# Changes in the NIS Sampling and Weighting Strategy for 1998

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# Executive Summary

The Healthcare Cost and Utilization Project (HCUP) is a Federal-State-industry partnership to build a standardized, multi-State health data system. In September 2000, the Agency for Healthcare Research and Quality (AHRQ) provided funding for The MEDSTAT Group (MEDSTAT) to continue existing development efforts and to expand this health data system through data year 2003. One objective was a redesign of the NIS sampling and weighting strategy. Some elements of the new sampling design were determined in advance by MEDSTAT and AHRQ. Other features of the sampling design required analysis of alternatives using the 1997 NIS and the 1997 AHA hospital survey.

## Sampling features determined in advance

### *Similarities to prior NIS strategy*

- We continue to sample 100 percent of all discharges for each hospital drawn into the NIS. This feature distinguishes the NIS from other discharge samples such as the National Hospital Discharge Survey and permits patient outcomes from individual hospitals can be estimated without sampling error.
- To assure geographic dispersion of the sample within the HCUP states, we continue to sort hospitals within strata by the first 3 digits of their zip code before selecting a systematic sample.
- We continue to sample a number of hospitals equal to 20 percent of the universe within each stratum. In any given year, there will be about 5,000 hospitals in the universe and about 1,000 hospitals for the NIS.
- We continue to produce two non-overlapping 10-percent subsamples that allow researchers to test programs and perform preliminary analyses. If desired, the two subsamples can be combined to form a single 20 percent subsample of NIS discharges.

### *Differences from prior NIS strategy*

#### Longitudinal Cohort

To maintain a longitudinal cohort, the previous sampling plan ensured that hospitals drawn for the sample in one year had a high probability of being drawn for the sample in the following year. Including the same hospitals across years improved the precision of trend analyses, although it may have introduced some form of bias into one or more years of the hospital sample. MEDSTAT and AHRQ decided to discontinue any sampling scheme that increased the chance that hospitals would be included in successive years of the NIS.

To test the impact of this change, we calculated the 1997 sample with and without the longitudinal weighting component. For this analysis we drew 500 samples using the old sampling design with and without the longitudinal preference. A comparison of each distribution of each 500 samples showed that removing the longitudinal component shifts the estimate very slightly and increases variation around the estimated mean.

#### Sampling Weights

In prior versions of the NIS, we calculated separate sampling weights for the state, frame, and universe. We no longer calculate weights to the frame or weights to the state.

## Analysis of selected sampling features

MEDSTAT performed three major sets of analyses to define the specifications of the new NIS sampling strategy. First, because the HCUP project has expanded from 8 states to 22 states, we re-evaluated whether differences between hospitals in HCUP states and non-HCUP states were substantial enough to require stratified sampling for the NIS. Second, we identified stratification variables that should be used and changed some variable definitions to minimize small cell sizes in the NIS database. Finally, we compared alternative weighting schemes to determine which would provide the most precise estimates of the target population for selected outcome variables.

### *Differences between HCUP and non-HCUP states*

The main objective of a stratified sample is to ensure that the sample is representative of the target universe. Stratification becomes advantageous when the sampling frame (HCUP states) differs substantially from the target universe (all states). HCUP hospitals tend to be larger than non-HCUP hospitals. As a result, HCUP hospitals have more beds and higher occupancy rates overall, suggesting a need for sample stratification. These differences are more pronounced in the Northeast and West, and HCUP states in these regions also tend to have higher Medicare managed care penetration and more discharges than their non-HCUP counterparts. HCUP hospitals in the Northeast also tend to have longer average lengths of stay (ALOS) than do non-HCUP hospitals in the Northeast. Although the number of differences between HCUP and non-HCUP hospitals in the Northeast and West is greater than in other regions, the impact of these differences is likely to be low because HCUP hospitals represent almost all discharges in those regions.

### *Review of stratification variables*

In previous NIS designs, we developed strata for geographic region, hospital ownership, urban/rural location, and teaching status. We re-evaluated our selection of stratification variables to reaffirm whether these or other strata explained significant differences in selected outcome variables, and also to identify strata that could be nested or collapsed to avoid small cells in the final sample. The changes described below reduced the number of NIS strata from 108 to 60.

In the course of analyzing stratification variables, we found that patients treated in rehabilitation hospitals tend to have lower mortality rates and longer lengths of stay than patients in other community hospitals, and the completeness of reporting for rehabilitation hospitals is very uneven across the states. Therefore, we decided to eliminate rehabilitation hospitals from the NIS (and the target universe) rather than retain this distinction as a stratification variable.

Bed size continues to be an important stratification variable, but the range of bed sizes varies across other strata, making it difficult to define a single set of cutpoints to define hospitals of various sizes. In the previous NIS, bed size categories were defined only within location/teaching status. However, even within these location/teaching categories, the bed size distributions still varied widely by geographic region. We decided to define small, medium, and large bed size categories nested within region and location/teaching category such that approximately one-third of the hospitals would be allocated to each category.

The distributions of U.S. hospitals by type of ownership (public, voluntary, and proprietary) varied significantly by geographic region, making it undesirable to stratify ownership uniformly across all regions. Therefore, we decided to nest ownership strata only within selected regions. We will use three ownership categories for rural hospitals in the South and for urban nonteaching hospitals in the South and West. We will stratify on ownership for rural hospitals in the West and Northcentral regions, but only after collapsing the proprietary and voluntary hospitals into a new “private” ownership category.

Finally, we redefined teaching hospitals. In prior versions of the NIS, a hospital was designated a teaching hospital only if it had some interns or residents and it was either a member of the Council of Teaching Hospitals or it had an AMA-approved residency program. The new definition still defines these same hospitals as teaching hospitals. However, it also includes all hospitals with a ratio of interns and residents to beds of .25 or higher. This intern-to-bed ratio is similar to a component of the Centers for

Medicare & Medicaid Services (CMS, formerly the Health Care Financing Administration) definition of teaching hospitals for Medicare payments.

### *Review of weighting strategies*

The discharge sample weights for previous versions of the NIS were calculated within each sampling stratum as the ratio of discharges in the universe to discharges in the sample. The discharge sample weights were constant for all discharges within each stratum. We decided to test an alternative weighting strategy that would yield four weights per stratum, with separate weights for Newborns, Medicare discharges (non-newborns), Medicaid discharges (non-newborns), and Other discharges (non-newborns). We compared estimates using a single weight per stratum to estimates using four weights per stratum using 1,000 simulated NIS hospital samples from the 1997 AHA and 1997 SID data. The two weighting schemes produced very similar average estimates for all outcomes except for the total number of discharges for each payer. We also found little difference by region between the two weighting strategies. Finally, we applied the two sampling strategies to the universe of HCUP states to compare their precision. Both schemes produced very precise estimates, with no clear difference in precision between them. Therefore, we will continue the previous strategy of one weight per stratum.

## Final NIS Design

In summary, the final sample design is as follows. The hospital universe is defined by all hospitals that were open during any part of the calendar year and were designated as community hospitals in the American Hospital Association (AHA) Annual Survey of Hospitals, excluding rehabilitation hospitals. For purposes of the NIS, the definition of a community hospital is that used by the AHA: "all nonfederal short-term general and other specialty hospitals, excluding hospital units of institutions." Consequently, Veterans Hospitals and other federal hospitals are also excluded. The NIS will be a stratified sample of hospitals drawn from the subset of hospitals in states that make their data available to the HCUP project and *that can be matched to the AHA survey data.* Hospitals will be stratified by region, location/teaching status (within region), bed size category (within region and location/teaching status), and ownership (within region, location/teaching, and bed size categories). The regions are defined by the four census regions (NE, NC, S, and W). Location is defined by AHA's designation of urban or rural. Teaching hospitals are those with COTH membership, or with an AMA-approved residency program, or with an intern-to-bed ratio of 25 percent or higher. Bed size categories are small, medium, and large, with separate size cutpoints defined for each combination of hospital region, teaching status, and urban/rural designation. Ownership breakdowns are based on the degree of observed ownership variation within each region across bed size categories. Within each stratum, we will draw a systematic random sample of hospitals equal in size to 20 percent of the universe for that stratum. The hospitals will be sorted by the first three digits of their zip code for the systematic sample. The NIS will include all discharges from the sampled hospitals.

## Conclusions

We expect several improvements due to the changes in the sampling design. The elimination of rehabilitation hospitals will make the universe more homogeneous with little loss of data. The revised sampling strata will substantially reduce the risk of small cell sizes. The new definition of teaching hospitals will improve consistency with Centers for Medicare and Medicaid Services (CMS)-sponsored analyses and it is expected to increase homogeneity of outcomes within each teaching status stratum. The elimination of the longitudinal component of the NIS sample design simplifies the sampling and removes a source of potential bias, although healthcare trends that span both the old design and the new design will be confounded by the design change.

# Changes in the Nationwide Inpatient Sample (NIS) Sampling and Weighting Strategy for 1998

## Introduction

The Healthcare Cost and Utilization Project (HCUP) is a Federal-State-Industry partnership to build a standardized, multi-State health data system. In September 2000, the Agency for Healthcare Research and Quality (AHRQ) provided funding for The MEDSTAT Group, Inc. (MEDSTAT) to continue existing development efforts and to expand this health data system through data year 2003. The major goals of this expansion are increasing the number of states contributing inpatient data, expanding the ambulatory surgery and emergency department databases, and possibly adding an ambulatory care database. One objective was a redesign of the Nationwide Inpatient Sample (NIS) sampling and weighting strategy. This document reports MEDSTAT's evaluation of the previous sampling and weighting strategy, alternative strategies, and describes the final design.

### Why Redesign?

Statisticians from MEDSTAT and AHRQ, along with an expert sampling consultant, developed the previous sampling and weighting strategy. While it has served the HCUP well, it was developed over eight years ago, when only eight states contributed data, compared to 22 states for the latest NIS. The stratification resulted in many small cells, which required adjustments in sampling and weighting, and which led to the omission of some hospitals from the frame due to state-specific sampling restrictions. Further, recent comparisons of NIS estimates to NHDS and MedPAR estimates indicate that differences may be widening. As a result, it was appropriate to re-evaluate the methodology.

### A Brief History of the NIS Sample Design

The previous sampling plan was straightforward, but complicated in the details. We sampled hospitals from the sampling frame defined by community hospitals in states that agreed to contribute their data. Hospitals were stratified by region, ownership, location, teaching status, and bed size. Within each stratum, after sorting hospitals by state and 3-digit zip code, we drew a systematic random sample of hospitals equal in number to 20 percent of the U.S. total number of hospitals in that stratum (based on counts derived from AHA data). Finally, the sample of discharges was composed of all of the discharges in the sampled hospitals.

Further, to maintain a longitudinal cohort, the previous sampling plan ensured that hospitals drawn for the sample in one year had a high probability of being drawn for the sample in the following year, but still allowed hospitals new to the sampling frame an opportunity to enter the sample. It allowed each hospital the same chance of entering the sample *over all the years for which it was eligible*, including previous sampling years; but favored previously selected hospitals for the sample *for each particular year*. If a large number of hospitals was new to the frame, as happened when a new state was added to the sampling frame, then it became necessary to randomly drop some hospitals that were in the previous year's sample to "make room" for the new hospitals. This procedure kept the sampling rate constant for all hospitals *within a stratum*.

*The Target Universe*

In all previous versions of the NIS, the hospital universe was defined by all hospitals that were open during any part of the calendar year and were designated as community hospitals in the American Hospital Association (AHA) Annual Survey of Hospitals for that year. The discharge universe was defined as all discharges from the target universe of hospitals for that year. The definition of a community hospital was that used by the AHA: "all nonfederal short-term general and other specialty hospitals, excluding hospital units of institutions." Consequently, Veterans Hospitals and other federal hospitals were excluded. Table 1 shows the number of universe hospitals for each prior NIS year based on the AHA Annual Survey.

**Table 1**
**Hospital Universe**

| Year | NUMBER OF HOSPITALS |
|---|---|
| 1988 | 5,607 |
| 1989 | 5,548 |
| 1990 | 5,468 |
| 1991 | 5,412 |
| 1992 | 5,334 |
| 1993 | 5,313 |
| 1994 | 5,290 |
| 1995 | 5,260 |
| 1996 | 5,182 |
| 1997 | 5,113 |

*Hospital Merges, Splits, and Closures*

All hospital entities that were designated community hospitals in the AHA hospital file were included in the hospital universe. Therefore, if two or more community hospitals merged to create a new community hospital, the original hospitals and the newly formed hospital were all considered separate hospital entities in the universe for the year of the merge. Likewise, if a community hospital split, the original hospital and all newly created community hospitals were considered separate entities in the universe for the year of the split. Finally, community hospitals that closed during a year were included as long as they were in operation during some part of the calendar year.

*Hospital Sampling Frame*

For each year, the *universe* of hospitals was established as all community hospitals located in the U.S. However, it was not feasible to obtain and process all-payer discharge data from a random sample of the entire universe of hospitals for at least two reasons. First, all-payer discharge data were not available from all hospitals for research purposes. Second, based on the experience of prior hospital discharge data collections, it was too costly to obtain data from individual hospitals and to process each hospital's unique data structure.

Therefore, the NIS *sampling frame* was constructed from the subset of universe hospitals that released their discharge data for research use. Two sources for all-payer discharge data were state agencies and private data organizations, primarily state hospital associations. For the 1997 NIS, AHRQ had agreements with 22 data sources that maintain statewide, all-payer discharge data files to include their data in the HCUP database. These states are shaded on the map in Figure 1.

The entire frame of hospitals was composed of all AHA community hospitals in each of the frame states *that could be matched to the discharge data provided to HCUP, subject to restrictions imposed by data sources*. If an AHA community hospital could not be matched to the discharge data provided by the data source, it was eliminated from the sampling frame (but not from the target universe). In the 1997 NIS, further restrictions were put on the sampling frames for Georgia, Hawaii, Illinois, Missouri, South Carolina, and Tennessee.

Georgia, Hawaii, South Carolina and Tennessee stipulated that only hospitals that appear in sampling strata with two or more hospitals were to be included in the NIS. The Illinois Health Care Cost Containment Council stipulated that no more than 40 percent of the discharges provided by Illinois could be included in the database for any calendar quarter. Missouri stipulated that only hospitals giving signed releases for public use should be included in the NIS.

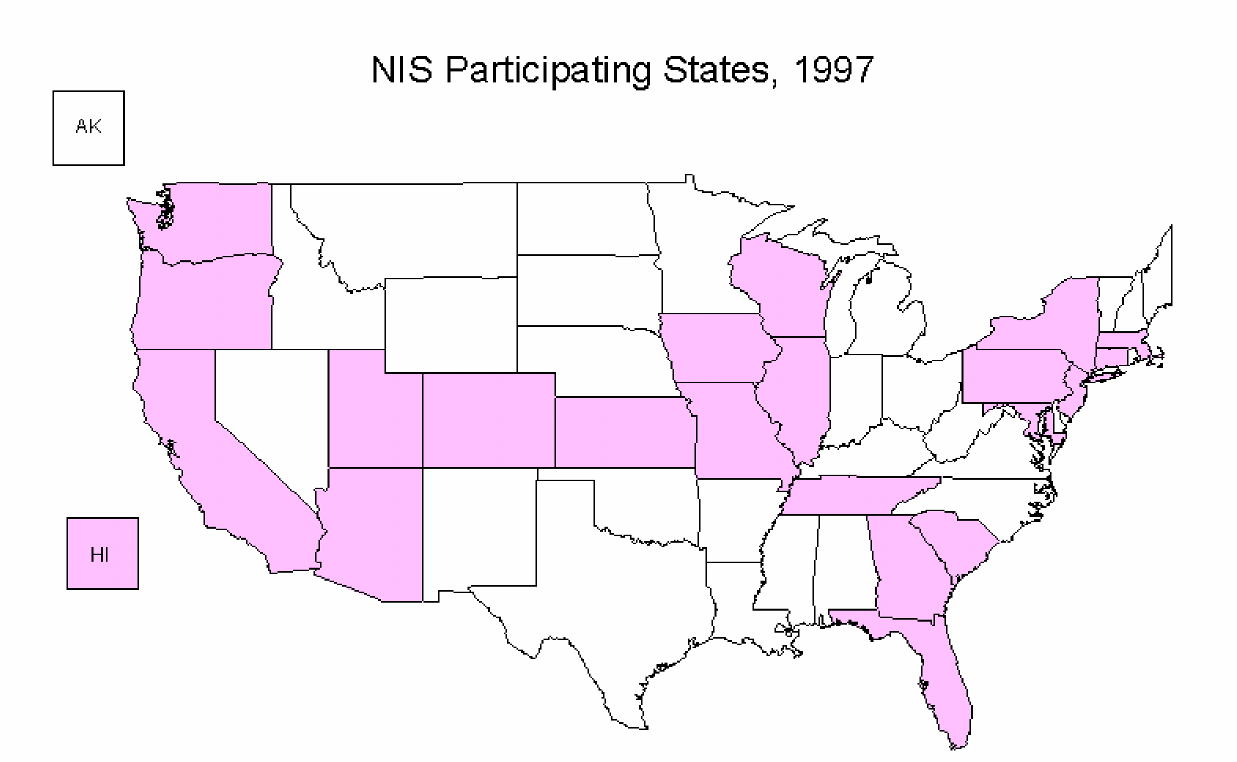
The number of frame hospitals for each prior NIS year is shown in Table 2.

**Table 2**
**Hospital Sampling Frame**

| Year | NUMBER OF HOSPITALS |
|---|---|
| 1988 | 1,247 |
| 1989 | 1,658 |
| 1990 | 1,620 |
| 1991 | 1,604 |
| 1992 | 1,591 |
| 1993 | 2,168 |
| 1994 | 2,135 |
| 1995 | 2,284 |
| 1996 | 2,268 |
| 1997 | 2,452 |

The number of hospitals in the sampling frame nearly doubled between 1988 and 1997, as the number of states expanded from 8 to 22. The 1997 frame included nearly half of the hospitals in the target universe.

**Figure 1**




### *Longitudinal Cohort*

During the project kickoff meeting, MEDSTAT and AHRQ decided to discontinue the aspect of the previous sampling plan designed to maximize the longitudinal cohort of hospitals. Previously, this feature was desirable for analyzing trends because year-to-year differences in hospital outcomes are measured more precisely from a single set of hospitals (paired t-test) than from two distinct sets of hospitals each year (ordinary two-sample t-test). Of course, due to year-to-year changes in the sampling frame, only a subset of the hospitals remained in the sample from one year to the next. A potential disadvantage of this feature was that the longitudinal subset of hospitals might have introduced some form of bias into one or more years of the hospital sample. The NIS is no longer the only HCUP database being disseminated, so it need no longer fulfill all research needs. In fact, AHRQ is considering the construction of a separate longitudinal database as one of the special databases under this contract.

### *Discharge Sampling Rate*

The sampling rate for discharges was 100 percent for each hospital drawn into the NIS. The advantage of including all discharges from each of the sampled hospitals is that patient outcomes from individual hospitals can be estimated without sampling error. For example, it allows researchers to:

- adjust the case-mix for an entire institution,
- look at the volume of services performed in each hospital, and
- create other hospital-level variables such as the percentage of discharges in each hospital that are uninsured.

Moreover, this unique feature differentiates it from other discharge samples, such as the National Hospital Discharge Survey. During the kickoff meeting, AHRQ and MEDSTAT agreed that the sampling rate for discharges should remain at 100 percent for each hospital drawn into the NIS.

### *Stratification*

Hospitals were stratified by region (Northeast, Northcentral[1], South, and West), ownership (government nonfederal [public], private not-for-profit [voluntary] and private investor-owned [proprietary]), location (urban and rural), teaching status (urban teaching and urban non-teaching), and bed size (small, medium, and large defined separately for rural, urban teaching, and urban non-teaching).

Stratification helps ensure that the sample of hospitals is representative of the target population of hospitals. A simple random sample of hospitals would tend to yield a sample that is representative of the sampling frame rather than the target population.

