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Using the HCUP Nationwide Inpatient Sample to Estimate Trends (Updated for 1988-2004)
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TABLE OF CONTENTS

INDEX OF TABLES

INDEX OF FIGURES

EXECUTIVE SUMMARY

The Nationwide Inpatient Sample (NIS) is an annual database of hospital inpatient stays. Researchers and policymakers use the NIS to identify, track, and analyze national trends in health care utilization, access, charges, quality, and outcomes. Presently, 17 NIS databases are available, one for each year from 1988 through 2004. The NIS is part of the Healthcare Cost and Utilization Project (HCUP), sponsored by the Agency for Healthcare Research and Quality (AHRQ).

The NIS contains all-payer data on hospital inpatient stays from States participating in HCUP. The NIS includes *all* discharges from an approximate 20 percent stratified sample of U.S. community hospitals. The table below shows the participating states, the percentage of the U.S. population covered by those states, the number of hospitals, and the number of discharges for each NIS year from 1988 to 2004. In total, these 17 annual NIS databases contain over 115 million discharge records.

Year	NIS States Added to Frame	Number of NIS States	Pct of U.S. Population Covered	Number of NIS Hospitals	Number of NIS Discharges
1988	CA, CO, FL, IL, IA, MA, NJ, WA	8	31	759	5,242,904
1989	AZ, PA, WI	11	40	882	6,067,667
1990	No states added	11	40	871	6,156,638
1991	No states added	11	40	859	5,984,270
1992	No states added	11	40	856	6,008,001
1993	CT, KS, MD, NY, OR, SC	17	54	913	6,538,976
1994	No states added	17	54	904	6,385,011
1995	MO, TN	19	58	938	6,714,935
1996	No states added	19	58	906	6,542,069
1997	GA, HI, UT	22	62	1,012	7,148,420
1998	No states added	22	62	984	6,827,350
1999	ME, VA	24	65	984	7,198,929
2000	KY, NC, TX, WV	28	77	994	7,450,992
2001	MI, MN, NE, RI, VT	33	84	986	7,452,727
2002	NV, OH, SD (AZ not available)	35	87	995	7,853,982
2003	AZ, IN, NH (ME not available)	37	91	994	7,977,728
2004	AR (PA dropped)	37	88	1,004	8,004,571
Total					115,555,170

Several revisions have been made to the NIS sample design since its inception that affect estimates calculated from the NIS. First, the sampling frame changed over time as more states made their data available to HCUP. The 1988 NIS was drawn from a frame of eight states representing 31 percent of the U.S. population. In contrast, later years of the NIS were drawn from a frame of states representing 85 to 90 percent of the U.S. population. Second, in 1998 the sampling method changed to better reflect the cross-sectional population of hospitals. The hospital stratification variables were redefined, rehabilitation facilities were dropped from the target universe, and sampling preference was no longer given to prior year NIS hospitals. Third, the definitions and availability of NIS database variables changed over time. For example, diagnosis and procedure codes and Diagnosis Related Groups (DRGs) changed annually.

Analysts who want to use the NIS to estimate trends in patient and hospital outcomes may need to adjust for these changes. This report describes these changes, provides information on the impact of these changes on estimates of number of discharges and other key variables, and contains recommendations for coping with these and other issues when doing trend analyses.

The following changes affected the NIS over time:

- Added states to the sampling frame
- Sample design changes in 1998:
    - Excluded short term rehabilitation hospitals from frame
    - Changed the definition of discharges
    - Discontinued the preference for NIS hospitals that were in the sample in prior years
    - Redefined the hospital stratification variables for sampling
- Changes in data element names and values.

Those issues with the greatest impact on estimates are summarized here (information on changes with less impact can be found in the body of the report). In addition, we summarize considerations for appropriately computing estimates for trends using the NIS, given its complex sample design.

