue for determining eligibility in the final rules, however. For example, these methods are not intended to identify fully low-access populations embedded in larger population groups, special access barriers that are masked by aggregate data, or the civil and postal boundary lines used to derive data that divide or arbitrarily delineate communities. The proposed measure is intended to be used only as an approach for determining eligibility for designation where applicant areas and populations that initially score above the threshold would receive designation but other applicants might also qualify under more subjective criteria if need is sufficiently documented in their application. The proposed data-driven formula is able to predict current designations remarkably well given that the application of the current rules makes extensive use of negotiation and local refinements of secondary data.

The data reported here were those used in the original development of the proposed modification; the impact analysis was completed soon after that work was done. The lengthy review process for the proposal has made those estimates somewhat dated but the system can be quickly revised to reflect more recent data. For example, the most recent MEPS visit rates (currently 2004) can be applied to the population weighting process and the area and population characteristics can be updated to the most recent U.S. Census enumeration data or estimates. Some of that work is progressing at the request of the Bureau of Health Professions but, based on preliminary analyses using these strategies, a full-scale re-estimation of modified impacts would not reveal a pattern of de- or re-designation substantially different from what is described here.

Safety net providers and advocates have expressed the greatest concern with the effects of any revision to the designation process. While safety net facilities and providers could be associated with particular geographic areas in the analysis, it was not possible to know whether these safety net facilities and providers were exclusively serving the low-income populations of those areas or whether a substantial amount of boundary-crossing took place. A potential loss of a geographic designation for an area with a safety net facility or provider may be replaced with a designation based more closely on a service population, provided those data are available. Our analysis of safety net facilities and providers therefore presents a worst-case scenario.

The key theoretical innovation of the process is the simultaneous estimation of parameters for factors that deter use of services with those that create need for care. In real communities and for real people, both things are happening. In places that have safety net programs such as a clinic, an access program is promoting appropriate utilization by overcoming access barriers. Where a program is absent, clinicians who might not see patients for preventive care are often called on to care for them in emergency conditions when complications have arisen because the patient did not seek care earlier. The amount of the increase in use brought about by delayed care must be added into the reduction in use to produce an accurate estimate of the entire access problem in a community.

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