### *Sample Weights*

In prior versions of the NIS, sample weights were developed separately for hospital- and discharge-level analyses. We calculated three hospital-level weights to weight NIS sample hospitals to the state, frame, and universe. Similarly, we calculated three discharge-level weights to weight NIS sample discharges to the state, frame, and universe.

Hospitals were post-stratified on the same variables used for sampling, and each hospital and discharge was weighted to the number of hospitals and discharges estimated to be in the corresponding target universe based on the AHA survey data.

## Summary of Changes

### *Sample Design*

The new sample design is similar to the previous design. However, it differs in four important ways as discussed below.

First, the universe now excludes rehabilitation hospitals. Our analysis clearly illustrates that patients treated in rehabilitation hospitals tend to have lower mortality rates and longer lengths of stay than do patients in other community hospitals. More compelling, the completeness of reporting for rehabilitation hospitals is inconsistent across the states. We considered making rehabilitation hospitals a separate stratum, but we lacked adequate representation in the frame for some regions of the country. Consequently, AHRQ decided to eliminate rehabilitation hospitals from the NIS.

Second, the cutoff points for bed size categories are modified to ensure that about one-third of hospitals fall into each of three bed size categories — small, medium, and large. While these cutoff points may not *maximize* the precision of estimates, they will *increase* the precision and simultaneously mitigate the small cells problem.

Third, we reduced the number of strata on ownership. Previously we defined three categories of ownership: government nonfederal (public), private not-for-profit (voluntary) and private investor-owned (proprietary). We stratified hospitals on these categories in all four regions. However, nearly all hospitals in the Northeast are voluntary. We now stratify on all three ownership categories only for South rural, South urban nonteaching, and West urban nonteaching hospitals. We also stratify by public vs. private (combined voluntary and proprietary) for Northcentral rural and West rural hospitals. Again, this change reduces the total number of strata and reduces the number of small cells.

Fourth, we redefined teaching hospitals. In prior versions of the NIS, a hospital was designated a teaching hospital only if it had some interns or residents and it was either a member of the Council of Teaching Hospitals or it had an AMA-approved residency program. The new definition still defines these same hospitals as teaching hospitals. However, it also includes all hospitals with a ratio of interns and

[1] The Northcentral region is sometimes called the Midwest in other HUCP documents.

residents to beds of .25 or higher. This intern-to-bed ratio is similar to a component of the Centers for Medicare & Medicaid Services (CMS, formerly the Health Care Financing Administration) definition of teaching hospitals for Medicare payments.

Overall, these changes result in a reduction from 108 strata to a more manageable 60 strata.

### *Sample Weights*

After a thorough analysis of a more complicated alternative as described later in this report, the calculation of sample weights to the universe remains essentially unchanged except for the changes in stratification described above. We will no longer calculate weights to the frame or weights to the state. These weights were seldom, if ever, used for previous versions of the NIS. Consequently, we elected to spare the expense of creating and validating them. In the future, we will supply only weights to the universe.

# Sample Design

## Longitudinal Component

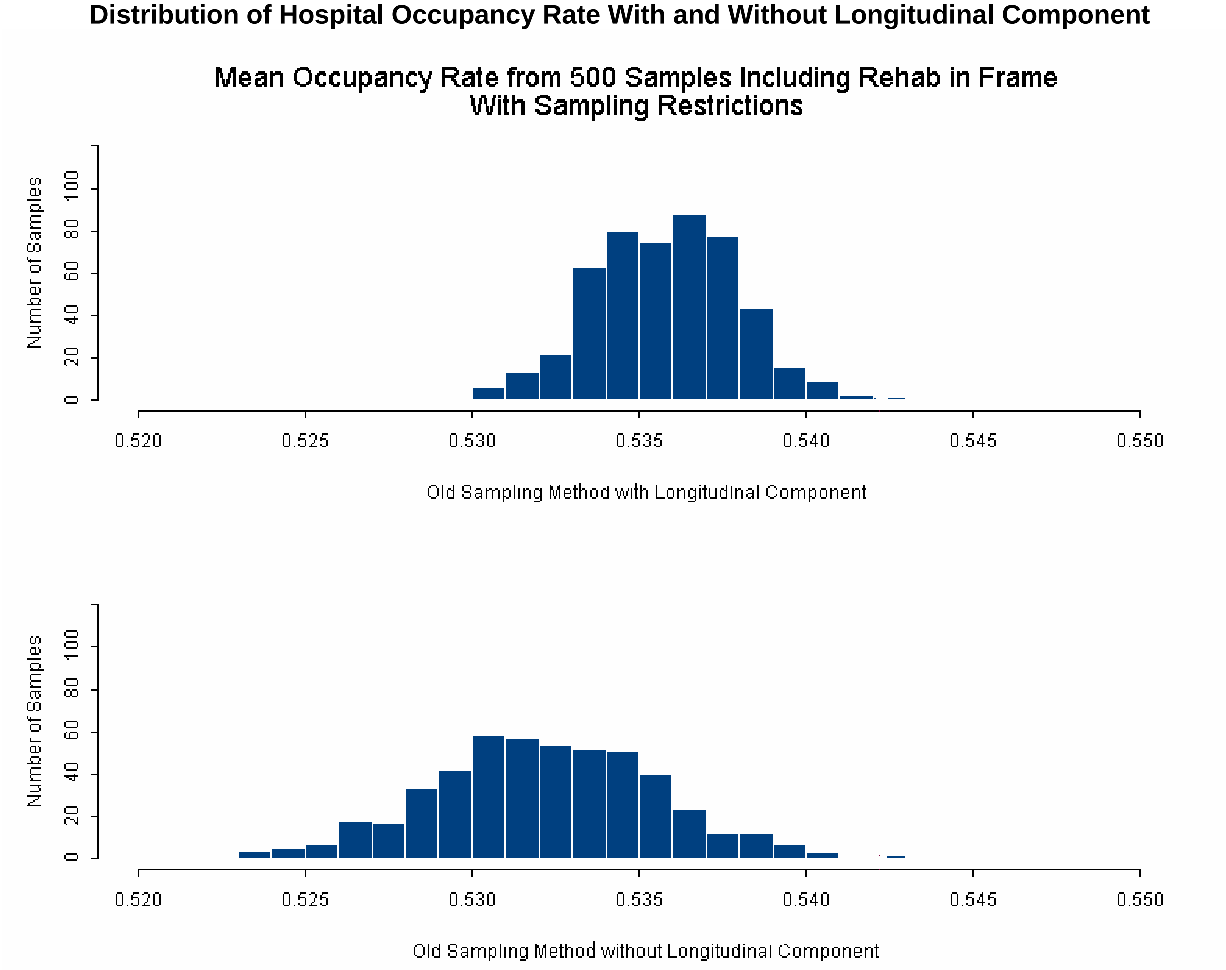
Previously, the longitudinal component of sampling spanned 10 years, from 1988 through 1997. Since we decided at the outset to omit this aspect of the sampling methodology in the future, we attempted to measure its effect only on the most recent NIS (1997). That is, we drew the 1997 sample both with and without the longitudinal component and compared estimates of hospital-level outcomes.

For this analysis we drew 500 samples using the old sampling design, which gave preference to previously selected NIS hospitals, and we drew another 500 samples using the old sampling design without giving preference to previously selected NIS hospitals (a systematic random sample of hospitals sorted by 3-digit zip code within each stratum). We then calculated the average hospital occupancy rate for each of the 500 samples and compared the distributions between the two sampling approaches.

The results are shown in Figure 2. The upper histogram shows the distribution of estimates with the longitudinal component and the lower histogram shows the distribution of estimates without the longitudinal component. Clearly, the upper distribution is less spread out, consistent with the preference to include hospitals from the previous NIS. In addition, the centers of the distributions are very slightly different. This result reinforced our supposition that the longitudinal component affected NIS estimates. In particular, variance estimates were probably biased downward.

**Figure 2**

**Distribution of Hospital Occupancy Rate With and Without Longitudinal Component**



## Comparison Between HCUP and Non-HCUP States

We can draw the NIS sample only from the 22 states that contribute their hospital discharge data to this project. If the collection of hospitals in these 22 states represents a random sample of hospitals from all 50 states, then stratification might be unnecessary. However, hospital characteristics differ between the "HCUP" states (the sampling frame) and the "non-HCUP" states.

The 22 HCUP states in 1997 are shaded on the map in Figure 1. HCUP states contained the following percentage of total discharges in each geographic region for 1997:

**Table 3**

**Percent of Discharges in HCUP**

| **Region** | **PERCENT IN HCUP** |
|---|---|
| West | 89% |
| Northcentral | 45% |
| South | 39% |
| Northeast | 94% |
| Total U.S. | 61% |

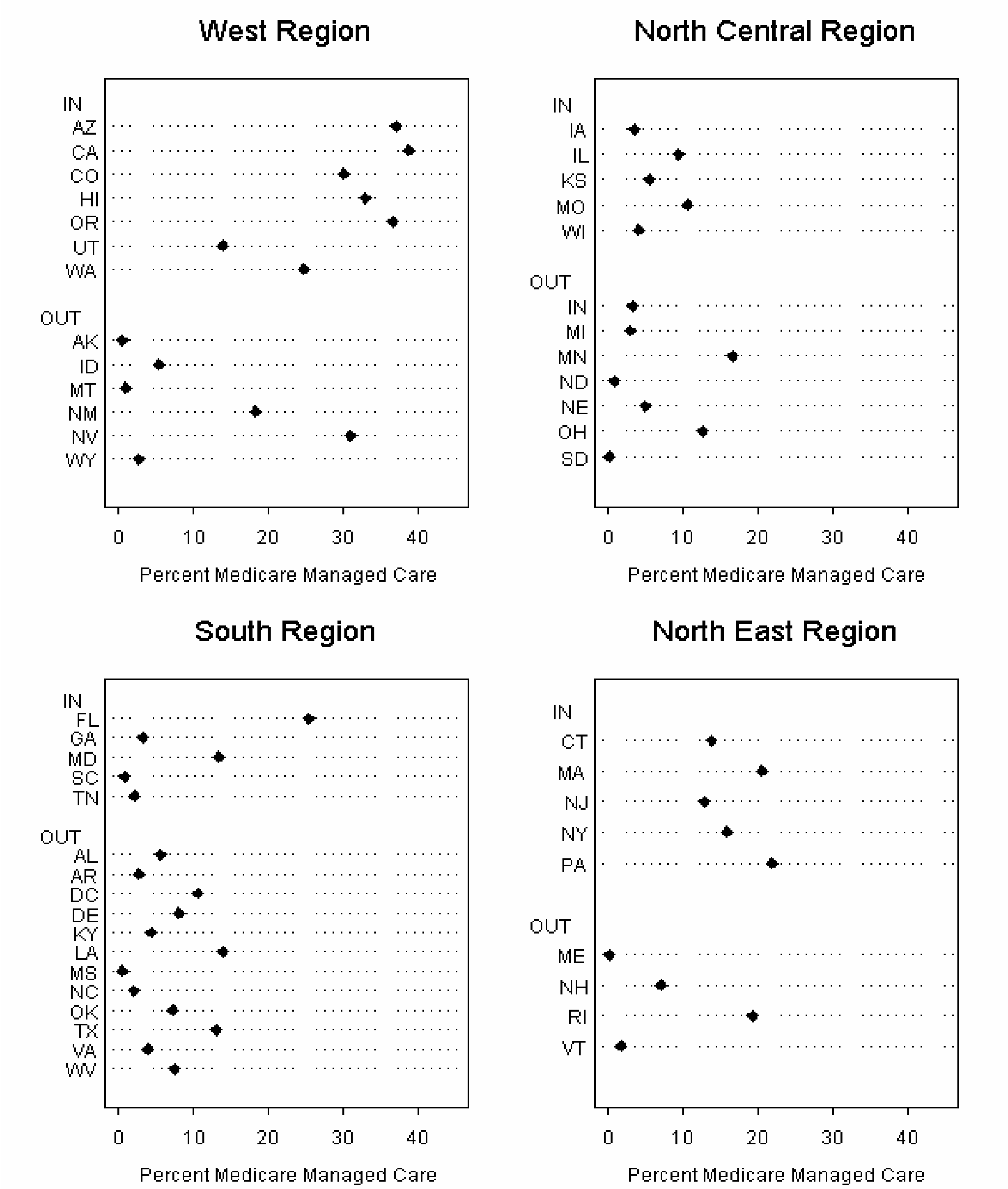
For 1997, HCUP has excellent coverage of discharges in the Northeast and West and fair coverage in the Northcentral and South regions. Consequently, differences between HCUP and non-HCUP states may be somewhat less a concern for the Northeast and West than they are for the Northcentral and South.

*Percent Medicare Managed Care*

Figure 3 displays four "dot charts," one for each region. Each dot corresponds to the percent of Medicare patients in managed care for that state in 1997, according to the Centers for Medicare & Medicaid Services (CMS). States within each region are sorted by "In" HCUP and "Out" of HCUP. The largest differences between HCUP and non-HCUP states are in the West and Northeast, where the managed care penetration rates tend to be higher for HCUP states. Those two regions also have the highest percentage of discharges in HCUP. Consequently, the impact of differences in these regions is likely to be small.

**Figure 3**

**Percent Medicare Managed Care**



*Bed size*

Figures 4 and 5 compare the bed size distributions between HCUP and non-HCUP states. Figure 4 is a density plot — a smoothed histogram — which shows that HCUP hospitals tend to be larger than non-HCUP hospitals overall. Figure 5 contains "box plots" that summarize the (logarithm of) bed size distribution for each region by whether the hospitals are in HCUP or out of HCUP. For example, "NE/Out" refers to hospitals in the Northeast that are out of HCUP. Within the plot, the darkened area of each box is bounded below by the 25$^{th}$ percentile and bounded above by the 75$^{th}$ percentile. The white line across the middle of the box represents the median. The "whiskers" extend above the 75$^{th}$ percentile and below the 25$^{th}$ percentile by 1.5 times the interquartile range, ending in a bracket "]". The small dashes beyond the brackets represent "outliers." For example, the 25$^{th}$ and 75$^{th}$ percentile of log (beds) for non-HCUP Northeast hospitals (NE/out) is about 3.5 and 4.7, respectively. There is one outlier at about 6.3. Again, the largest differences occur in the West and Northeast regions, where HCUP hospitals tend to be larger than non-HCUP hospitals.

**Figure 4**

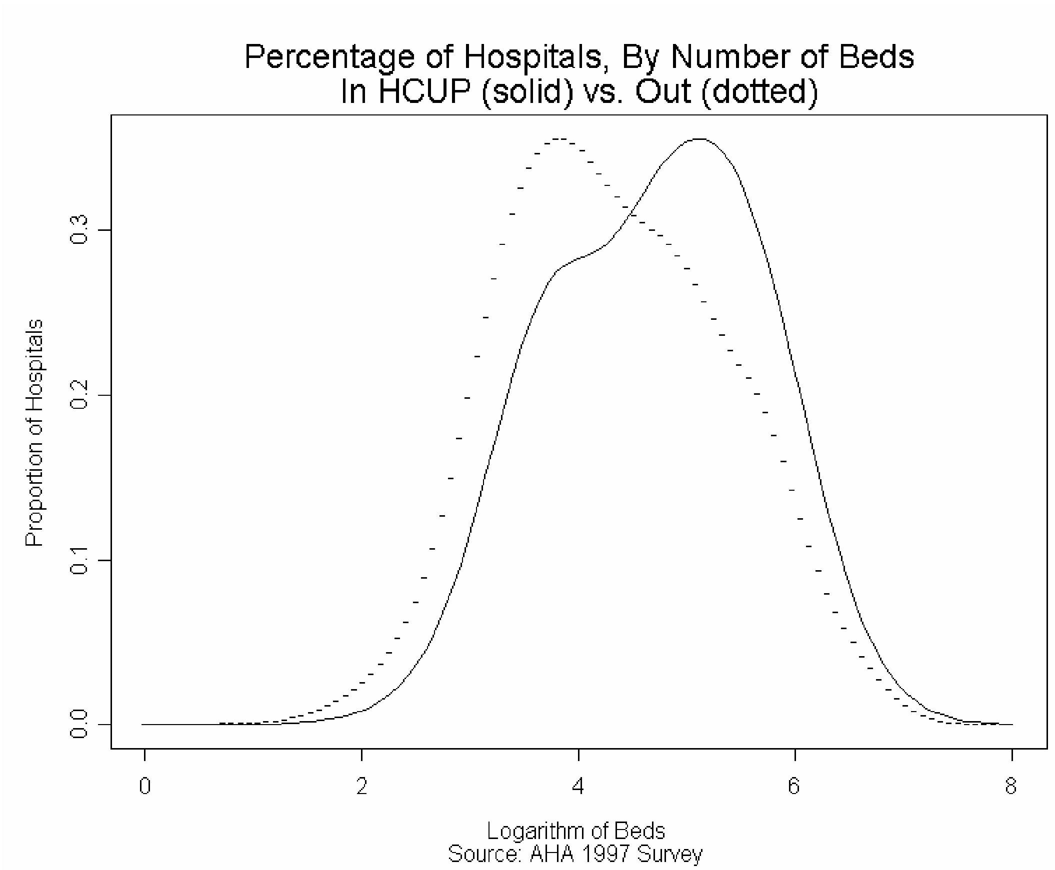
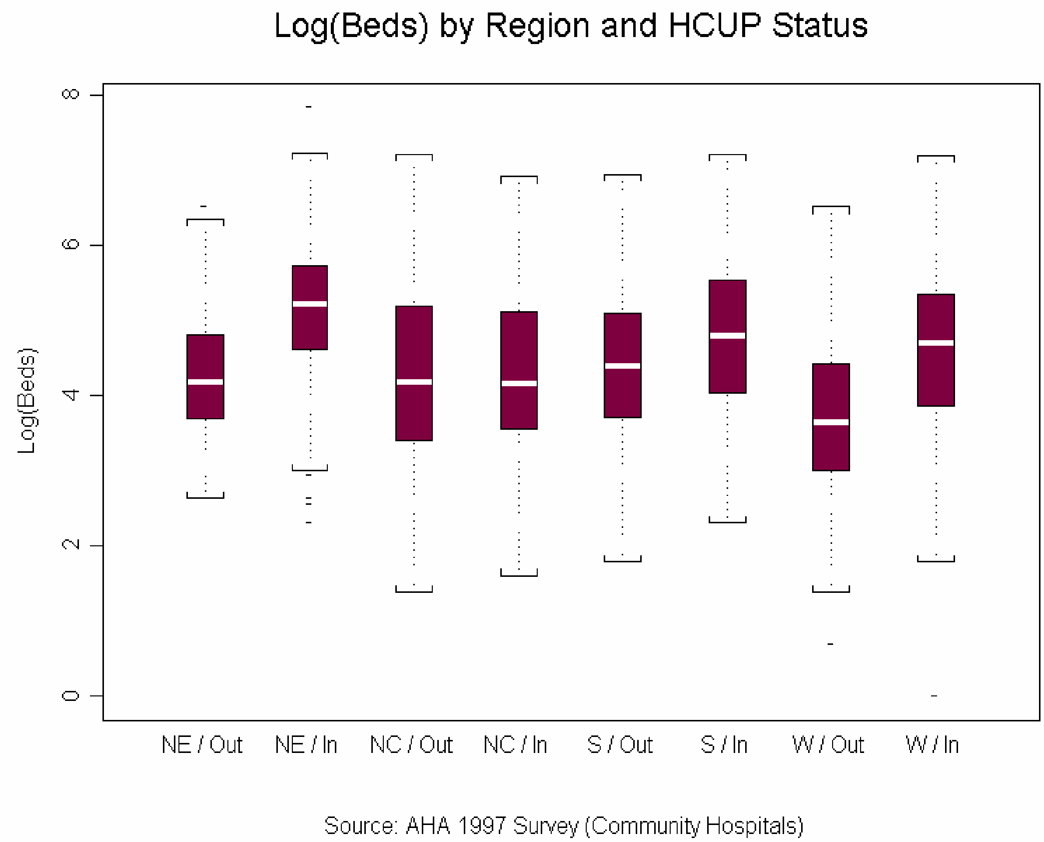


**Figure 5**


Log(Beds) by Region and HCUP Status
Log(Beds)
0
2
4
6
8
NE / Out
NE / In
NC / Out
NC / In
S / Out
S / In
W / Out
W / In
Source: AHA 1997 Survey (Community Hospitals)

*Occupancy Rate*

Figures 6 and 7 summarize the differences between HCUP and non-HCUP states on average occupancy rate. Figure 6 demonstrates that HCUP hospitals tend to have higher occupancy rates than non-HCUP hospitals, overall. Figure 7 shows box plots for each region comparing the distribution of hospitals in HCUP states versus those out of HCUP states. The highest occupancy rates are in hospitals in the Northeast. The biggest differences between HCUP and non-HCUP hospitals are in the West and the Northeast, where HCUP hospitals tend to have a higher occupancy rate. Within the South and Northcentral regions, the distributions are similar between HCUP and non-HCUP hospitals.