Added States to the Sampling Frame. Perhaps the most significant changes to the NIS over time were additions of states to the sampling frame. As shown in the above table, states were frequently added to the sampling frame. Consequently, the NIS increasingly covered a greater percentage of the hospital discharge population and became increasingly more representative through the years. ***Based primarily on considerations of coverage, we recommend that trend analyses should exclude the 1988 – 1992 period and begin with 1993.*** Six states were added to the NIS in the 1993 data year, including New York, tipping the sampling frame over the 50 percent mark in terms of population covered.

Changed the Definition of Discharges. One of the most important changes to the NIS sample design, beginning with the 1998 data year, was the change from the use of *total* discharges to the use of *hospital* discharges to estimate NIS discharge weights using data from the American Hospital Association (AHA) annual surveys of hospitals. The number of total discharges is often greater than the number of hospital discharges because it includes patients from units such as skilled nursing facilities and long-term rehabilitation. Consequently, the NIS sample discharge weights for 1988 – 1997 tend to be larger than the weights for 1998 – 2004. ***This definitional change causes a "discontinuity" between 1997 and 1998 in estimates of trends in totals, such as total discharges, which can be corrected by the use of revised weights for the 1988 – 1997 NIS files. These revised weights are now available on the HCUP Web site*** (http://www.hcup-us.ahrq.gov/db/nation/nis/nisdbdocumentation.jsp). Importantly, there is little effect on estimated trends of means and rates with discharges as denominators. Therefore, previous studies of trends in averages for variables such as total charges and length of stay that spanned 1997 – 1998 and that used the existing discharge weights most likely remain valid.

Redefined the Hospital Stratification Variables for Sampling. The NIS hospital stratification scheme was also altered beginning with the 1998 data year. We find that these changes to strata definitions have little effect on estimates of trends. However, the change in some definitions, like teaching status, could be problematic to the extent that researchers rely on these definitions to classify hospitals over time. Unfortunately, we are unable to provide revised stratum definitions conforming to the 1998 definitions for the 1988 – 1997 NIS files because of confidentiality constraints. A number of states do not allow the release of hospital identifiers; providing stratum definitions that are consistent across time could result in identification of specific institutions. Therefore, ***analysts must either find some other way to consistently define hospital characteristics over time, or they must acknowledge the potential impact of such changes on their conclusions***. For example, hospital size could be measured in terms of total discharges instead of total beds.

Changes in Data Element Names and Values. Changes to other NIS data elements are easier to manage. First, several variables were renamed in the NIS files. For example, the discharge weight is named DISCWT_U in the 1988 – 1997 files and it is named DISCWT in the 1998 – 2004 files. Such alterations are easily dealt with by simple programming statements. Second, ICD-9-CM diagnosis and procedure codes have changed annually to account for new disease and treatment coding. These changes can make it difficult to consistently classify patients over time. A conversion table mapping code changes between 1986 and 2004 is available online (http://www.cdc.gov/nchs/data/icd9/icdcnv05.pdf). ***We recommend that analysts take ICD-9-CM coding revisions into account when classifying discharges by medical conditions or by surgical interventions over time.*** One simple solution is to use AHRQ's Clinical Classification Software, available from AHRQ's Web site (http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp), although the broad categories of conditions may not be appropriate for all applications. This software is updated annually to account for revisions to the ICD-9-CM codes and can be used for all data years of the NIS.

Appropriate Statistical Computations for Trends. Finally, ***NIS trend analyses should be conducted using statistical software capable of accounting for the complex sampling design of the NIS***, such as SAS, Stata, and SUDAAN. Estimates of means, rates, and totals that do not account for the sampling design might not be severely biased. However, estimates of standard errors will almost certainly be too small, which could lead to incorrect inferences concerning statistical significance and reliability.

A new tool is now available to aid researchers in using the NIS for trends analysis. See *User Guide for the 1988-2002 NIS Trends Supplemental Files*, which is available on the AHRQ-sponsored HCUP User Support Website at http://www.hcup-us.ahrq.gov. This tool includes programs and files that provide trend weights and data elements that are consistently defined across data years. It builds on this report by providing files that:

- rename and recode variables from earlier years to their later form (post-1998),
- add data elements that were added in later years (to the extent possible), and
- provide the recalculated weights for NIS data years 1993-1997.