**Figure 6**

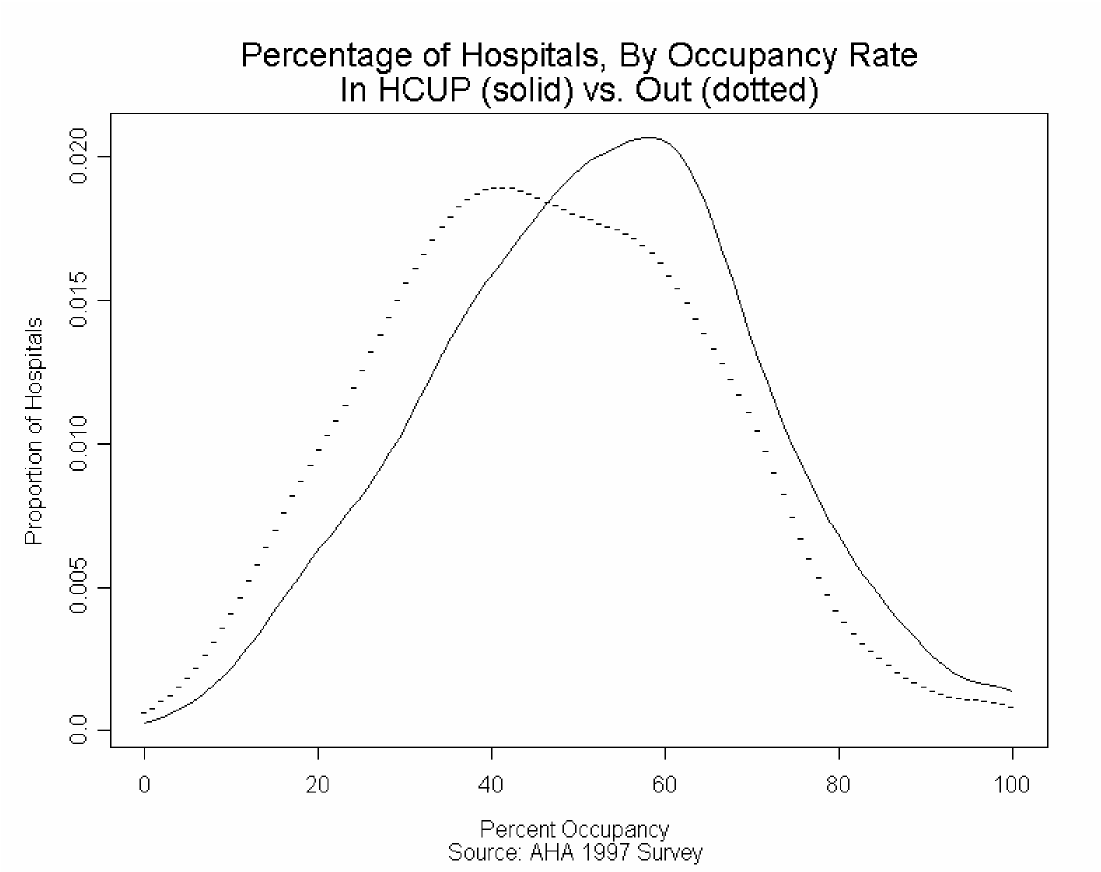
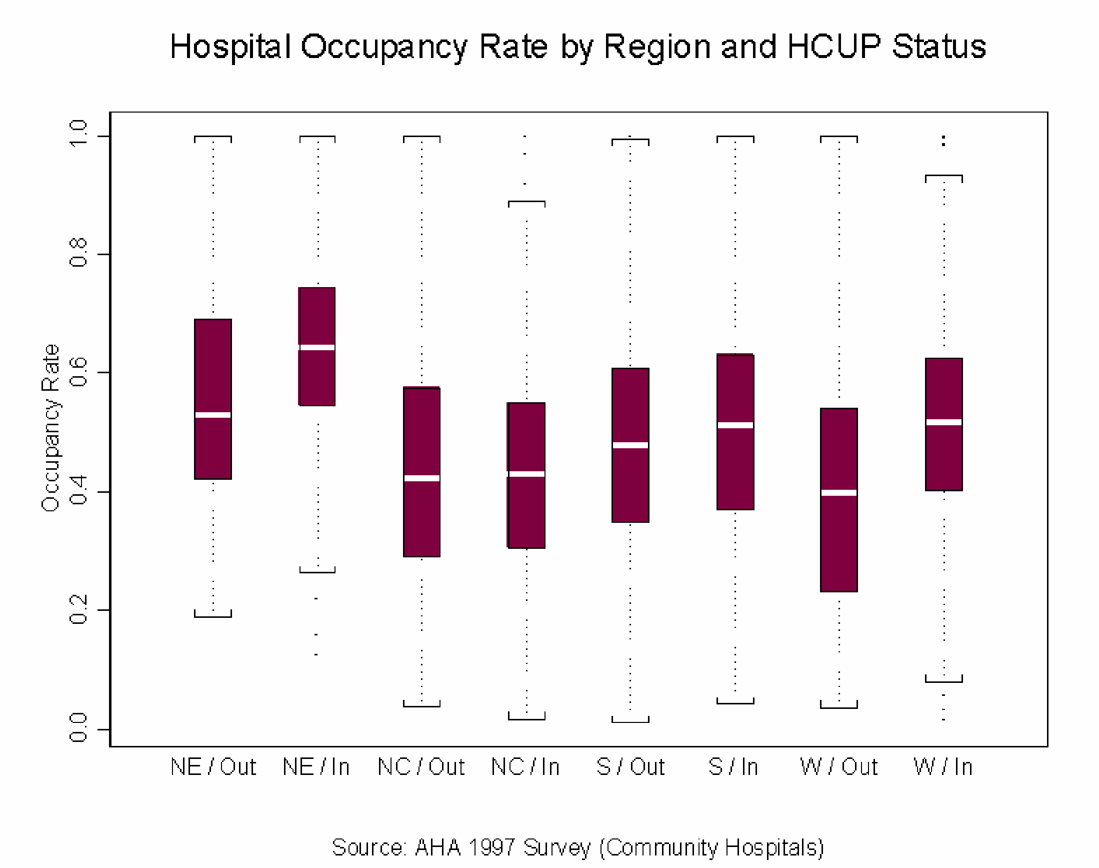


**Figure 7**


Hospital Occupancy Rate by Region and HCUP Status
Occupancy Rate
0.0
0.2
0.4
0.6
0.8
1.0
NE / Out
NE / In
NC / Out
NC / In
S / Out
S / In
W / Out
W / In
Source: AHA 1997 Survey (Community Hospitals)

*Average Length of Stay*

Figure 8 indicates that the distribution of hospitals' average lengths of stay (ALOS) is similar between HCUP and non-HCUP states, overall. The box plots in Figure 9 show that distributions are similar in all regions except the Northeast, where the ALOS tends to be higher for HCUP hospitals than it is for non-HCUP hospitals. However, it is important to keep in mind that non-HCUP hospitals represent only about 6 percent of all discharges in the Northeast.

**Figure 8**

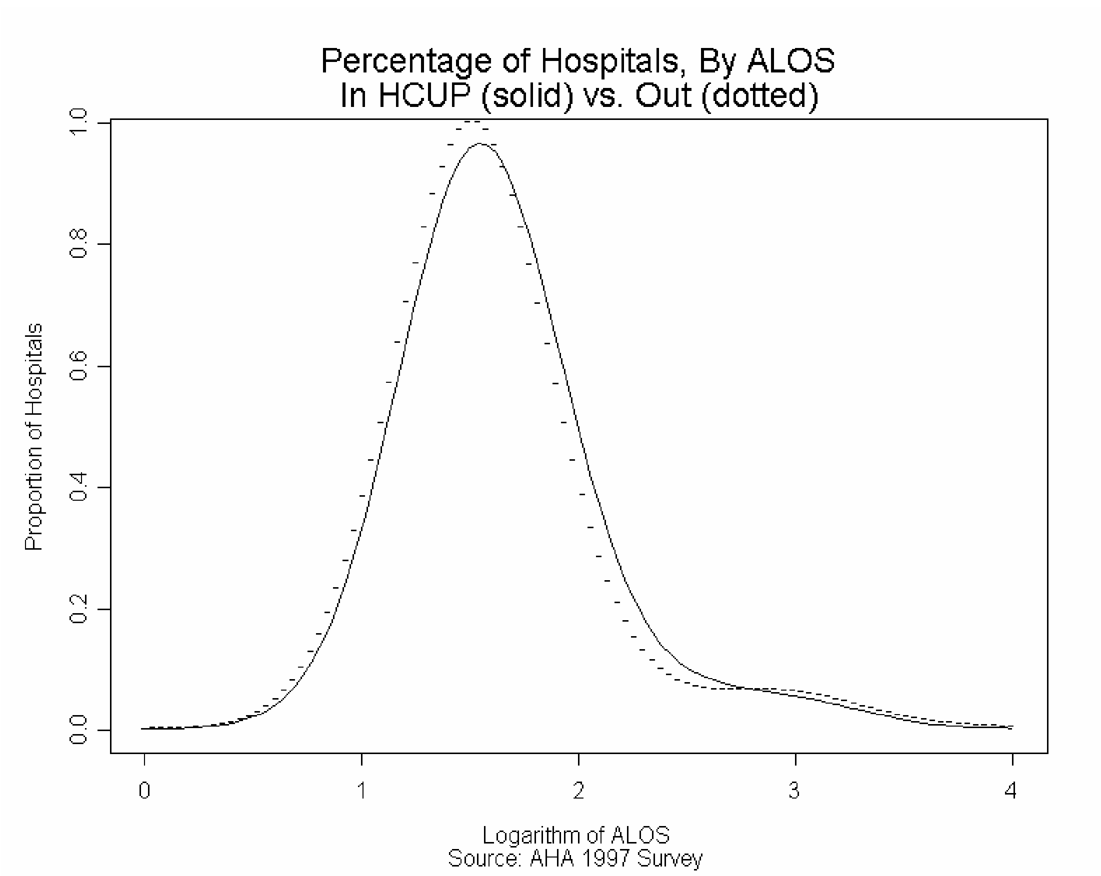
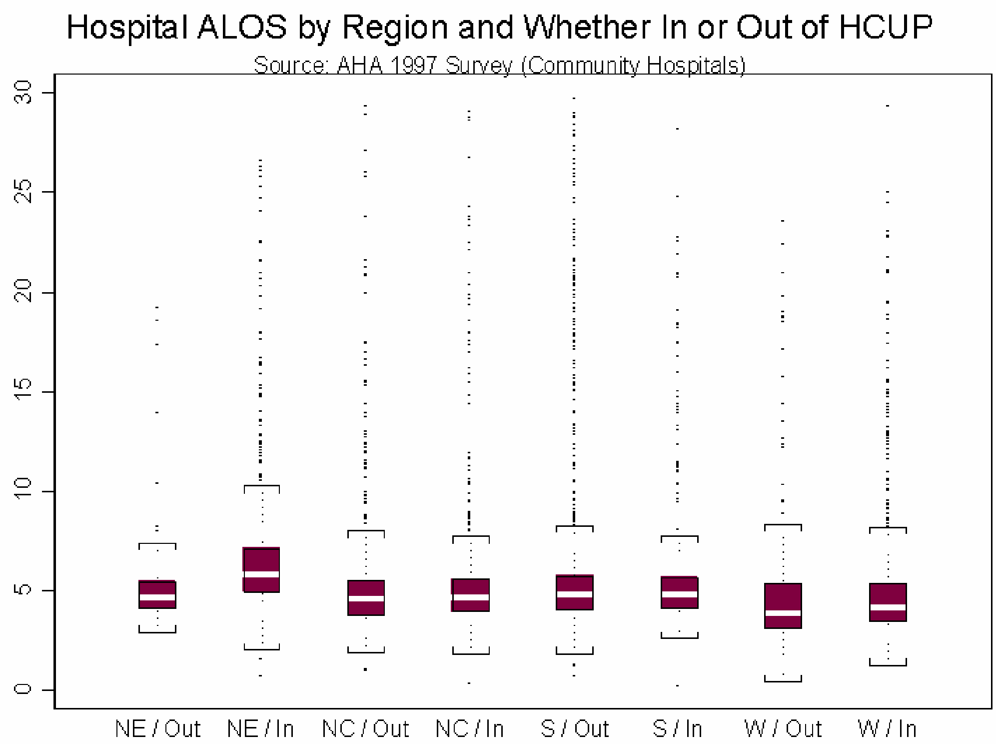


**Figure 9**


Hospital ALOS by Region and Whether In or Out of HCUP
Source: AHA 1997 Survey (Community Hospitals)
0
5
10
15
20
25
30
NE / Out
NE / In
NC / Out
NC / In
S / Out
S / In
W / Out
W / In

*Number of Discharges*

Figures 10 and 11 summarize the differences between HCUP and non-HCUP hospitals on another size measure, total discharges. The results are similar to those we found for bed size, except in the West where the difference is greater for total discharges than it is for bed size. HCUP hospitals tend to have more discharges than non-HCUP hospitals in both the Northeast and the West.

**Figure 10**

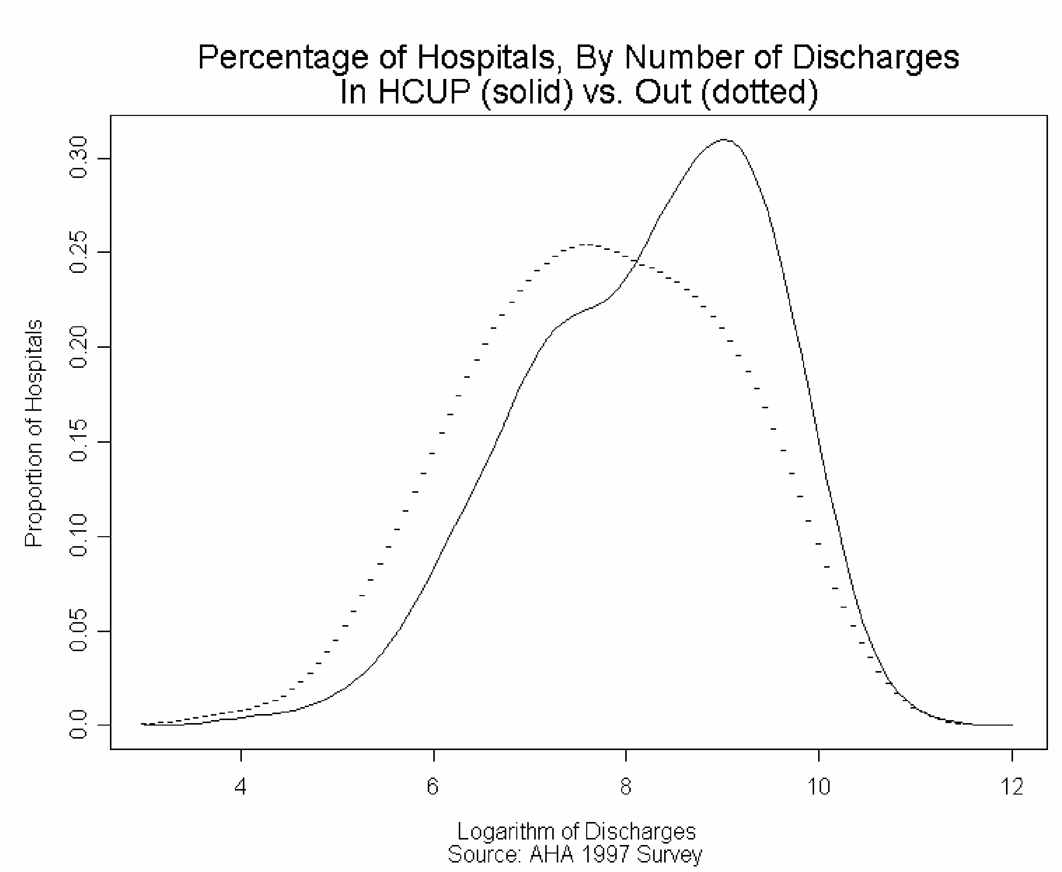
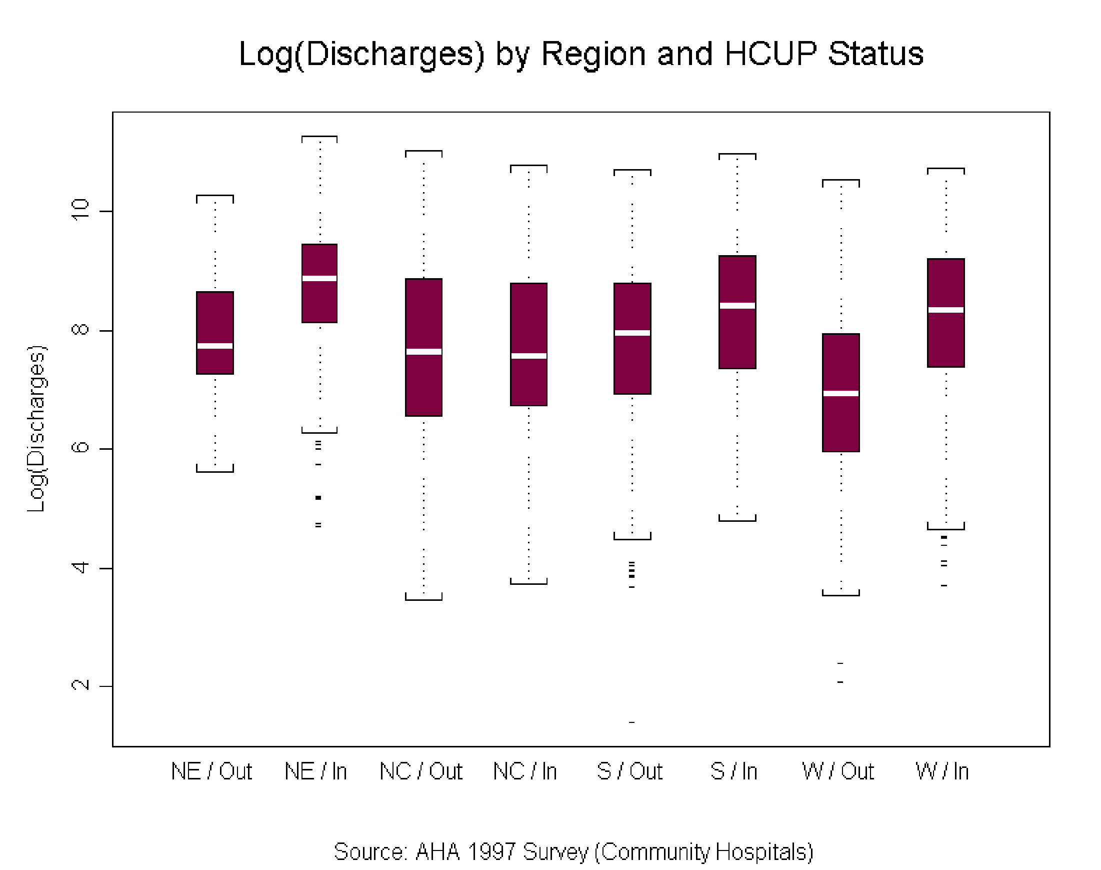


**Figure 11**


Log(Discharges) by Region and HCUP Status
Log(Discharges)
2
4
6
8
10
NE / Out
NE / In
NC / Out
NC / In
S / Out
S / In
W / Out
W / In
Source: AHA 1997 Survey (Community Hospitals)

## Finding Good Stratification Variables

It is clear that there are differences that should not be ignored between hospitals in HCUP and non-HCUP states. Hospitals in HCUP states tend to have higher Medicare managed care rates, tend to be larger both in terms of bed size and discharges, and tend to have higher occupancy rates. One way to minimize these differences for the NIS is to draw a sample of hospitals from the HCUP states that is representative of hospitals across the U.S. by stratifying on important hospital characteristics so that the NIS is a "microcosm" of U.S. hospitals. For example, we should strive to have about the same percentage of teaching hospitals in the NIS as there are teaching hospitals in the U.S.

Here is a summary of the stratification used in previous NIS designs:

- **Geographic Region** – Northeast, Northcentral, South, or West
- **Ownership** – Government Nonfederal (Public), Private Not-for-profit (Voluntary) and Private Investor-owned (Proprietary)
- **Location** – Urban or Rural
- **Teaching Status (for Urban hospitals only**) – Teaching or Nonteaching. Two Conditions Required:
    - o COTH Member or AMA Approved Residency Program
    - o Positive Number of Interns and Residents
- **Bed size** – Small, Medium, and Large.

| Location/Teaching | Small | Medium | Large |
|---|---|---|---|
| Rural | 1 – 49 | 50 – 99 | 100+ |
| Urban Nonteaching | 1 – 99 | 100 – 199 | 200+ |
| Urban Teaching | 1 – 299 | 300 – 499 | 500+ |

This resulted in a potential of 108 Strata (4 Regions x 3 Ownership categories x 3 Location/Teaching categories x 3 Bed size categories). In application, the effective number of strata was lower because of very small or missing cells, which forced us to combine strata. This collapsing was a concern because it required manual review to achieve at least two (2) sample hospitals per stratum. Moreover, small cells were a concern to some states because of restrictions on hospital identification, which forced us to remove some HCUP hospitals from the sampling frame.

One reason for small strata was the use of fixed bed size categories across all regions, which created imbalances in the distribution of hospitals across strata. For example, in the West fewer than 10 percent of the urban teaching hospitals fell into the "large" category (500+ beds), whereas in the South about one-third of the urban teaching hospitals fell into this category for 1997.

We found that these previous stratification variables were correlated with outcomes of interest such as hospital charges, lengths of stay, and in-hospital mortality rates, making them good candidates for defining hospital strata.

However, below we also assess the usefulness of other stratification variables. Candidate AHA variables are listed in Appendix A. The main objective is to form strata such that the sample is representative of the target universe and such that hospitals are relatively more homogeneous in their outcomes within strata than they are between strata.

We used the AHA Annual Survey Databases for Fiscal Years 1997-1998 to identify community hospitals and to identify potential stratification variables in the 1997 state data. Unfortunately, the AHA uses different hospital identifiers than each of the state data organizations use. Therefore, we linked the AHA identifiers to the State Inpatient Database (SID) hospital identifiers by matching on hospital name, address, and other available information.  The primary objective was to create crosswalk files for linking AHA ID numbers to HCUP discharge data for the years 1997 and 1998.  This effort verified new or deleted AHA ID numbers and validated an electronic file that allowed the tracking of hospital closings, openings, mergers, and de-mergers.

In our experience, data obtained from a state data organization does not necessarily contain a complete enumeration of hospitals.  For example, the confidential research files purchased from the Massachusetts Division of Health Care Finance and Policy for the 1997 HCUP SID and NIS nominally contained discharges from all general acute care hospitals in the state, but 13 percent of the community hospitals in Massachusetts were not included in those files.

Further, as a part of the AHA data processing, we compared AHA data with state data for each year.  To do this, we created a separate table for each participating state that compared the number of admissions for each AHA ID to the number of discharges for the corresponding state-assigned hospital identification number.  The AHA estimates agree substantially with the actual discharge counts for most hospitals in the database.  This is important because we use the AHA data to develop discharge weights to the universe.

## Regression Trees

To investigate the potential for the vast array of AHA variables to be used for stratification, we employed a recursive partitioning methodology called regression trees using the "RPART" function with the S-PLUS statistical software (Atkinson and Therneau, 2000).  RPART builds regression models of a very general structure using a two-stage procedure.  The resulting model can be represented as a binary tree.  In the first stage, RPART recursively splits the observations into subsets using the independent variables that explain the most variation in the dependent variable at each iteration.  In the second stage, RPART eliminates variables that appear to be fitting noise in the data based on 10-fold cross-validation.

This process is best explained through an example.  We have seen that HCUP hospitals tend to have a higher occupancy rate than non-HCUP hospitals.  However, we do not want to stratify hospitals on occupancy rate for the NIS because it is an outcome rather than a (more stable) hospital institutional characteristic.  In addition, institutional characteristics are likely to correlate with a number of other outcomes of interest.  We want to ensure that the NIS produces a range of hospital outcomes similar to that shown in the entire hospital population and simultaneously reduce the variation within strata on hospital outcomes to reduce the variance in estimates of outcomes from the sample.  Therefore, we sought to identify institutional characteristics (Appendix A) on which we could stratify, and that explain variation in hospital occupancy rates.  Below, we also sought out stratification variables correlated with average lengths of stay, Medicare charges per admission, and Medicare mortality.

### *Occupancy Rate*

The regression tree methodology produced the tree shown in Figure 12 for occupancy rate.  Starting at the top of the tree, the observations are first split by whether the hospital has an AMA approved residency program (variable A102).  Hospitals with an AMA approved program split to the right and that subset of hospitals is further split according to whether the hospital is a member of the Council of Teaching Hospitals (COTH).  COTH members split to the right, resulting in a "terminal node" composed of 302 hospitals with an average occupancy rate of 73 percent.  Non-COTH members split to the left in a terminal node of 686 hospitals with an average occupancy rate of 64 percent.

Returning to the top of the tree, hospitals without an AMA approved residency program are split to the left.  Hospitals in that subset are further split according to bed size.  Hospitals with more than 140 beds are split to the right, resulting in a terminal node of 1,047 hospitals with an average occupancy rate of 59 percent.  Hospitals with fewer than 141 beds are further split into two terminal nodes: 1) 928 hospitals having 75 or more beds with an average occupancy rate of 53 percent, and 2) 2,150 hospitals having less than 75 beds with an average occupancy rate of 45 percent.

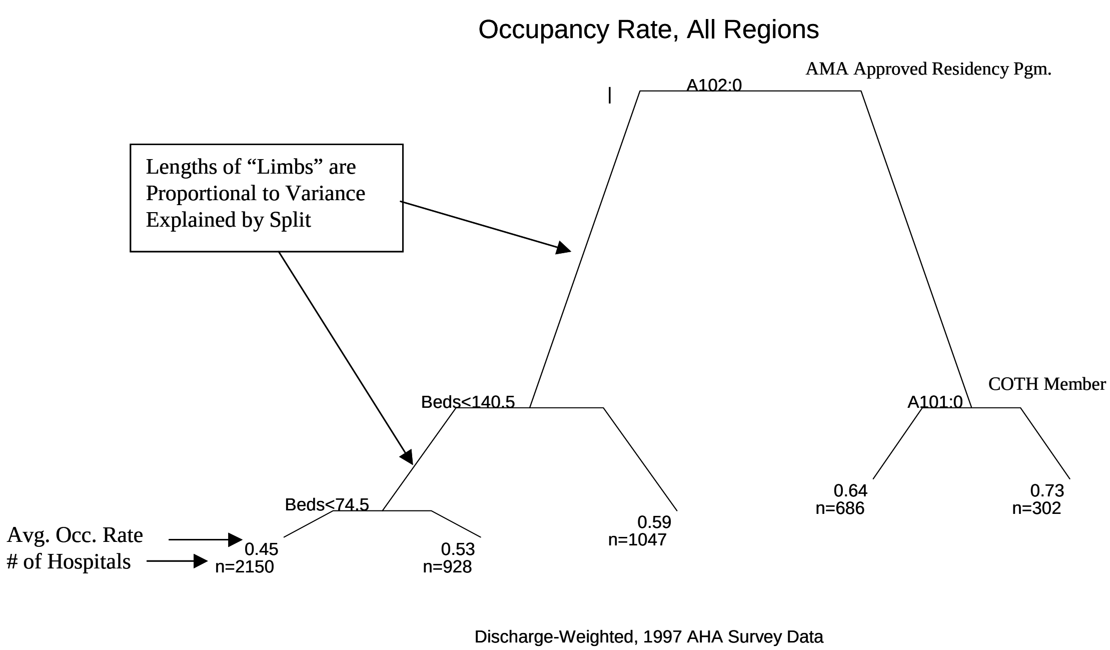
Therefore, the "predictor" variables in the regression tree are: 1) the presence of an AMA approved residency program, 2) COTH membership, and 3) bed size. Depending on the values of these three variables, a hospital is placed in one of the terminal nodes and the estimated occupancy rate is the average occupancy rate for that node. For example, a nonteaching hospital with 200 beds would have an estimated occupancy rate of 59 percent. This regression tree explains about 27 percent of the variance in occupancy rate measured by 10-fold cross-validation.[2] In fact, the first split on AMA residency alone explains about 17 percent of the variation. The lengths of the "limbs" on the tree are proportional to the variance explained by the split at each node.

Figure 13 further illustrates the relationship between hospital bed size and occupancy rate. Each point represents a community hospital. The line through the points is a smoothed local regression estimator, which highlights the strong correlation between hospital bed size and occupancy rate.

Although the geographic region was a potential predictor variable (that was not selected by the tree-building algorithm), we also fit regression trees for occupancy rate separately for each of the four regions. The results for all regions combined, shown in Figure 12, were similar to the results for each region individually.

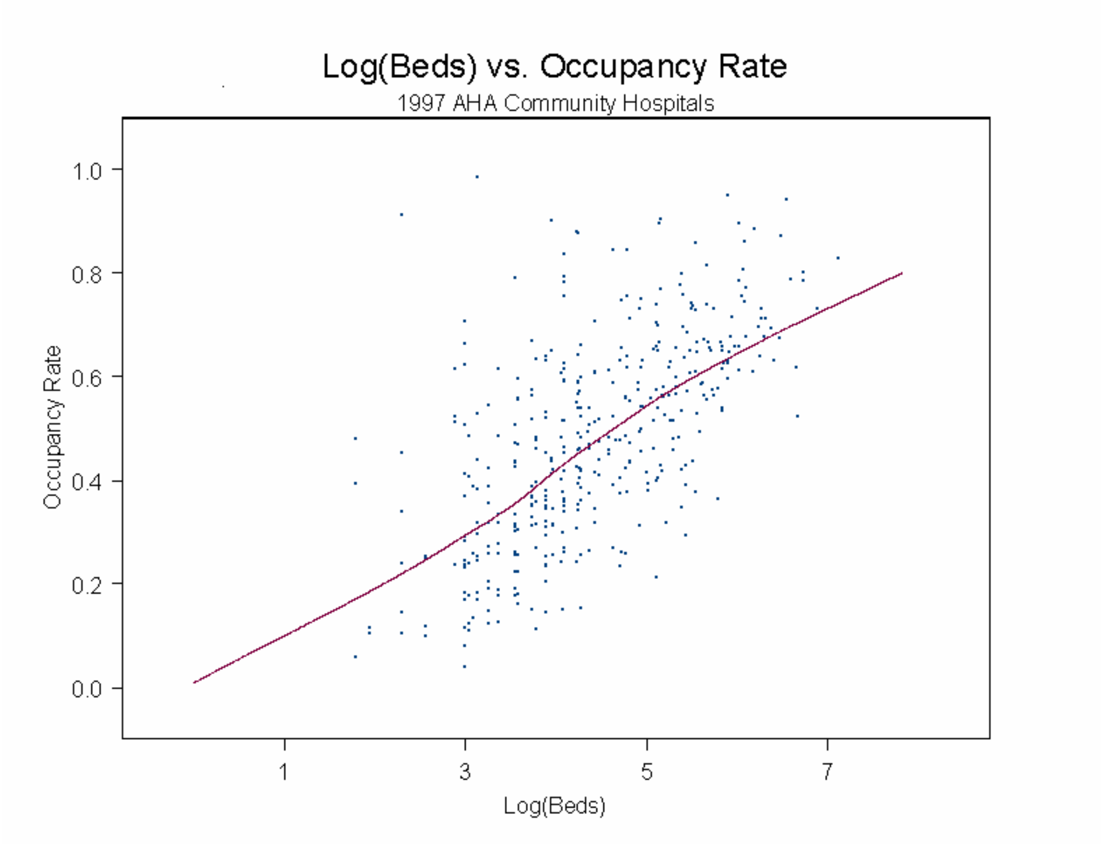
What we learn from this exercise is that, of all the variables considered by the regression tree (see Appendix A), those that explain the most variation in occupancy rate are teaching status and bed size. Therefore, we should consider these variables for stratifying hospitals in the sampling design. We also looked at the best alternative split at each node. In this example, having a medical school affiliation or having any intern or resident program would have resulted in nearly as good a split as that on an AMA approved residency program at the top of the tree. However, for the other splits in the tree there were no competing variables that were nearly as good as COTH membership or the number of beds for further explaining variation in hospital occupancy rates.

**Figure 12**




[2] Variance explained is measured by the squared correlation between actual occupancy rate and predicted occupancy rate based on 10-fold cross-validation.

**Figure 13**



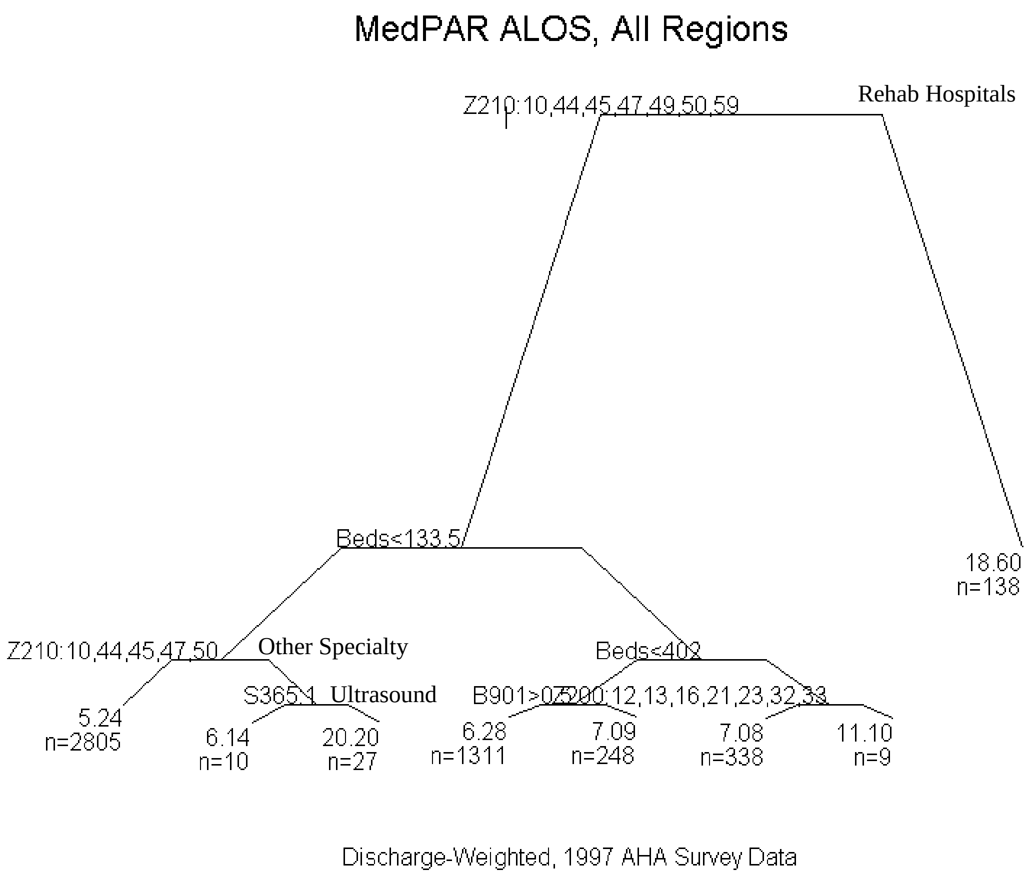
Log(Beds) vs. Occupancy Rate
1997 AHA Community Hospitals
Occupancy Rate
1.0
0.8
0.6
0.4
0.2
0.0
1
3
5
7
Log(Beds)

### *Average Length of Stay*

Earlier, we compared HCUP hospitals to non-HCUP hospitals on their average lengths of stay based on hospital-level data: the total number of inpatient days and the total number of inpatients reported in the 1997 AHA survey data. Here, we calculated the ALOS for Medicare patients based on patient-level data, the 1997 MedPAR data obtained from the Centers for Medicare & Medicaid Services. We fitted regression trees to both the AHA-based ALOS and the MedPAR-based ALOS. The results were very similar. The regression tree for Medicare ALOS is shown in Figure 14.

The striking feature of this tree is that rehabilitation hospitals explain the most variation in ALOS (34 %). The variable Z210 is hospital type, which takes on discrete values designating children's hospitals, psychiatric hospitals, and so on. Rehabilitation hospitals split to the right resulting in a terminal node having 138 hospitals with an ALOS of 18.6 days. The terminal nodes to the left result from splits that are most important on bed size and have ALOS values that range from 5.24 days to 11.10 days, with one node containing 27 hospitals with an ALOS of 20.2 days. This one node is for hospital types that are labeled "other specialty" (either adult or children), with fewer than 134 beds, and which do not have diagnostic ultrasound as a service (variable S365). This one split was not observed for the AHA-based ALOS regression tree (not shown).

**Figure 14**



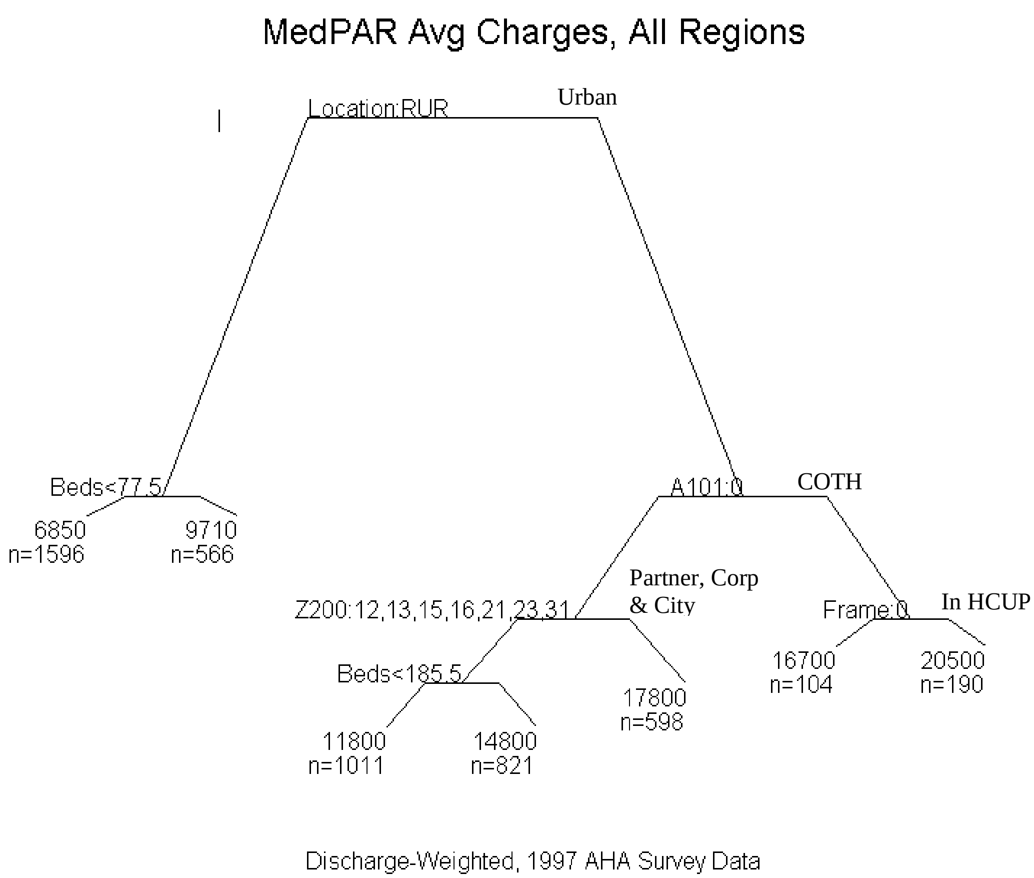
*Medicare Average Charges*

We again used 1997 MedPAR data for hospital charges, because we lacked a data source for inpatient charges that covered the entire U.S. hospital population. The regression tree is shown in Figure 15.