The NIS Supplemental Trends Files are intended to simplify the steps necessary for using the NIS across data years.

INTRODUCTION

The Nationwide Inpatient Sample (NIS) is an annual database of hospital inpatient stays. Researchers and policymakers use the NIS to identify, track, and analyze national trends in health care utilization, access, charges, quality, and outcomes. Presently, 17 NIS databases are available, one for each year from 1988 through 2004. The NIS is part of the Healthcare Cost and Utilization Project (HCUP), sponsored by the Agency for Healthcare Research and Quality (AHRQ), formerly the Agency for Health Care Policy and Research.

This report is intended to aid analysts who wish to estimate trends or conduct other analyses based on multiple years of the NIS. Several revisions were made to the NIS sample design between 1988 and 2004 that should be taken into account in most trend analyses. First, the sampling frame changed over time as more states made their data available to HCUP. The 1988 NIS was drawn from a frame of eight states representing 31 percent of the U.S. population. In contrast, the 2004 NIS was drawn from a frame of 37 states representing 88 percent of the U.S. population. Second, in 1998 the sampling method changed to better reflect the cross-sectional population of hospitals. The hospital stratification variables were redefined, rehabilitation facilities were dropped from the target universe, and sampling preference was no longer given to prior year NIS hospitals. Third, the definitions and availability of NIS database variables changed over time. For example, diagnosis and procedure codes and Diagnosis Related Groups (DRGs) changed annually.

Analysts who want to use the NIS to estimate trends in patient and hospital outcomes may need to adjust for these changes. At the least, analysts need to keep them in mind as potential confounders in explaining trends. In this report we enumerate the important revisions to the NIS sample design between 1988 and 2004, we suggest ways to manage these changes, and we offer advice on statistical methods that may be useful for investigating trends. In addition, we refer to the new NIS Trends Supplemental Files which provide data elements and trends weights that are consistently defined over time and are intended to simplify trend analysis using the NIS.

EXAMPLES OF PUBLISHED STUDIES USING MULTIPLE YEARS OF THE NIS

More than 25 papers have been published using multiple years of the NIS (many of these studies appear as references in this report). A few examples illustrate the depth and breadth of topics that have previously been addressed using multiple years of the NIS.

- A study by Bao and Sturm (2001) used annual NIS data from 1988 through 1997 to estimate the 10-year trend in hospitalization rates and average lengths of stay (ALOS) for mental health and substance abuse (MHSA) problems. They found that ALOS declined for all conditions (21 percent), but it declined at a higher rate for MHSA conditions (40 percent), probably as a result of cost-containment measures. They also discovered that the discharge rate decreased for all conditions, but increased for MHSA conditions. Taken together, these findings suggested that the rapid decline in lengths of stay may have led to higher readmission rates for MHSA as a result of premature discharges.
- Ritchie et al. (1999) employed two years of NIS data, 1993 and 1994, to study the relationship between the volume of coronary angioplasties and three outcomes: in-hospital mortality, same-admission coronary artery bypass surgery (CABG), and a

combined endpoint of either death, same-admission CABG, or both. They found that adverse outcomes tended to occur at a lower rate in hospitals with a high volume of surgeries than was the case for hospitals with a low volume of surgeries. This study was not a trend analysis. However, it did use more than one year of NIS data. Consequently, many of the same issues apply to this study that apply to trend studies.