The first split is on whether the hospital is located in a rural or an urban area. Rural hospitals are split to the left, and are then split on whether they have fewer than 78 beds. The average charge is $6,850 for patients in rural hospitals with fewer than 78 beds and it is $9,710 in rural hospitals with 78 or more beds.

Returning to the top of the tree, urban hospitals are split to the right. They are subsequently split on COTH membership (A101), type of ownership (Z200), bed size, and whether the hospital is in a frame state (HCUP state). It turns out that among urban COTH hospitals, the 190 hospitals in HCUP states have an average charge of $20,500 compared hospitals in non-HCUP states with an average charge of $16,700. For the split on ownership, the right leg is for partnerships, corporations, and city-owned hospitals with an average charge of $17,800. The left leg is for mostly government and nonprofit hospitals with average charges of $11,800 (beds < 185.5) and $14,800 (beds > 185.5). Note that the legs on some of the final splits are very short, indicating that they explain relatively little variance.

**Figure 15**



*Medicare Mortality*

Only one hospital characteristic predicted in-hospital mortality for Medicare inpatients. Rehabilitation hospitals had a much lower mortality rate (0.3 percent) than other hospitals (4.7 percent). Clearly, this is just a proxy for case-mix differences between rehabilitation hospitals and other types of hospitals. In fact, in the aggregate one would expect mortality to be predicted by case-mix severity rather than institutional characteristics of hospitals. Therefore, this result is not surprising.

## Rehabilitation Hospitals

Undoubtedly rehabilitation hospitals are quite different from other short-term community hospitals. They have much longer average lengths of stay and much lower mortality rates. While these differences can be explained by disease and severity measures in patient-level analyses, we decided to eliminate rehabilitation hospitals from the NIS (and the target universe) primarily because they represent a unique, small segment of the hospital population with uneven reporting across the states. Consequently, we could not be confident that these hospitals would be represented adequately in the NIS and including them could bias some analyses.

## Cutoff Points for Bed Size Categories

The previous analyses all point to bed size as an important factor in hospital outcomes. The previous NIS bed size categories were nested only within location/teaching status (small, medium, and large defined separately for rural, urban nonteaching, and urban teaching hospitals). Also, the previous cutoff points matched those used in reports by the AHA. However, even within these location/teaching categories, the bed size distributions vary widely by geographic region.

For example, Figure 16 summarizes the bed size distribution for rural hospitals for each region. The horizontal axis shows the number of beds and the vertical axis shows the proportion of hospitals with a greater number of beds. For instance, the lowest line in the plot is for hospitals in the West. It indicates that only 27 percent of rural hospitals in the West have more than 50 beds. By contrast, about 62 percent of rural hospitals in the Northeast (top line in the plot) have more than 50 beds. Yet, in the previous NIS design, rural hospitals with 50 or fewer beds were defined as “small” regardless of the region.

This regional imbalance in the percentage of small, medium, and large hospitals also occurred for urban nonteaching and urban teaching hospitals. Therefore, we decided to define small, medium, and large bed size categories nested within region and location/teaching category such that approximately one-third of the hospitals would be allocated to each bed size category. Our intent was to reduce the number of small strata for sampling hospitals.

This is illustrated for the definition of small rural hospitals in Figure 17. The horizontal line in the plot is drawn at .667 (two-thirds) because we want one-third of hospitals in the small category and two-thirds in the two larger size categories combined. The vertical arrows pointing down intersect the bed size axis at the desired cutoff points: 25 beds for the West, 30 beds for the Northcentral, 40 beds for the South, and 50 beds for the Northeast.

Bed size cutoff points for urban nonteaching and urban teaching hospitals were derived similarly. The results are shown in Table 4.

**Table 4**

**Bed Size Cutoff Points for Small, Medium, and Large Hospitals**

| Region | Location/Teaching | Small | Medium | Large |
|---|---|---|---|---|
| Northeast | Rural | 1 – 49 | 50 – 99 | 100+ |
| | Urban Non-teaching | 1 – 124 | 125 – 199 | 200+ |
| | Urban Teaching | 1 – 249 | 250 – 424 | 425+ |
| Northcentral | Rural | 1 – 29 | 30 – 49 | 50+ |
| | Urban Non-teaching | 1 – 74 | 75 – 174 | 175+ |
| | Urban Teaching | 1 – 249 | 250 - 374 | 375+ |
| South | Rural | 1 – 39 | 40 – 74 | 75+ |
| | Urban Non-teaching | 1 – 99 | 100 – 199 | 200+ |
| | Urban Teaching | 1 – 249 | 250 – 449 | 450+ |
| West | Rural | 1 – 24 | 25 – 44 | 45+ |
| | Urban Non-teaching | 1 – 99 | 100 – 174 | 175+ |
| | Urban Teaching | 1 – 199 | 200 – 324 | 325+ |

**Figure 16**

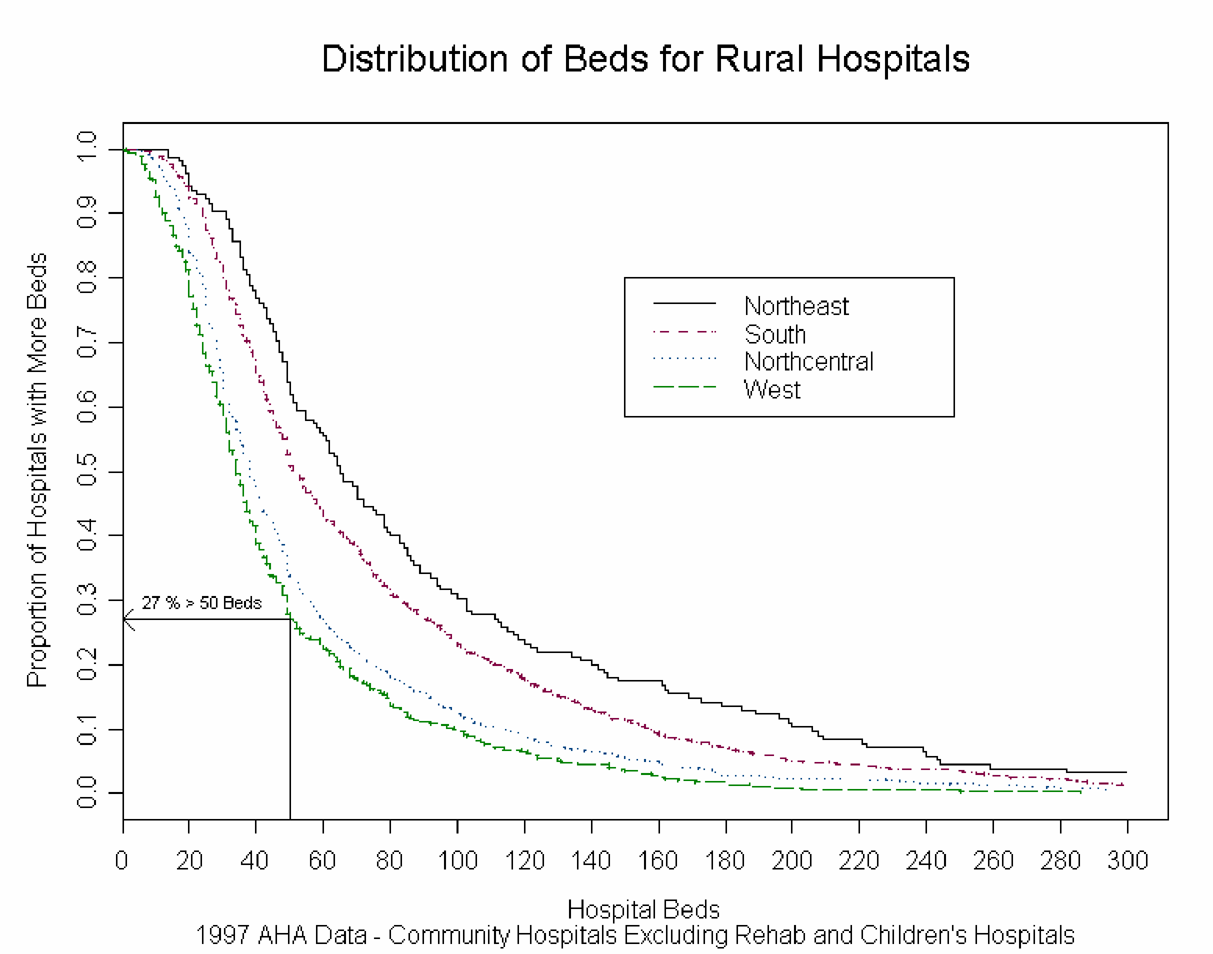
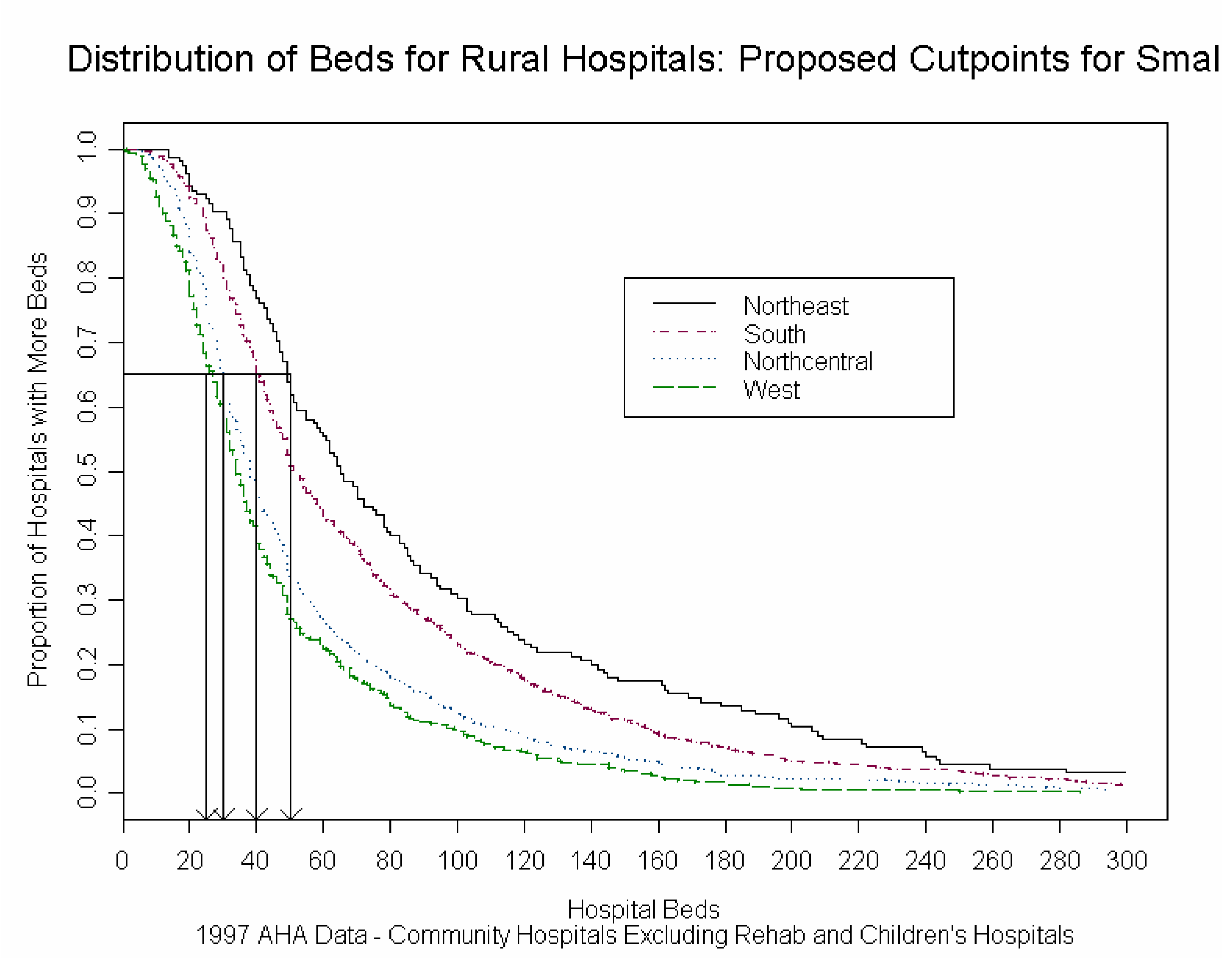

Distribution of Beds for Rural Hospitals
Proportion of Hospitals with More Beds
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
27 % > 50 Beds
Northeast
South
Northcentral
West
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
Hospital Beds
1997 AHA Data - Community Hospitals Excluding Rehab and Children's Hospitals

**Figure 17**




## Ownership Breakdowns

The earlier analyses indicate that the hospital type of ownership is predictive of average hospital charges. The distributions of U.S. hospitals by type of ownership (government nonfederal [public], private not-for-profit [voluntary] and private investor-owned [proprietary]) are shown for each region in the bar charts in Figures 18 – 21. Each plot contains nine subplots corresponding to urban teaching hospitals (top row of plots), urban nonteaching hospitals (middle row of plots), rural hospitals (bottom row of plots), by the new hospital bed size categories corresponding to large (first column), medium (second column), and small (third column). Each of the nine subplots contains three vertical bars corresponding to the number of hospitals in the universe that are public, voluntary, and private. Some subplots appear to contain only one or two bars because no hospitals exist for some categories. Each bar is shaded. The darker shade represents the number of HCUP hospitals and the lighter shade represents the number of non-HCUP hospitals.

The Northeast region, shown in Figure 18, is comprised almost entirely of voluntary hospitals. In addition, since 96 percent of discharges are in HCUP states in the Northeast, nearly all of the bars are heavily shaded. The lowest level of representation is for small rural hospitals. It is clear that there is little to be gained by stratifying hospitals on ownership in the Northeast.

For the Northcentral region, shown in Figure 19, it makes sense to stratify on ownership only for rural hospitals. However, there are very few proprietary rural hospitals. Consequently, for the Northcentral region, we will stratify rural hospitals according to Public and Private, combining Voluntary and Proprietary.

For the South region, shown in Figure 20, we will ignore ownership for urban teaching hospitals because there are so few of them. However, we will keep all three ownership categories for rural and urban non-teaching hospitals.

For the West region, shown in Figure 21, we will ignore ownership for urban teaching hospitals, retain all three categories for urban nonteaching hospitals, and stratify on only two ownership categories, Public and Private, for rural hospitals.

In summary, we will eliminate ownership as a stratifier except as follows. We will stratify according to public, voluntary, and proprietary for hospitals in the South that are rural and urban nonteaching and for hospitals in the West that are urban nonteaching. We will stratify according to public and private for rural hospitals in the West and Northcentral regions.

**Figure 18**

**Hospital Ownership: Northeast Region**

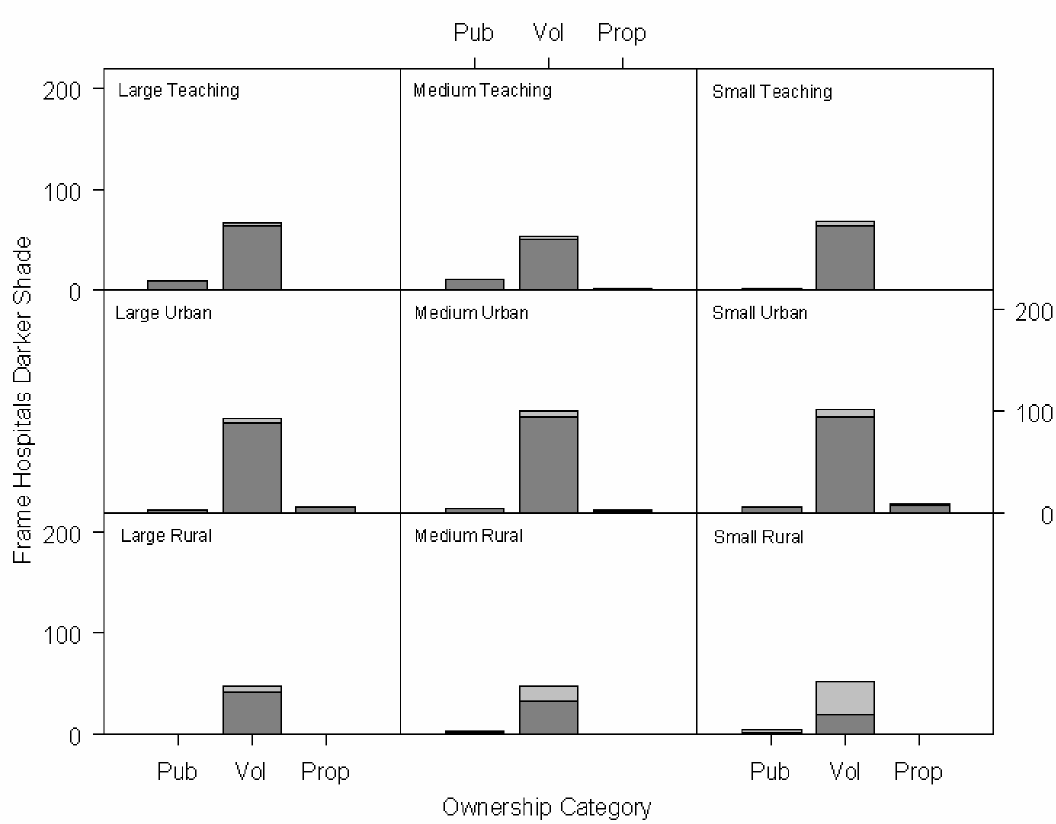


**Figure 19**

**Hospital Ownership: Northcentral Region**

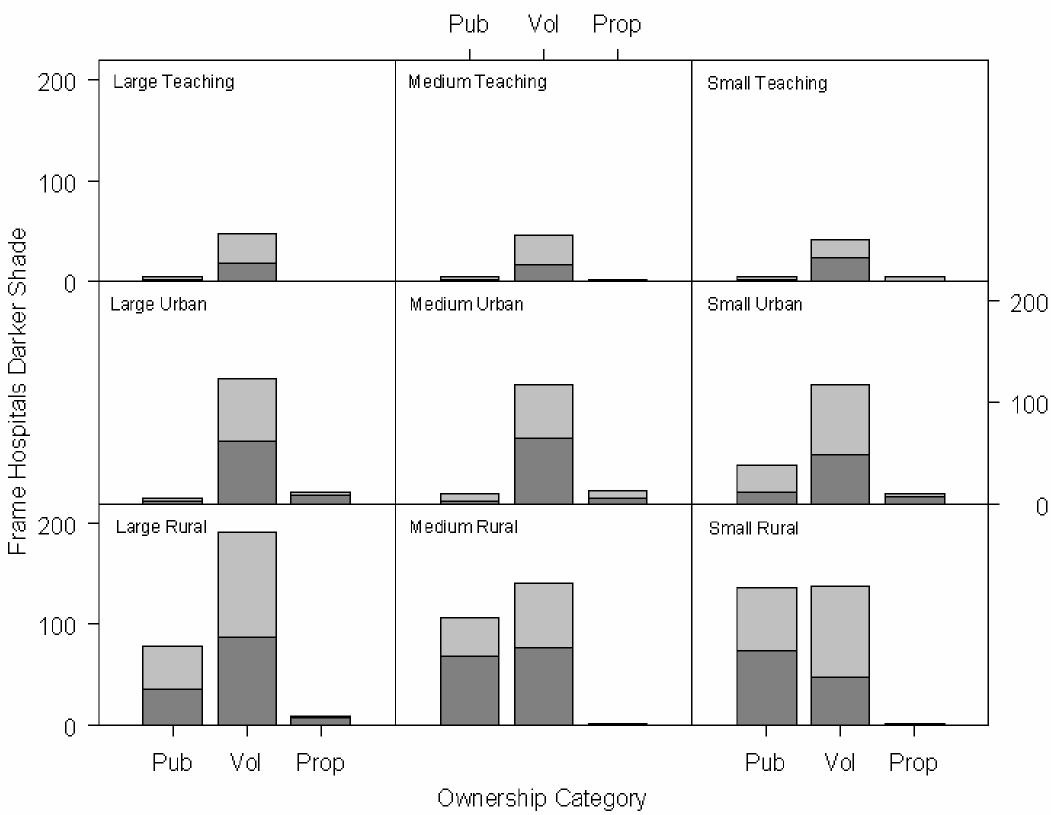


**Figure 20**

**Hospital Ownership: South Region**

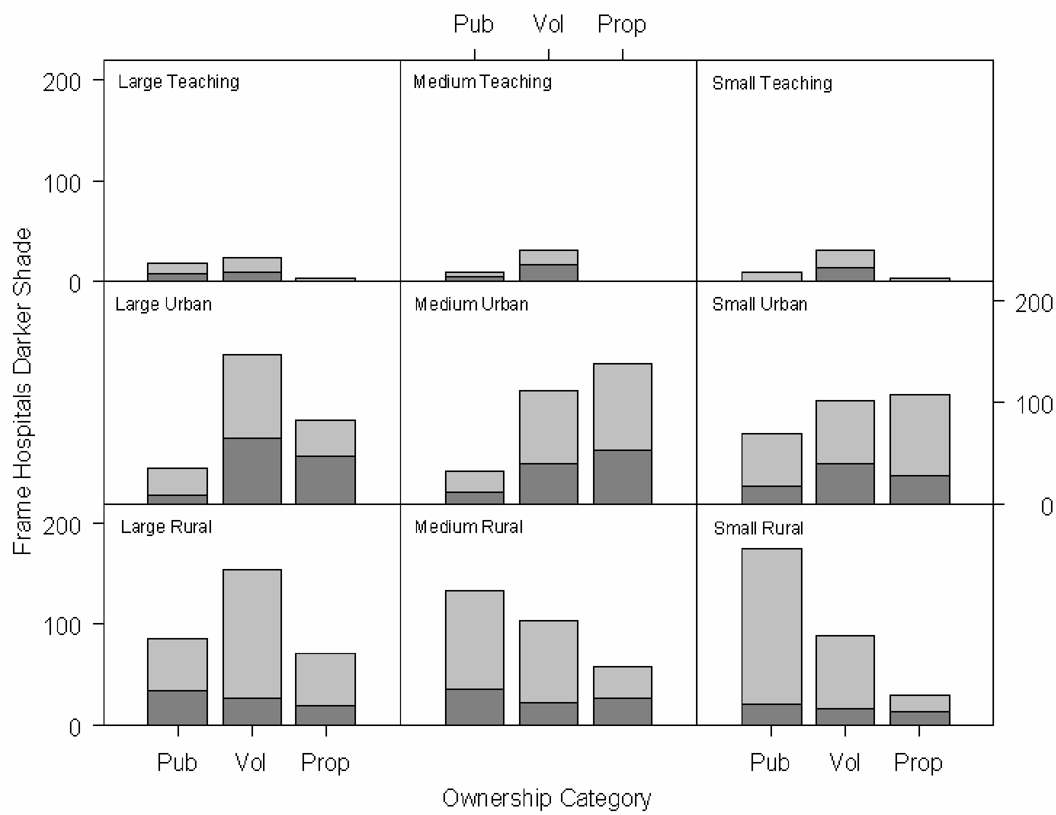
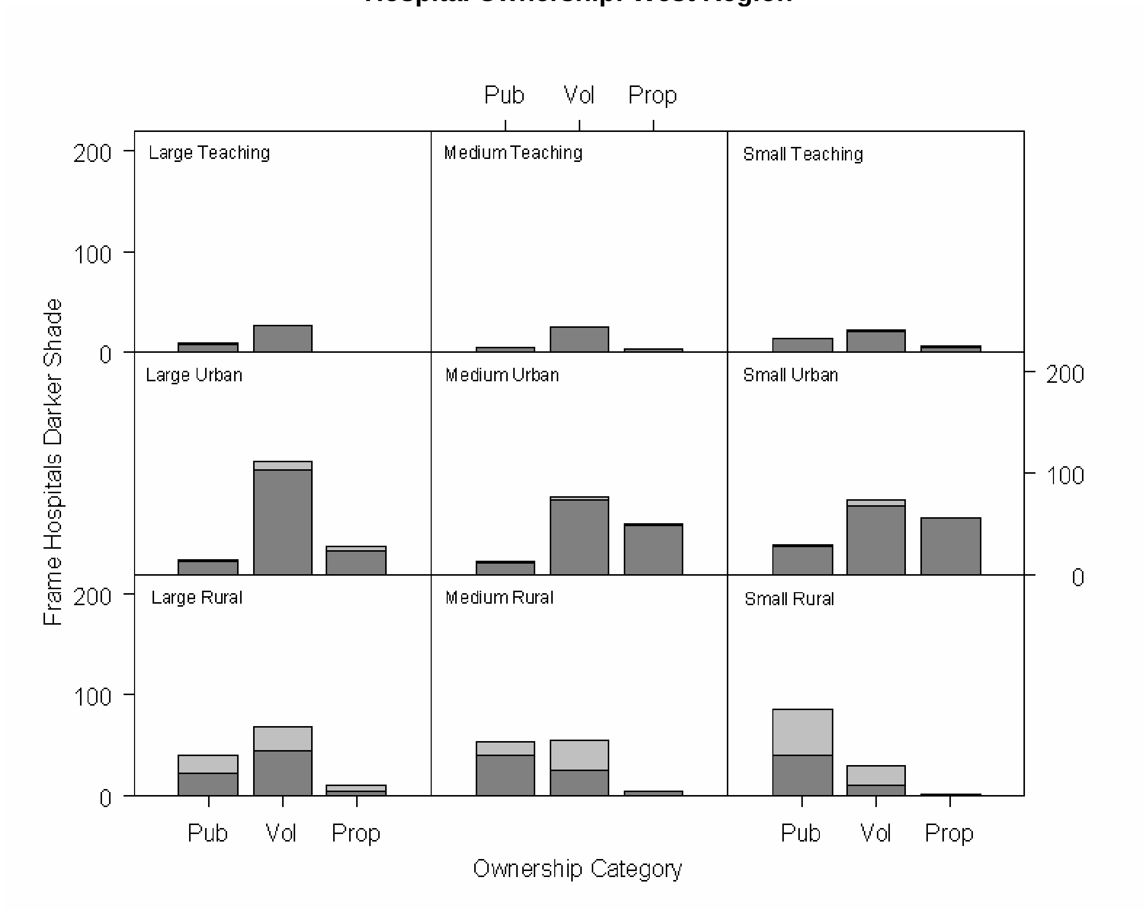


**Figure 21**

**Hospital Ownership: West Region**




## Teaching Status

Teaching status is clearly an important hospital characteristic. For example, teaching hospitals have a distinct mission that the Centers for Medicare & Medicaid Services (CMS) recognizes with higher payments for Medicare inpatient care. Moreover, patients may tend to receive different treatments and even have different lengths of stay in support of the teaching function. Prior NIS sampling designs defined teaching hospitals as those that had 1) a positive number of interns or residents, and 2) either COTH membership or an AMA approved residency program.

We compared this to CMS's designation of a teaching hospital (indirect medical education (IME) for 4,611 hospitals that could be matched between CMS's file and the AHA file. The results are in Table 5.

**Table 5**

**CMS Teaching Hospitals versus HCUP Teaching Hospitals**

| | HCUP Teaching Hospital | |
|---|---|---|
| **CMS IME** | **No** | **Yes** |
| No | 3,519 | 18 |
| Yes | 488 | 586 |

Nearly half of the hospitals designated by CMS as teaching hospitals were not defined as teaching hospitals by HCUP. It is difficult to replicate all of CMS's criteria using AHA data — it requires an "approved medical residency training program." However, one key criterion is that the interns plus residents to beds ratio (IRB) should be greater than 0.25. Therefore, we modified the HCUP definition to include hospitals that satisfied any one of three conditions:

1. COTH membership, or
2. AMA approved residency program, or
3. IRB >= 0.25.

This definition expands on the old NIS definition in two ways. First, hospitals do not require interns or residents if they are COTH members or have an AMA approved residency program. Second, hospitals do not have to satisfy either of those two conditions if they have an IRB of 0.25 or higher.

## Zip Code Sort

For previous versions of the NIS, we sorted hospitals within strata by the first three digits of their zip code before selecting a systematic sample. This was to ensure geographic dispersion of the sample within the HCUP states. We will continue this feature in the new design.

## Sample Size

We will continue to sample a number of hospitals equal to 20 percent of the universe within each stratum. If fewer than 20 percent of all U.S. community hospitals are contained in the HCUP states, then all HCUP hospitals will be selected for the sample, subject to any state's restrictions. In any given year, there will be about 5,000 hospitals in the universe. Therefore, we will sample about 1,000 hospitals for the NIS.

## Two 10-percent Subsamples

In the past, researchers have found it useful to test programs and perform preliminary analyses on a small subset of the NIS before analyzing the entire NIS. Therefore, we will continue to produce two non-overlapping 10-percent subsamples. The subsamples will be selected by drawing every tenth discharge starting with two different starting points (randomly selected between 1 and 10). The different starting points for each of the two subsamples guarantees that they will not overlap. Discharges will be sampled so that 10 percent of each hospital's discharges in each quarter are selected for each of the subsamples. If desired, the two subsamples can be combined to form a single, generalizable 20 percent subsample of NIS discharges.

## Final Design

In summary, the final sample design is as follows. The hospital universe is defined by all hospitals that were open during any part of the calendar year and were designated as community hospitals in the American Hospital Association (AHA) Annual Survey of Hospitals, excluding rehabilitation hospitals. For purposes of the NIS, the definition of a community hospital is that used by the AHA: "all nonfederal short-term general and other specialty hospitals, excluding hospital units of institutions." Consequently, Veterans Hospitals and other federal hospitals are also excluded. The NIS will be a stratified sample of hospitals drawn from the subset of hospitals in states that make their data available to the HCUP project and *that can be matched to the AHA survey data.* Hospitals will be stratified by region, location/teaching status (within region), bed size category (within region and location/teaching status), and ownership (within region, location/teaching, and bed size categories). The regions are defined by the four census regions (Northeast, Northcentral, South, and West). Location is defined by AHA's designation of urban or rural. Teaching hospitals are those with COTH membership, or with an AMA-approved residency program, or with an intern-to-bed ratio of 25 percent or higher. Bed size categories are small, medium, and large, with cutoff points defined in Table 4. Ownership breakdowns are those described in the section on ownership earlier in this report. Within each stratum, we will draw a systematic random sample of hospitals equal in size to 20 percent of the universe for that stratum. The hospitals will be sorted by the first three digits of their zip code for the systematic sample. The NIS will include all discharges from the sampled hospitals.

# Weighting Strategy

The discharge sample weights for previous versions of the NIS were calculated within each sampling stratum as the ratio of discharges in the universe to discharges in the sample (adjusted for missing quarters of data). The total number of discharges in the universe, which includes both HCUP and non-HCUP hospitals, was based on AHA survey data for each year. Consequently, the discharge sample weights were constant for all discharges within each stratum except when adjusted for missing quarters of HCUP data. However, recognizing that we had a finer breakdown of discharges reported in the AHA survey, we decided to test an alternative weighting strategy that would yield four weights per stratum, with separate weights for

1. Newborns
2. Medicare discharges (non-newborns)
3. Medicaid discharges (non-newborns)
4. Other discharges (non-newborns).

We reasoned that weighting discharges separately to each of these categories would yield better estimates of outcomes (number of discharges, ALOS, average charges, and average mortality), especially payer-specific outcomes, than using the same weight for all four types of discharges within a stratum.

Consequently, we compared estimates using a single weight per stratum to estimates using four weights per stratum using the 1997 AHA and 1997 SID data. To accomplish this we used the new sampling design described earlier and simulated 1,000 NIS hospital samples. For each of the 1,000 samples we assigned two sets of discharge weights corresponding to 1) one weight per stratum and, 2) four weights per stratum. We then compared the distribution of estimates from the 1,000 NIS samples. We compared estimates for the number of discharges, the ALOS, the average charges, and the average in-hospital mortality within each region.

## Weight Calculations

All analyses are based on the new stratification scheme described earlier. Therefore, we assigned each hospital in the 1997 SID to one of the 60 hospital strata. We drew a NIS sample using the new sample design. For each NIS sample, we then used the 1997 AHA survey data to calculate weights as follows.

### *One Weight per Stratum*

Total discharges for a stratum in the universe was equal to the number of hospital discharges reported in the AHA survey for 1997, which is the sum of newborns (variable B901) and hospital discharges (variable B005H) summed over all universe hospitals in the stratum. We substituted total facility discharges (variable B005) if the number of hospital discharges was missing.

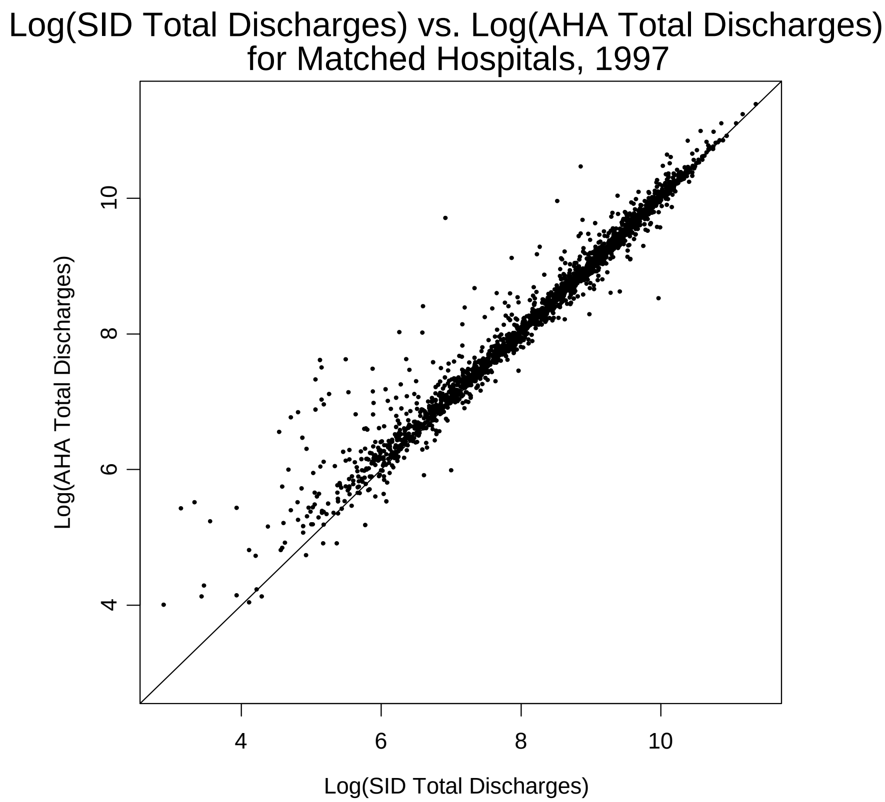
For each hospital sample, we calculated discharge weights to the universe by post-stratification. Within stratum s, for hospital i, each NIS sample discharge's universe weight was calculated as:

$$W_{is}(\text{universe}) = [N_s(\text{universe}) / AN_s(\text{sample})] * (4 / Q_i),$$

where $N_s$(universe) is the number of discharges from universe hospitals within stratum s; $AN_s$(sample) is the number of *adjusted* discharges from sample hospitals selected for the NIS; and $Q_i$ is the number of quarters of discharge data contributed by hospital i to the NIS (usually $Q_i = 4$). Thus, each discharge's weight is equal to the number of universe discharges it represents in stratum s. To calculate *adjusted* discharges for a hospital with “missing” quarters of data, we compared the hospital’s number of total discharges in the data with the hospital’s number of total discharges reported in the AHA survey to determine whether there appeared to be a true shortfall (as opposed to a closure, merger, or demerger). For each hospital judged to have missing data, we set $Q_i$ to the number of non-missing quarters of data.

The plot in Figure 22 shows that the actual number of discharges in the SID is in close agreement with the total number of discharges reported in the 1997 AHA survey.

**Figure 22**




### *Four Weights per Stratum*

The count of universe discharges for each type of discharge was taken from the AHA survey as:

1. Newborns = Variable B903
2. Medicare hospital discharges (non-newborns) = B015H (or B015 if B015H was missing)
3. Medicaid hospital discharges (non-newborns) = B025H (or B025 if B025H was missing)
4. Other hospital discharges (non-newborns) = B005H – Newborns – Medicare – Medicaid. (We used B005 if B005H was missing) B005H is the total number of hospital discharges reported on the AHA survey.

The discharge weights to the universe were calculated separately for each type of discharge using the same method described above for one weight per stratum. For example, the weight for each newborn was the sum of B903 for all universe hospitals in the stratum divided by the sum of all newborns in the discharge data for the sample hospitals (possibly adjusted for missing quarters of data). Likewise, the weight for Medicare discharges was the ratio of universe Medicare discharges to the sample count of Medicare discharges in each stratum.

These weights are predicated on the accuracy of the payer-specific discharge counts in the AHA data. Figures 23 through 26 show the agreement between the actual count of discharges in the SID and the count of discharges reported to the AHA for each of the four types of discharges. The agreement for each of the four weight categories is not as good as the agreement in total (shown in Figure 22).