- In a later study, Birkmeyer, et al. (2002) found that the relationship between mortality and surgical volume held, but it varied markedly among six types of cardiovascular procedures and eight types of major cancer resection procedures performed between 1994 and 1999. Both of these studies indicate that surgical patients might improve their outcomes by seeking surgical care from high-volume providers.
- Rutledge (1997) used five years of the NIS, from 1988 to 1992, to determine whether hospitals affiliated with medical schools were competitively priced compared to non-affiliated hospitals for patients undergoing cholecystectomy. He found that both hospital charges and lengths of stay were similar between the two types of institutions.
- Meurer et al. (2000) analyzed the trend between 1990 and 1995 for hospitalizations of severe cases of pediatric asthma. While the number of children with asthma increased and the number of hospitalizations decreased, these researchers determined that the proportion of high-severity cases remained constant over the study period. They also found that the proportion of high-severity cases varied according to age, sex, geographic region, and hospital teaching status.
- Xiao et al. (2002) examined trends in organ transplantation between 1988 and 1997 to determine whether there were significant differences among ethnic groups. The authors concluded that the trend in transplantation rates did not vary significantly across ethnic groups.

Other examples could be cited. However, the above studies indicate the range of conditions that have been studied using multiple years of the NIS. These studies varied on conditions (e.g., MHSA, asthma), on procedures (e.g., CABG, cholecystectomy), on patient age (e.g., pediatrics), and on both frequent and infrequent conditions (e.g., asthma and transplantations). All of these multi-year studies addressed important topics in health services research.

HISTORICAL OVERVIEW OF THE NIS

The Nationwide Inpatient Sample (NIS) contains all-payer data on hospital inpatient stays from States participating in the Healthcare Cost and Utilization Project (HCUP). Each year the NIS provides information on 5 to 8 million discharges from between 749 and 1,012 hospitals. The NIS includes all discharges from the sampled hospitals. Table 1 shows the participating states, the percentage of the U.S. population covered by those states, the number of hospitals, and the number of discharges for each NIS year from 1988 to 2004. In total, these 17 annual NIS databases contain over 115 million discharge records.

To facilitate the production of national estimates, both hospital and discharge weights are provided for each of the NIS databases, along with information necessary to calculate variance estimates. For each year, the sum of the discharge weights estimates the total number of hospital discharges in the hospital universe for that year. Figure 1 depicts the trends in total discharges, average length of stay (ALOS), and in-hospital mortality rate estimated from the NIS compared to those estimated from the National Hospital Discharge Survey (NHDS).