**Figure 23**

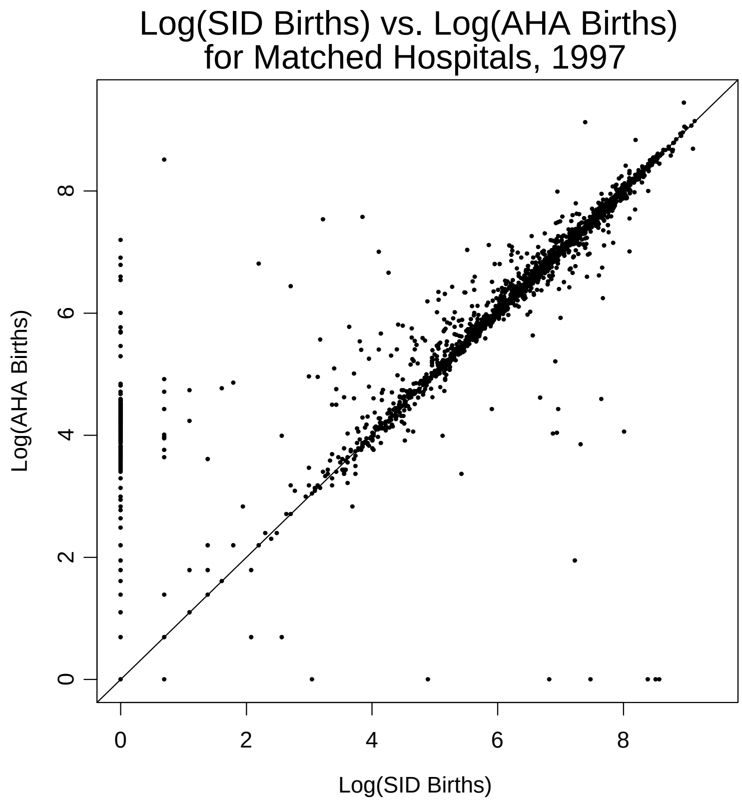


**Figure 24**

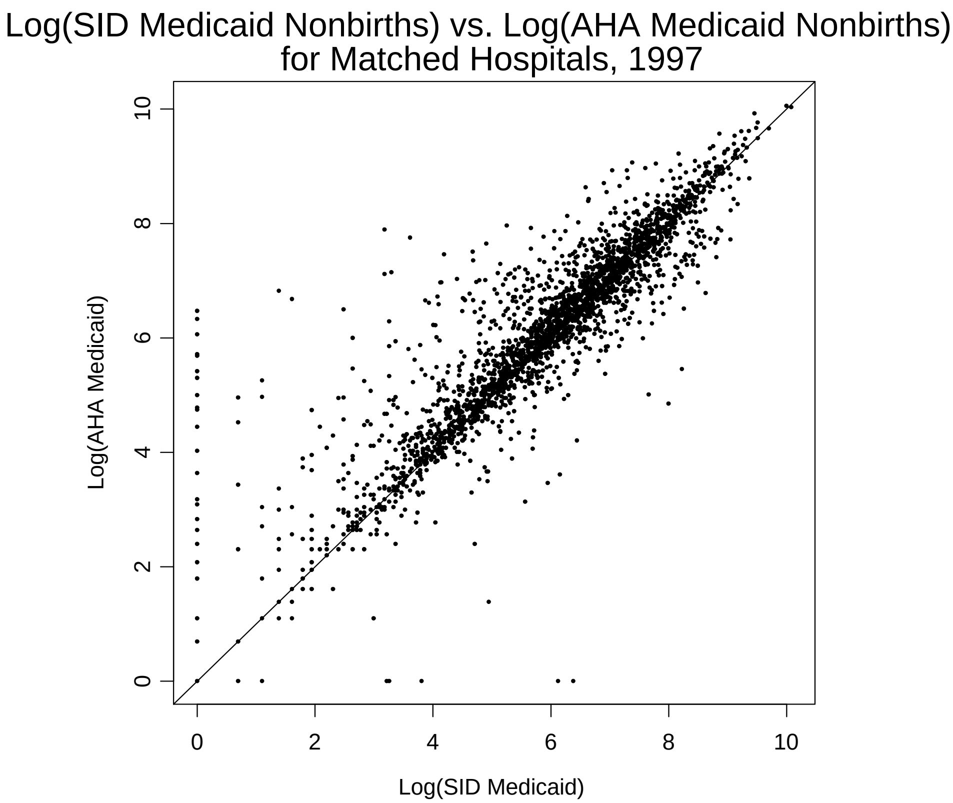
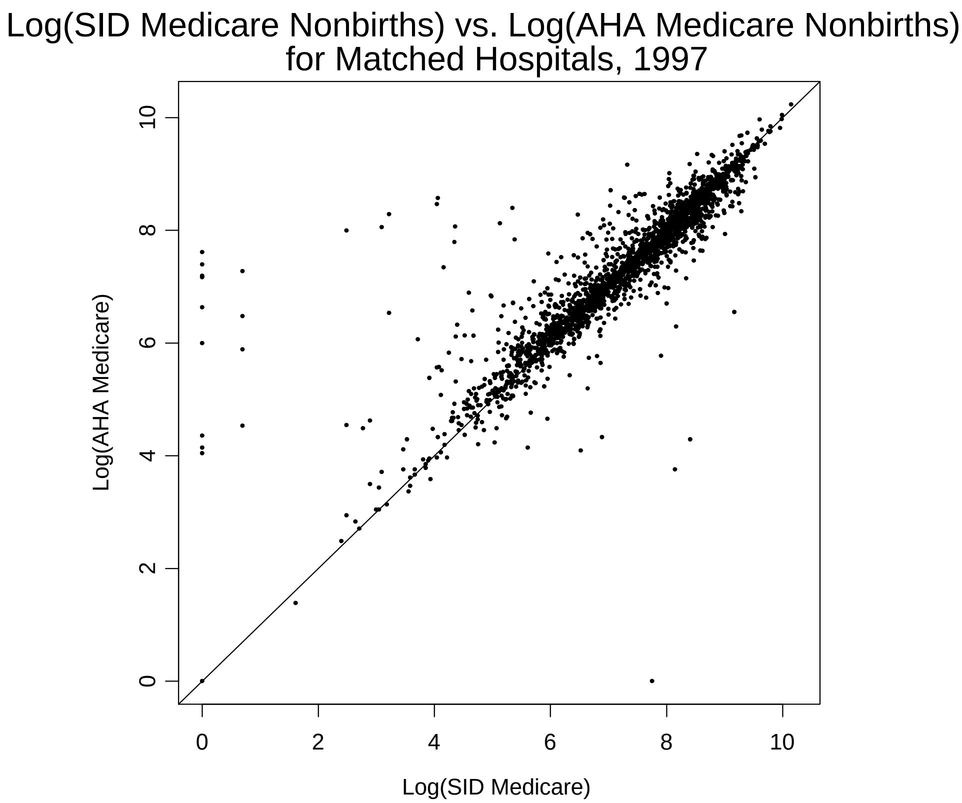
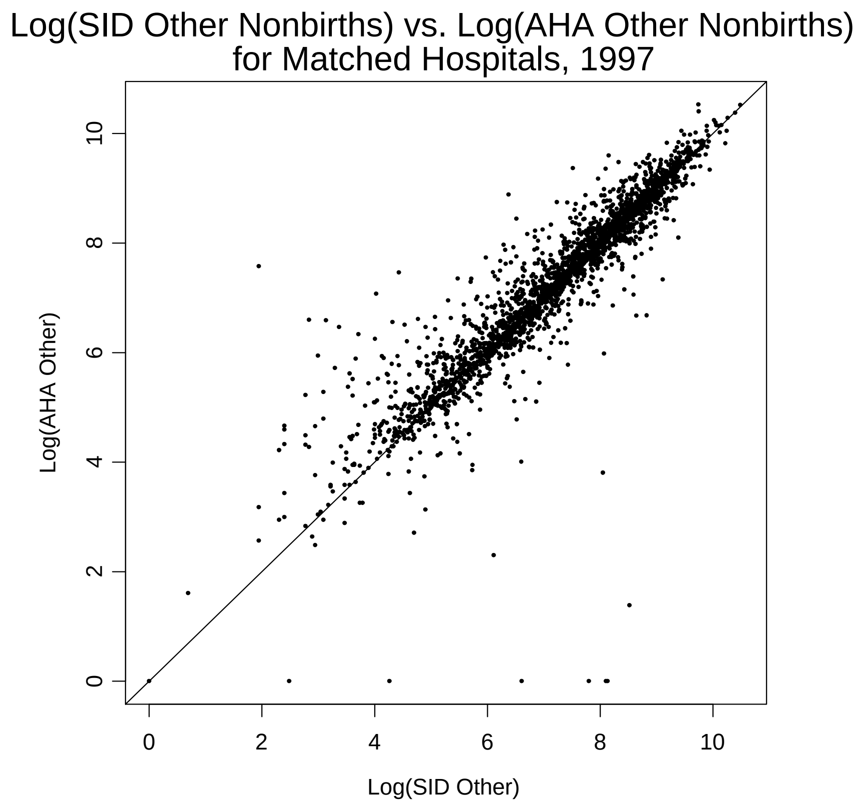

Log(SID Medicaid Nonbirths) vs. Log(AHA Medicaid Nonbirths)
for Matched Hospitals, 1997
Log(AHA Medicaid)
0
2
4
6
8
10
Log(SID Medicaid)

**Figure 25**



Log(SID Medicare Nonbirths) vs. Log(AHA Medicare Nonbirths)
for Matched Hospitals, 1997
Log(AHA Medicare)
Log(SID Medicare)
0
2
4
6
8
10

**Figure 26**




## Comparisons

Table 6 shows the average estimates over 1,000 samples for the total number of discharges, the average mortality rate, the average length of stay and the average inpatient charge using four weights per stratum (payer-specific weights) and one weight per stratum (constant weights). By design, there is no difference between the two estimates on total discharges. Both weights are designed to yield 34.7 million discharges, the total number of discharges reported by community hospitals in the 1997 AHA survey. The differences are small between the two estimates for mortality, ALOS, and average total charges.

**Table 6**

**Comparison of Weighted Estimates Based on 1,000 Samples**

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| Four Weights | 34,685,677 | 0.0245 | 4.8972 | $ 11,302 |
| One Weight | 34,685,677 | 0.0251 | 4.9266 | 11,384 |
| Difference | 0 | -0.0006 | -0.0294 | -82 |

Tables 7, 8, 9 and 10 show these estimates separately for each of the four weight categories defined by newborns and payers. The two weighting schemes produced very similar average estimates for all outcomes except the total number of discharges for each payer. For example, the estimated ALOS for Medicare patients differed very little between the two weighting schemes. However, the estimated number of Medicare discharges differed by 524,816 discharges, or about 4.4 percent. The four-weight estimate of total Medicare discharges reproduces the total number of Medicare discharges given by the AHA survey data for 1997. Similarly, the four-weight estimates for total newborns, Medicaid, and Other categories also reproduce those totals given by the AHA survey. The differences between the one-weight estimates and the four-weight estimates on total discharges are due to slightly different distributions of newborn/payers in the sample data compared to the universe within some strata (in an average NIS sample).

**Table 7**

Comparison of Weighted Estimates Based on 1,000 Samples: Births

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| Four Weights | 3,746,553 | 0.0034 | 2.9411 | $ 3,612 |
| One Weight | 3,711,353 | 0.0035 | 2.9835 | 3,731 |
| Difference | 35,200 | -0.0001 | -0.0424 | -119 |

**Table 8**

Comparison of Weighted Estimates Based on 1,000 Samples: Medicare (nonbirths)

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| Four Weights | 12,016,214 | 0.0483 | 6.3794 | $ 14,498 |
| One Weight | 12,541,030 | 0.0484 | 6.3725 | 14,507 |
| Difference | -524,816 | 0.0000 | 0.0069 | -9 |

**Table 9**

Comparison of Weighted Estimates Based on 1,000 Samples: Medicaid (nonbirths)

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| Four Weights | 4,952,703 | 0.0125 | 5.1264 | $ 10,311 |
| One Weight | 4,630,531 | 0.0125 | 5.1337 | 10,401 |
| Difference | 322,172 | 0.0000 | -0.0072 | -90 |

**Table 10**

Comparison of Weighted Estimates Based on 1,000 Samples: Other (nonbirths)

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| Four Weights | 13,970,207 | 0.0139 | 4.0656 | $ 10,967 |
| One Weight | 13,802,764 | 0.0139 | 4.0657 | 10,933 |
| Difference | 167,443 | 0.0000 | 0.0000 | 33 |

Tables 11, 12, 13 and 14 display these comparisons for each of the four geographic regions. Again, by design both methods produce the same estimate for the total number of discharges, which is equal to the number reported in the AHA survey data. In fact, there is little difference between the estimates for any of the outcomes within each region.

**Table 11**

**Comparison of Weighted Estimates Based on 1,000 Samples: Northeast**

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| Four Weights | 7,293,705 | 0.0268 | 5.6706 | $ 12,191 |
| One Weight | 7,293,705 | 0.0273 | 5.7054 | 12,267 |
| Difference | 0 | -0.0006 | -0.0348 | -76 |

**Table 12**

**Comparison of Weighted Estimates Based on 1,000 Samples: Midwest**

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| Four Weights | 8,128,063 | 0.0235 | 4.7972 | $ 10,622 |
| One Weight | 8,128,063 | 0.0235 | 4.7894 | 10,590 |
| Difference | 0 | 0.0000 | 0.0078 | 33 |

**Table 13**

**Comparison of Weighted Estimates Based on 1,000 Samples: South**

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| Four Weights | 12,853,767 | 0.0253 | 4.7300 | $ 10,481 |
| One Weight | 12,853,767 | 0.0263 | 4.7877 | 10,651 |
| Difference | 0 | -0.0010 | -0.0577 | -171 |

**Table 14**

**Comparison of Weighted Estimates Based on 1,000 Samples: West**

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| Four Weights | 6,410,142 | 0.0218 | 4.4793 | $ 12,899 |
| One Weight | 6,410,142 | 0.0220 | 4.4930 | 12,954 |
| Difference | 0 | -0.0003 | -0.0137 | -55 |

We also compared these average estimates to those obtained from the MedPAR and NHDS files. However, MedPAR and NHDS estimates also have reporting or sampling errors associated with them. The MedPAR file under-reports Medicare managed care patients. The NHDS is the realization of a single sample rather than the average of 1,000 samples as we calculate for the NIS estimates. Therefore, it is difficult to judge the accuracy of the NIS estimates; and given how close estimates are between the two weighting schemes, these comparisons, shown in Table 15, were not very helpful.

**Table 15**

**Comparison to MedPAR and NHDS, 1997 Data**

| | **Total Discharges (Thousands)** (Standard Error) | | | |
|---|---|---|---|---|
| | **MedPAR** | **NHDS** | **4 Weight** | **1 Weight** |
| **Total Discharges** | | 34,704 (1811) | 34,686 | 34,686 |
| **Medicare Discharges** | 11,317 | 12,263 (491) | 12,021 | 12,543 |
| | **Average Length of Stay** (Standard Error) | | | |
| | **MedPAR** | **NHDS** | **4 Weight** | **1 Weight** |
| **Total ALOS** | | 4.84 (0.35) | 4.90 | 4.93 |
| **Medicare ALOS** | 6.58 | 6.40 (0.44) | 6.38 | 6.38 |
| | **Mortality Rate (Percent)** (Standard Error) | | | |
| | **MedPAR** | **NHDS** | **4 Weight** | **1 Weight** |
| **Total Mortality Rate** | | 2.29 (0.05) | 2.45 | 2.51 |
| **Medicare Mortality Rate** | 4.69 | 4.56 (0.11) | 4.83 | 4.83 |

To better investigate the accuracy of the estimates, we temporarily treated the HCUP states as the universe to determine how well the sample weights estimated outcomes for the HCUP states as a whole. That is, we drew a 20 percent sample of hospitals from the HCUP states, calculated sample discharge weights to weight discharges up to the HCUP states as a whole, and produced weighted estimates of the outcomes. That way we could compare the sample estimates to known outcomes for the universe (the average taken over all discharges in HCUP states). Table 16 shows the results in total. Tables 17 through 20 show the results for each of the four weight categories. Tables 21 through 24 show the results for each of the four census regions. Neither weighting scheme produced clearly better estimates than the other did, and both schemes produced estimates that were very close to the actual, known HCUP averages.

**Table 16**

**Comparison of Weighted Estimates Using HCUP States as Universe: Total**

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| HCUP Actual | 20,131,311 | 0.0250 | 4.9950 | $ 11,924 |
| Four Weights | 20,946,107 | 0.0245 | 4.9894 | 11,881 |
| One Weight | 20,946,107 | 0.0250 | 5.0165 | 11,954 |

**Table 17**

**Comparison of Weighted Estimates Using HCUP States as Universe: Births**

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| HCUP Actual | 2,238,973 | 0.0033 | 2.9132 | $ 3,848 |
| Four Weights | 2,295,169 | 0.0033 | 2.8973 | 3,792 |
| One Weight | 2,313,994 | 0.0034 | 2.9284 | 3,866 |

**Table 18**

**Comparison of Weighted Estimates Using HCUP States as Universe: Medicare (nonbirths)**

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| HCUP Actual | 7,063,172 | 0.0491 | 6.5637 | $ 15,463 |
| Four Weights | 7,055,372 | 0.0491 | 6.5697 | 15,466 |
| One Weight | 7,357,690 | 0.0492 | 6.5722 | 15,490 |

**Table 19**

**Comparison of Weighted Estimates Using HCUP States as Universe: Medicaid (nonbirths)**

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| HCUP Actual | 2,734,781 | 0.0130 | 5.3392 | $ 11,082 |
| Four Weights | 3,065,941 | 0.0131 | 5.3887 | 11,018 |
| One Weight | 2,854,356 | 0.0131 | 5.3972 | 11,102 |

**Table 20**

**Comparison of Weighted Estimates Using HCUP States as Universe: Other (nonbirths)**

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| HCUP Actual | 2,238,973 | 0.0033 | 2.9132 | $ 3,848 |
| Four Weights | 2,295,169 | 0.0033 | 2.8973 | 3,792 |
| One Weight | 2,313,994 | 0.0034 | 2.9284 | 3,866 |

**Table 21**

Comparison of Weighted Estimates Using HCUP States as Universe: Northeast

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| HCUP Actual | 6,368,452 | 0.0273 | 5.7286 | $ 12,474 |
| Four Weights | 6,780,450 | 0.0268 | 5.7037 | 12,421 |
| One Weight | 6,780,450 | 0.0273 | 5.7341 | 12,490 |

**Table 22**

Comparison of Weighted Estimates Using HCUP States as Universe: Midwest

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| HCUP Actual | 3,458,470 | 0.0234 | 4.7246 | $ 10,268 |
| Four Weights | 3,555,804 | 0.0234 | 4.7381 | 10,296 |
| One Weight | 3,555,804 | 0.0234 | 4.7305 | 10,285 |

**Table 23**

Comparison of Weighted Estimates Using HCUP States as Universe: South

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| HCUP Actual | 4,680,255 | 0.0264 | 4.8219 | $ 11,049 |
| Four Weights | 4,901,158 | 0.0255 | 4.7788 | 10,949 |
| One Weight | 4,901,158 | 0.0264 | 4.8290 | 11,072 |

**Table 24**

Comparison of Weighted Estimates Using HCUP States as Universe: West

| | Total Discharges | Mortality Rate | ALOS | Average Charge |
|---|---|---|---|---|
| HCUP Actual | 5,624,134 | 0.0221 | 4.4745 | $ 13,131 |
| Four Weights | 5,708,695 | 0.0218 | 4.4783 | 13,113 |
| One Weight | 5,708,695 | 0.0221 | 4.5033 | 13,200 |

The only argument for using the more complicated four weight per stratum scheme is that it might produce better estimates of the number of discharges broken down by payer. Neither scheme demonstrated a clear advantage in estimating ALOS, average charges, and average mortality. Moreover, comparing the agreement between the AHA and the SID on the total number of discharges to the agreement on the number of discharges broken down by payer (compare Figure 22 to Figures 23 through 26), we feel more comfortable relying on the AHA data to benchmark the total number of discharges than to benchmark the number of discharges individually for newborns, Medicare, Medicaid, and other. Therefore, we recommend using the simpler of the two weighting schemes: one weight per stratum.

# Conclusion

## Redesign Benefits

We expect the changes in the sampling design to reap several rewards. First, the elimination of rehabilitation hospitals drops a small percentage of hospitals from the universe while making the universe more homogeneous. The outcomes of rehabilitation hospitals in the sample might have had an unwanted effect on estimates for two reasons. First, rehabilitation hospitals had lower mortality rates and higher average lengths of stay than most other community hospitals, potentially leading to biased estimates for those outcomes within strata. Second, the underreporting of rehabilitation hospitals for several states would have led to a severe under-representation in the NIS for some regions, which would have compounded the bias problem.

Second, the redefinition of bed size categories and the reduction in ownership stratification will greatly reduce the number of strata with small numbers of hospitals, both in the NIS and in the universe. This is important for two reasons. First, in the past many small strata had to be collapsed manually by analysts to achieve at least two hospitals per stratum to facilitate variance calculations. Second, some states prohibited their hospitals from entering the NIS if they landed in small strata. The virtual elimination of small strata will avoid these difficulties in the future.

Third, the new definition of teaching hospitals is more closely aligned with the definition used by CMS. To the extent that the newly added teaching hospitals have outcomes similar to the previously defined teaching hospitals, this should improve NIS estimates overall because outcomes within strata will be more homogeneous than they were before this change. In addition, analysts familiar with the CMS definition of teaching hospitals may be more comfortable with the new definition for the NIS.

Fourth, the elimination of the longitudinal component of the NIS sample design has two advantages. First, it simplifies the sampling. It is no longer necessary to keep track of previous year's sampling probabilities and sampling status in selecting the NIS hospitals. Second, it removes a source of potential bias. Although the previous sample design ensured that each hospital had the same chance of entering the sample *over all the years for which it was eligible*, including previous sampling years, it favored previously selected hospitals for the sample *for each particular year*. To the extent hospitals that persisted from year to year differed from those that did not persist, this preference could have resulted in some bias.