Table 1: NIS States in the Sampling Frame, 1988 – 2004

Year	NIS States Added to Frame	Number of NIS States	Pct of U.S. Population Covered	Number of NIS Hospitals	Number of NIS Discharges	Notes
1988	CA, CO, FL, IL, IA, MA, NJ, WA	8	31	759	5,242,904	5,265,756 Total sample discharges*
1989	AZ, PA, WI	11	40	882	6,067,667	6,110,064 Total sample discharges*
1990	No states added	11	40	871	6,156,638	6,268,515 Total sample discharges*
1991	No states added	11	40	859	5,984,270	6,156,188 Total sample discharges*
1992	No states added	11	40	856	6,008,001	6,195,744 Total sample discharges*
1993	CT, KS, MD, NY, OR, SC	17	54	913	6,538,976	
1994	No states added	17	54	904	6,385,011	
1995	MO, TN	19	58	938	6,714,935	
1996	No states added	19	58	906	6,542,069	
1997	GA, HI, UT	22	62	1,012	7,148,420	
1998	No states added	22	62	984	6,827,350	Sample design changed: Redefined stratification variables, dropped short term rehabilitation facilities, and discontinued longitudinal component.
1999	ME, VA	24	65	984	7,198,929	
2000	KY, NC, TX, WV	28	77	994	7,450,992	
2001	MI, MN, NE, RI, VT	33	84	986	7,452,727	
2002	NV, OH, SD (AZ not available)	35	87	995	7,853,982	
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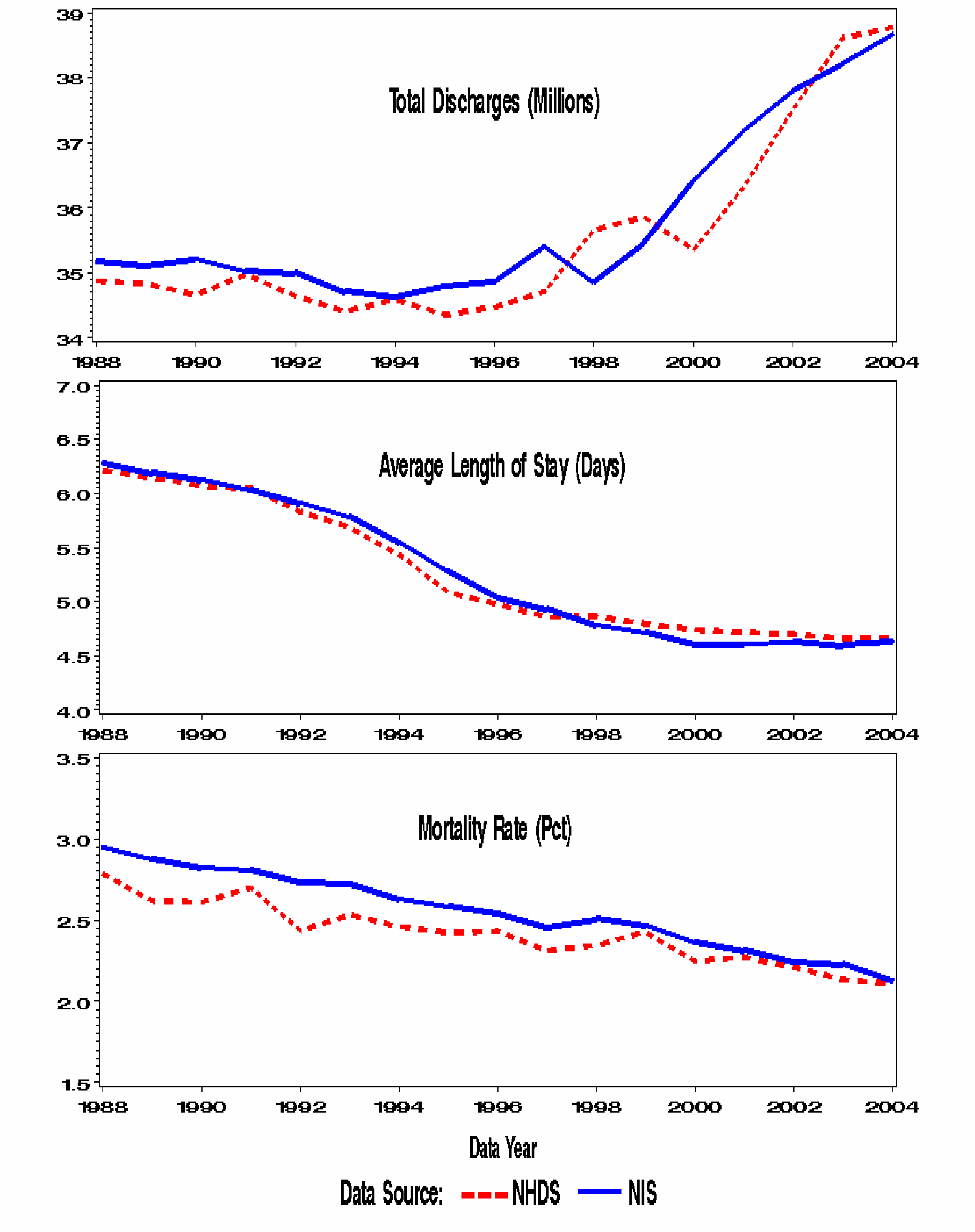
2004	AR (PA dropped)	37	88	1,004	8,004,571	
Total					115,555,170	

* Total sample discharges include discharges from zero-weight hospitals which were split or merged hospitals included in the NIS in order to allow researchers to study hospitals that had undergone these changes, a practice discontinued in 1993. Only NIS regular sample discharges are used in this report.

Figure 1: Trend in Estimated Total Discharges, ALOS, and Mortality Rate, NIS vs. NHDS



Of particular interest is the abrupt decline for total discharges in the NIS estimate for 1998, which will be explained later in this report. There is also a sharp decline in the NHDS estimate of total discharges in 2000, for which we have no explanation. Detailed information on the NIS design is available in the report, *Design of the Nationwide Inpatient Sample*. This report is available on the AHRQ-sponsored HCUP User Support Website at http://www.hcup-us.ahrq.gov.