## Other Considerations

One potential disadvantage to the redesign is its impact on longitudinal analyses. An estimate calculated under the new sample design will differ from that which would have been calculated under the previous sample design. This difference will be solely attributable to the changes in the sample design. Consequently, trends that span both the old design and the new design will be confounded by the changes in the sample design, especially between the 1997 and the 1998 NIS. Moreover, the previous longitudinal component ensured that a large core of hospitals remained in the sample from year to year. Consequently, the year-to-year sample variation was most likely smaller under the old plan than it will be in the future. However, this potential disadvantage has to be measured against the potential increase in cross-sectional representation each year.

Finally, analysts may desire to calculate finite-sample statistics from the NIS. The sampling design can be considered a stratified, single-stage cluster sample. A stratified random sample of hospitals (clusters) was drawn and then *all* discharges were included from each selected hospital. To the extent that HCUP hospitals are similar to non-HCUP hospitals within a stratum, the sample hospitals can be treated as if they were randomly selected from the entire universe of hospitals within each stratum. Consequently, standard formulas for a stratified, single-stage cluster sample without replacement could be used to calculate statistics and their variances in most applications. Several statistical programming packages allow weighted analyses. For example, nearly all SAS (Statistical Analysis System) procedures incorporate weights. In addition, several statistical analysis programs, including PROC SURVEYMEANS and PROC SURVEYREG in SAS Version 8, have been developed that specifically calculate finite sample statistics and their standard errors from survey data. For an excellent review of such programs, visit the following web site: http://www.fas.harvard.edu/~stats/survey-soft/survey-soft.html. Appendix B contains a summary of survey analysis capabilities for SAS, Stata, and SUDAAN copied from this web site.

# References

Atkinson, E. J. and Therneau, T. M., (2000). An Introduction to Recursive Partitioning Using the RPART Routines. Technical Report, Mayo Clinic, Section of Statistics.

# Appendix A:  Candidate AHA Variables

| AHA Annual Survey Elements Considered for Hospital Stratification | |
|---|---|
| ***Survey Question*** | ***Field Description*** |
| B.1. | Control Code – type of authority responsible for establishing policy concerning overall operation of the hospitals |
| B.2. | Service Code – category best describing the hospital of the type of service provided to the majority of admissions |
| B.3.a. | Does the hospital restrict admissions primarily to children? |
| B.3.b. | Is the hospital primarily osteopathic? |
| B.3.f. | Is the hospital contract-managed? |
| C.1. | General medical and surgical care (adult) |
| C.1. | General medical and surgical (adult) beds |
| C.2. | General medical and surgical care (pediatric) |
| C.2. | General medical and surgical (pediatric) beds |
| C.3. | Obstetric care |
| C.3. | Obstetric care beds |
| C.3. | Obstetric unit care level |
| C.4. | Medical/surgical intensive care |
| C.4. | Medical/surgical intensive care beds |
| C.5. | Cardiac intensive care |
| C.5. | Cardiac intensive care beds |
| C.6. | Neonatal intensive care |
| C.6. | Neonatal intensive care beds |
| C.7. | Neonatal intermediate care |
| C.7. | Neonatal intermediate care beds |
| C.8. | Pediatric intensive care |
| C.8. | Pediatric intensive care beds |
| C.9. | Burn care |
| C.9. | Burn care beds |
| C.11. | Rehabilitation care beds |
| C.12. | Alcohol/drug abuse or dependency inpatient care beds |
| C.13. | Psychiatric care beds |
| C.14. | Skilled nursing care beds |
| C.15. | Intermediate nursing care beds |
| C.16. | Other long-term care beds |
| Calculated | Total hospital beds |
| C.19. | Alcohol/drug abuse or dependency outpatient services |
| C.20. | Angioplasty |
| C.25 | Cardiac catheterization laboratory |
| C.26. | Case Management |
| C.31.a. | Level of emergency department |
| C.31.b. | Level of trauma center |
| C.32. | Extracorporeal shock-wave lithotripter (ESWL) |
| C.34. | Freestanding outpatient center |
| C.39. | HIV-AIDS services |
| C.40. | Home health services |
| C.41. | Hospice |
| C.42. | Hospital-base outpatient care center/services |
| C.46. | Oncology services |

| AHA Annual Survey Elements Considered for Hospital Stratification | |
|---|---|
| ***Survey Question*** | ***Field Description*** |
| C.47. | Open-heart surgery |
| C.48. | Outpatient surgery |
| C.51. | Physical rehabilitation outpatient services |
| C.52. | Primary care department |
| C.53.d. | Psychiatric emergency services |
| C.53.f. | Psychiatric outpatient services |
| C.53.g. | Psychiatric partial hospitalization program |
| C.54. | Radiation therapy |
| C.55.a. | Computed-tomography (CT) scanner |
| C.55.b. | Diagnostic radioisotope facility |
| C.55.c. | Magnetic resonance imaging (MRI) |
| C.55.d. | Positron emission tomography (PET) |
| C.55.e. | Single photon emission computerized tomography (SPECT) |
| C.55.f. | Ultrasound |
| C.62. | Transplant services |
| C.64. | Urgent care center |
| C.67.a. | Independent practice association |
| C.67.b. | Group practice without walls |
| C.67.c. | Open physician-hospital organization |
| C.67.d. | Closed physician-hospital organization |
| C.67.e. | Management service organization |
| C.67.f. | Integrated salary model |
| C.67.g. | Equity model |
| C.67.h. | Foundation |
| C.68.a. | Health maintenance organization (HMO) |
| C.68.b. | Preferred provider organization (PPO) |
| C.68.c. | Indemnity fee for service plan |
| C.69.a. | Does the hospital have a formal written contract with an HMO? |
| C.69.b. | Number of HMO contracts |
| C.69.c. | Does the hospital have a formal written contract with a PPO? |
| C.69.d. | Number of PPO contacts |
| C.70. | Percentage of net patient revenue paid on a capitated basis |
| C.71. | Does the hospital contract with employers or a coalition of employers to provide care on a capitated, predetermined or shared risk basis? |
| C.72. | Number of lives covered under a capitated basis |
| Calculated | Does the hospital maintain a separate nursing-home type of long-term care unit? |
| E.1.a. | Total facility beds set up and staffed at the end of reporting period |
| E.1.a. | Nursing home beds set up and staffed |
| Calculated | Hospital unit beds set up and staffed |
| E.1.b. | Bassinets set up and staffed |
| E.1.c. | Total births (excluding fetal deaths) |
| E.1.d. | Total facility admissions |
| E.1.d. | Nursing home admissions |
| Calculated | Hospital unit admissions |
| E.1.e. | Total facility inpatient days |
| E.1.e. | Nursing home inpatient days |
| Calculated | Hospital unit inpatient days |
| E.1.f. | Emergency room visits |
| E.1.g. | Total outpatient visits |
| Calculated | Other outpatient visits |

| AHA Annual Survey Elements Considered for Hospital Stratification | |
|---|---|
| ***Survey Question*** | ***Field Description*** |
| E.1.h. | Inpatient surgical operations |
| E.1.i. | Outpatient surgical operations |
| Calculated | Total surgical operations |
| E.2.a. | Total facility Medicare discharges |
| E.2.a. | Nursing home Medicare discharges |
| Calculated | Hospital unit Medicare discharges |
| E.2.b. | Total facility Medicare days |
| E.2.b. | Nursing home Medicare days |
| Calculated | Hospital unit Medicare days |
| E.2.c. | Total facility Medicaid discharges |
| E.2.c. | Nursing home Medicaid discharges |
| Calculated | Hospital unit Medicaid discharges |
| E.2.d. | Total facility Medicaid days |
| E.2.d. | Nursing home Medicaid days |
| Calculated | Hospital unit Medicaid days |
| | State Code |
| | State 2-digit abbreviation |
| | ZIP code |
| | Community hospital code (as defined by AHA membership) |
| | Bed size code |
| | Short-term, long-term classification code |
| | Average daily census |
| | Adjusted admissions |
| | Adjusted patient days |
| | Adjusted average daily census |
| | Full time equivalent physicians and dentists |
| | Full time equivalent medical and dental residents and interns |
| | Full time equivalent other trainees |
| | Full time equivalent registered nurses |
| | Full time equivalent licensed practical or vocational nurses |
| | Full time equivalent other personnel |
| | Full time equivalent total trainees |
| | Full time equivalent hospital unit total personnel |
| | Full time equivalent nursing home total personnel |
| | Full time equivalent total personnel |
| | Metropolitan Statistical Area Type |
| | MSA Size |
| | Accreditation by Joint Commission on Accreditation of Health Care Organizations (JCAHO) |
| | Cancer program approved by American College of Surgeons |
| | Residency training approval by Accreditation Council for Graduate Medical Education |
| | Medical school affiliation reported to American Medical Association |
| | Hospital-controlled professional nursing school reported by National League for Nursing |
| | Accreditation by Commission on Accreditation of Rehabilitation Facilities (CARF) |
| | Member of Council of Teaching Hospital of the Association of American Medical Colleges (COTH) |
| | Blue Cross contracting or participating |
| | Medicare certification by the U.S. Department of Health and Human Services |
| | Accreditation by American Osteopathic Association |

| AHA Annual Survey Elements Considered for Hospital Stratification | |
|---|---|
| ***Survey Question*** | ***Field Description*** |
| | Internship approved by American Osteopathic Association |
| | Residency approved by American Osteopathic Association |
| | Registered Osteopathic Hospital (member of AOHA) |
| | Registered Osteopathic Hospital (non-member of AOHA) |
| | Catholic church operated |
| | Member of Federation of American Health Care Systems |

# Appendix B: Summary of Survey Analysis Capabilities for SAS, Stata, and SUDAAN

## Summary of survey software: SAS/STAT

Vendor:

SAS Institute Inc.

Types of Designs That Can Be Accommodated

For the sample selection procedure, the sample design can be a complex multistage sample design that includes stratification, clustering, replication, and unequal probabilities of selection.

For survey data analysis procedures, the sample design can be a complex survey sample design with stratification, clustering, unequal weighting, and with or without replacement.

Types of Estimands and Statistical Analyses That Can Be Accommodated

SAS/STAT Software now provides the SURVEYSELECT, SURVEYMEANS, and SURVEYREG procedures. These procedures were made available as experimental procedures in Version 7 of the SAS System, and were released as production procedures in Version 8.

- **The SURVEYSELECT procedure** provides a variety of methods for selecting probability-based random samples. The procedure can select a simple random sample, or samples with design features such as stratification, clustering or multistage sampling, or unequal probabilities of selection. It can accomodate very large sampling frames. It can draw a replicated sampling, i.e. a sample composed of a set of replicates, each selected in the same way.
- PROC SURVEYSELECT accepts the sampling frame as a SAS data set. Control language specifies the selection methods, the desired sample size or sampling rate, and other parameters. The output data set contains the selected units, with selection probabilities and sampling weights.
- **The SURVEYMEANS procedure** estimates population totals and means, with estimates of their variances, confidence limits, and other descriptive statistics, under sample designs that may include stratification, clustering, and unequal weighting.
- **The SURVEYREG procedure** estimates regression coefficients by generalized least squares, using elementwise regression, assuming that the regression coefficients are the same across strata and PSUs.

Restrictions on Number of Variables or Observations.

None

Primary Methods Used for Variance Estimation.

Taylor expansion.

General Description of the "Feel" of the Software.

The interface is similar to other SAS procedures. Programs may be entered from command files or through a windowing system. The Explorer window is used to view and manage SAS files. The Program Editor is used to enter, edit, and submit SAS programs, and messages appear in the Log window. Output from SAS programs is viewed in the Output window and navigate and managed in the Results window.

Platforms on which the Software Can Be Run.

Version 7 of the SAS System is available as production on the following platforms:

- Microsoft Windows:
  Windows 95 (Build 950 or greater)
  Windows 98 (Build 1998)
  Windows NT 4.0 (Build 1381: Service Pack 3),
  Windows NT 5.0 (in an experimental mode only)
- IBM OS/2® Warp 3.0, Warp 4.0
- IBM AIX® 4.2, 4.3
- HP HP-UX 10.20, 11.0
- Sun Solaris 2.6
- Digital UNIX 4.0d
- OpenVMS Alpha 7.1
- OpenVMS VAX 6.2
- IBM OS/390® V1R1, V1R2, V1R3, V2R4
- IBM MVS 4.2
- IBM CMS 10

Availability, Pricing and Terms.

SAS Software is licensed on an annual basis. Please contact SAS Institute directly for more information.

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Fax: (919) 677-4444
SAS Home Page: http://www.sas.com/
Statistics and Operations Research: http://www.sas.com/rnd/app/

Additional Information.

Recent papers and documentation on the survey selection and analysis procedures are available from SAS Institute's Statistics and Operations Research website at http://www.sas.com/rnd/app/da/new/dasurvey.html; see links at bottom of that page for papers and documentation.

## Summary of survey software: Stata

Vendor:

Stata Corporation

Types of designs that can be accommodated.

- stratified designs;
- cluster sampling;
- variance estimation for multistage sample data can be carried out through the customary between-PSU-squared-differences calculation;
- finite-population corrections can be calculated for simple random sampling without replacement of sampling units within strata.

Types of estimands and statistical analyses that can be accommodated.

Estimation of means, totals, ratios, and proportions; also linear regression, logistic regression, and probit. Point estimates, associated standard errors, confidence intervals, and design effects for the full population or subpopulations are displayed. Auxiliary commands will display all this information for linear combinations (e.g., differences) of estimators, and conduct hypothesis tests. New in Stata 6: contingency tables with Rao-Scott corrections of chi-squared tests; new survey-corrected regression commands including tobit, interval, censored, instrumental variables, multinomial logit, ordered logit and probit, and Poisson.

Restrictions on number of variables or observations.

Maximum number of observations limited only by computer RAM (virtual memory can be used, but commands run slower). Maximum number of variables is 2,047.

Primary methods used for variance estimation.

Taylor-series linearization is used in the survey analysis commands. There are also commands for jackknife and bootstrap variance estimation, although these are not specifically oriented to survey data.

General description of the "feel" of the software.

Stata is a complete statistical software package with full statistical, data management, and graphical capabilities. It can be run interactively or in batch mode, and is fully programmable. The survey commands are part of the standard software package. Initially, data can be read in from ASCII files and a Stata-format data file created; or data in other file formats can be translated to Stata format using a stand-alone software package (Stat/Transfer or DBMS/Copy).

Platforms on which the software can be run.

Windows 95, WindowsNT, Windows 3.1, DOS;
Macintosh running System 7.x (both Power Macintosh and 680x0 versions);
DEC Alpha AXP running OSF 1, Version 1.3 or higher;
DECstation with ULTRIX 4.1 or higher;
HP-9000 with HP-UX A.08 or higher;
Intel 80486/Pentium with Linux version 1.1.59 or higher;
RS/6000 or Power PC running AIX 3.2 or higher;
SPARC with SunOS 4.1 or higher or Solaris.

Software distributed as precompiled object program.

Availability, pricing and terms.

One-time purchase. Upgrade purchases are optional. Generous academic discount. Volume discounts. Student discounts.
Example: academic price of one, single-user copy is $395 and includes documentation.

Contact information.

Stata Corporation
702 University Drive East
College Station TX 77840
800-782-8272 (U.S.)
800-248-8272 (Canada)
409-696-4600 (Worldwide)
409-696-4601 (Fax)
E-mail: stata@stata.com
Web site: http://www.stata.com

Additional information

This software is discussed in the review article from *The Survey Statistician*.

## Summary of survey software: SUDAAN

Vendor:

Research Triangle Institute

Types of designs that can be accommodated.

Multiple design options allow users to analyze data from stratified, cluster sample, or multistage sample designs. Sample members may have been selected with unequal probabilities, and either with or without replacement. Any number of strata and stages can be specified. In addition, different design options may be combined in one study if different sampling methods were used for parts of the population.

Types of estimands and statistical analyses that can be accommodated.

SUDAAN includes the following statistical procedures:

- MULTILOG: Fits multinomial logistic regression models to ordinal and nominal categorical data and computes hypothesis tests for model parameters. Estimates odds ratios and their 95% confidence intervals for each model parameter. Has GEE (Generalized Estimating Equation) modeling capabilities for efficient parameter estimation.
- REGRESS: Fits linear regression models to continuous outcomes and performs hypothesis tests concerning the model parameters.
- LOGISTIC: Fits logistic regression models to binary data and computes hypothesis tests for model parameters. Estimates odds ratios and their 95% confidence intervals for each model parameter.
- SURVIVAL: Fits proportional hazards (Cox regression) models to failure time data. Estimates hazard ratios and their 95% confidence intervals for each model parameter.
- CROSSTAB: Computes frequencies, percentage distributions, odds ratios, relative risks, and their standard errors (or confidence intervals) for user-specified cross-tabulations, as well as chi-square tests of independence and the Cochran-Mantel-Haenszel chi-square test for stratified two-way tables.
- DESCRIPT: Computes estimates of means, totals, proportions, percentages, geometric means, quantiles, and their standard errors. Also computes standardized estimates and tests of single degree-of-freedom contrasts among levels of a categorical variable.
- RATIO: Computes estimates and standard errors of generalized ratios of the form (Summation y) / (Summation x), where x and y are observed variables. Also computes standardized estimates and tests single-degree-of-freedom contrasts among levels of a categorical variable.
- The EFFECT statement allows users to specify contrasts of regression coefficients and hypothesis tests using simple effect names.

Restrictions on number of variables or observations.

None

Primary methods used for variance estimation.

The Taylor series linearization method (GEE for regression models) is used combined with variance estimation formulas specific to the sample design. The user does not need to develop special replicate weights since the sample design can be specified directly to the program.

Jackknife and Balanced Repeated Replication (BRR) variance estimation is also supported.

General description of the "feel" of the software.

SUDAAN uses a SAS-like language. Under Sun/Solaris and Windows 95 or NT, SUDAAN can be called directly as a SAS procedure, while on other platforms SUDAAN reads SAS files. Sudaan also can read SPSS files. On all platforms, the same program language is used.

Platforms on which the software can be run.

Standalone Versions:

- PCs under Windows 3.1 or MS-DOS (reads SAS files)
- Windows 3.1 and DOS versions of SUDAAN will also run under Windows 95, Windows NT and OS/2
- IBM mainframes under MVS (reads SAS files)
- DEC VAX mainframes and workstations under VMS (reads SAS files)
- DEC VAX mainframes and workstations under ULTRIX
- DEC Alpha workstations under Open VMS
- Sun SPARCstations under Solaris

SAS-Callable versions :

- Sun SPARCstations under Solaris
- DEC VAX mainframes and workstations under VMS
- IBM mainframes under MVS

SUDAAN is distributed as a precompiled program.

Availability, pricing and terms.

Release 7.5 of Sudaan became available in September, 1997 (see list of enhanced features ).

On PCs, SUDAAN is available under either an annual site license or as a one-time purchase. Annual academic PC site license prices range from $50 to $300 per user. Universities with a PC site license may issue free student copies for educational purposes. Government and commercial annual PC site license prices range from $50 to $450 per user. The one-time purchase price for a single user PC license is $995 with substantial discounts on future upgrades. Students may purchase a two-year license for $295. On mainframes and workstations, SUDAAN is available under an annual site license with academic discounts.

Contact information.

SUDAAN Product Coordinator
Research Triangle Institute
3040 Cornwallis Road
Research Triangle Park NC 27709-2194
Telephone: 919-541-6602
FAX: 919-541-7431
Email: SUDAAN@rti.org
URL: http://www.rti.org/patents/sudaan/sudaan.html

Additional information.

SUDAAN offers public 2-day or 3-day training classes several times each year. Classes can also be taught at user sites.

The following papers about Sudaan are available on-line:

- Bieler and Williams (1996), "Application of the SUDAAN Software Package to Clustered Data Problems: Pharmaceutical Research."
- "Analyzing Repeated Measures and Cluster-Correlated Data Using SUDAAN Release 7.5" (1997).
- "Analyzing Survey Data Using SUDAAN Release 7.5" (1997, compares Taylor series, jackknife and BRR variance estimates)

An extensive on-line help library is included for interactive use.

This software is discussed in the review article from *The Survey Statistician*.
See also Shah and Barnwell (1993), "Recent developments and future plans for SUDAAN" in *Proceedings of the Survey Research Methods Section, ASA*, 657-661.