Each NIS record contains patient-level clinical and resource use information included in a typical discharge abstract. Except in those states that do not allow the release of hospital identifiers, the NIS can be linked directly to hospital-level data from the American Hospital Association (AHA) Annual Survey of Hospitals, to county-level data from the Health Resources and Services Administration Bureau of Health Professions' Area Resource File (ARF), and to ZIP Code level data from the Census Bureau or private vendors. (County and ZIP Code information pertains to the hospital, not to individual discharges.)

The NIS is designed to approximate a 20-percent sample of U.S. community hospitals, defined by the AHA to be "all nonfederal, short-term, general, and other specialty hospitals, excluding hospital units of institutions." Included among community hospitals are specialty hospitals such as orthopedic, pediatric, obstetrics-gynecology, and ear-nose-throat institutions. Also included are public hospitals and academic medical centers. Excluded are short-term rehabilitation hospitals (beginning with 1998 data), long-term hospitals, psychiatric hospitals, and alcoholism/chemical dependency treatment facilities. However, rehabilitation, psychiatric and substance abuse discharges are included if they are discharged from community hospitals.

The NIS is a stratified probability sample of hospitals in the frame, with sampling probabilities proportional to the number of U.S. community hospitals in each stratum. The frame is limited by the availability of inpatient data from the data sources. The hospital sampling strata are based on five hospital characteristics obtained from the AHA: ownership/control, bed size, teaching status, urban/rural location, and U.S. region.

In order to improve the representativeness of the NIS, the sampling and weighting strategy was modified beginning with the 1998 data. This is especially important for trend analyses that cross between 1997 and 1998 because these design changes might be confounded with other changes between 1997 and 1998. A full description of these changes can be found in the special report on *Changes in NIS Sampling and Weighting Strategy for 1998.* This report is also available on the AHRQ Website.

Briefly, the 1998 sampling and weighting modifications were as follows.

Longitudinal Cohort

To maintain a longitudinal cohort, the pre-1998 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. This was intended to provide a "core" longitudinal sample of hospitals that would improve the precision with which hospital trends could be estimated. However, AHRQ researchers and others began to suspect that this improved precision may have been at the cost of some cross-sectional bias in one or more years of the hospital sample. Consequently, 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 simulated the 1997 NIS sample with and without the longitudinal component. For this analysis we drew 500 samples using the old sample design, with and without the preference for hospitals in the 1996 NIS. A comparison of the distribution of estimates across the 500 samples showed that removing the longitudinal component only slightly shifted the average for some variables and tended to increase variation around the estimated mean.

Stratification Variables

Stratification helps ensure that the NIS sample is representative of the target universe, at least with respect to the stratification variables. Stratification becomes advantageous when the sampling frame (community hospitals in participating HCUP states) differs substantially from the target universe (community hospitals in the U.S.). In 1998, HCUP hospitals tended to be larger than non-HCUP hospitals. As a result, HCUP hospitals had more beds and higher occupancy rates overall, suggesting a continuing need for sample stratification. These differences were more pronounced in the Northeast and West, and HCUP states in these regions also tended to have higher Medicare managed care penetration and more discharges than their non-HCUP counterparts. In the Northeast, HCUP hospitals also tended to have longer average lengths of stay (ALOS) than did non-HCUP hospitals. Although the number of differences between HCUP and non-HCUP hospitals in the Northeast and West was greater than in other regions, the impact of these differences on estimates was low because HCUP hospitals represented almost all discharges in those regions.

The pre-1998 NIS sample designs specified 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 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. For the 1998 NIS, we redefined some stratification variables and identified strata that could be nested or collapsed to avoid small cells in the final sample. This reduced the potential number of NIS strata from 108 to 60.

Redefining the bed size strata. 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. In 1997, for example, fewer than 10 percent of the urban teaching hospitals located in the West were designated as “large” hospitals (500+ beds). In contrast, about 33 percent of the urban teaching hospitals located in the South were designated as large hospitals. Consequently, we defined small, medium, and large bed size categories nested within both region and location/teaching category to ensure that approximately one-third of the hospitals would be allocated to each bed size category.

Redefining the ownership strata. 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, as had been done prior to 1998. Therefore, beginning in 1998, we nested ownership strata only within selected regions. We used the three original ownership categories for rural hospitals in the South and for urban non-teaching hospitals in the South and West. However, we collapsed the proprietary and voluntary hospitals into a new “private” ownership category for rural hospitals in the West and Midwest regions.

Redefining the teaching strata. Finally, beginning in 1998, we redefined teaching hospitals. Prior to 1998, a hospital was designated a teaching hospital only if it had 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 defined these same hospitals as teaching hospitals. However, it also included all hospitals with a ratio of interns and residents to beds of .25 or higher. This intern-to-bed ratio was similar to the definition of teaching hospitals employed by the Centers for Medicare & Medicaid Services (CMS, formerly the Health Care Financing Administration).

Rehabilitation Hospitals

In the course of analyzing stratification variables, we found that patients treated in short–term rehabilitation hospitals tended to have lower mortality rates and longer lengths of stay than patients in other types of community hospitals. (Long-term rehabilitation hospitals had always been excluded from the NIS.) Moreover, the completeness of reporting for rehabilitation hospitals was very uneven across the states. Therefore, beginning in 1998, we eliminated short-term rehabilitation hospitals from the NIS (and the target universe).

Change in Counts of Discharges

Prior to 1998, we calculated the number of discharges in the universe as the sum of births and <u>total facility discharges</u> reported for each U.S. community hospital in the AHA Annual Survey. Beginning in 1998, we calculated total universe discharges as the sum of births and <u>hospital discharges</u>, a number that is more consistent with the number of discharges provided by the state data sources—and we substituted total facility discharges only if the number of hospital discharges was missing.

Zero-Weight Hospitals

Up until 1992, to enhance researchers' ability to study the effects of hospital splits and merges, if a hospital was the result of either a split or a merger involving one or more NIS sample hospitals, it was added to the NIS file. However, unless it was selected as a part of the regular NIS sample, it was assigned a sampling weight of zero. Also, any NIS hospital that closed (according to the AHA) was retained in the NIS file and assigned sample weights of zero, if it was not selected for the regular NIS sample in the year it closed.

Beginning with the 1993 NIS, we stopped including the zero-weight hospitals in the NIS. Unless a study is concerned with hospital splits and mergers between 1988 and 1992, the zero-weight hospitals can be safely eliminated from analyses. As implied by the name, discharges from zero-weight hospitals are assigned zero weights. Consequently, they have no effect on weighted estimates. We excluded all discharges from zero-weight hospitals for analyses in this report.

Specialty Hospitals

The NIS was not stratified on hospital specialty. Consequently, the proportion of specialty hospitals in the sample varies from year to year. Analyses of childrens' hospitals might be better served by the Kids' Inpatient Database (KID) files for 1997 and 2000. Analysts of other specialty hospitals might prefer to use one or more of the State Inpatient Databases that include all hospitals.

NIS REPRESENTATIVENESS AND CHANGES TO THE SAMPLING FRAME

Longitudinally, as new states were added to the NIS sampling frame, representativeness has increased. This is quantified in Table 1, shown earlier, and in Figures 2 and 3, which illustrate the trend in the percentage of U.S. states and the percentage of the U.S. population covered by the NIS, respectively. The growth in the South and Midwest was more gradual than the growth in the West and Northeast. Figure 4 displays the geographic distribution of states in the sampling frame over time. Overall, in 2004, the sampling frame for the NIS comprises 73 percent of states and 88 percent of the U.S. population. By region, the sampling frame comprises 84 percent of the population in the South, 99 percent in the Midwest, 75 percent in the Northeast, and 92 percent in the West.

Figure 2: Percentage of States Covered by NIS, by Region

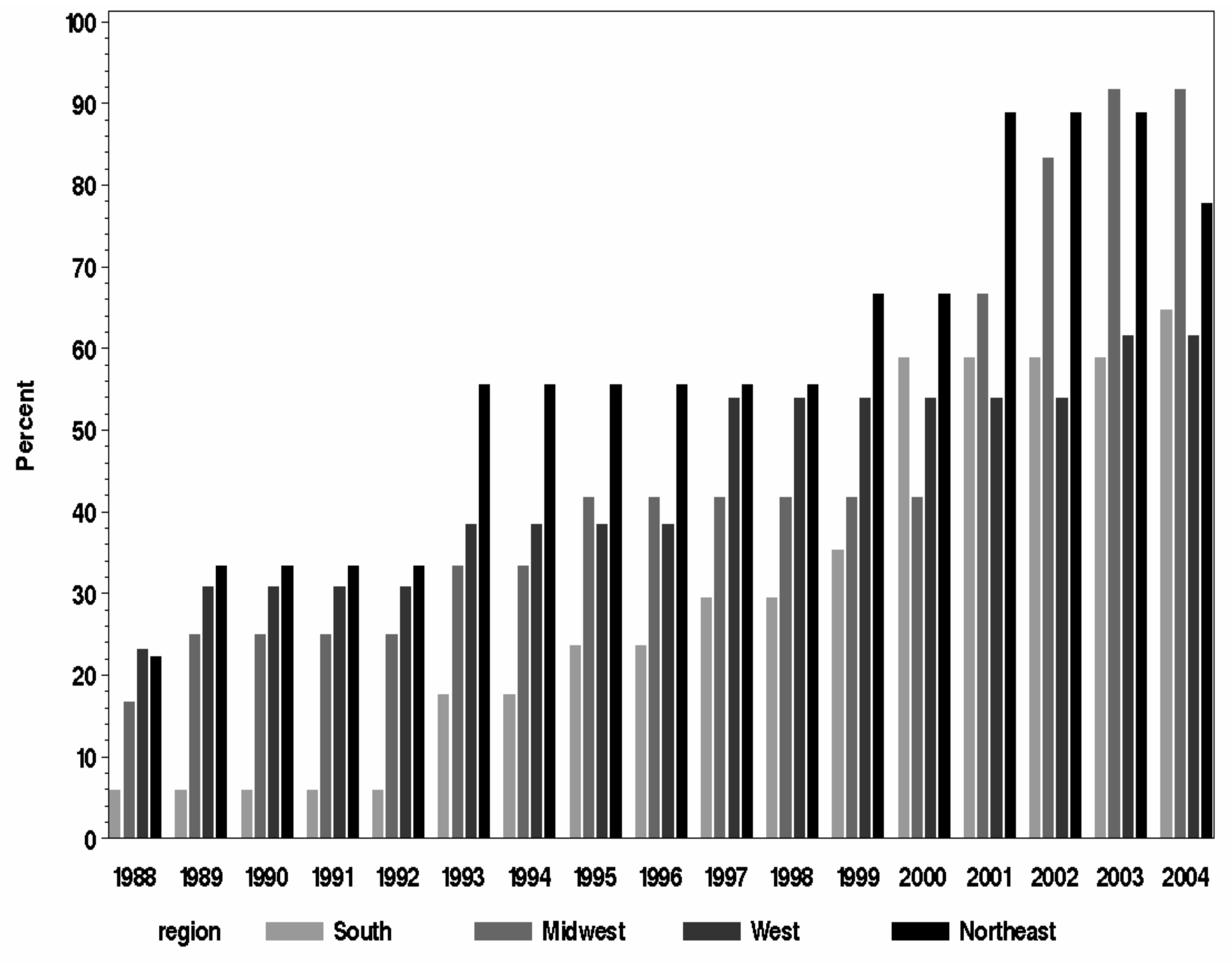


Figure 3: Percentage of Population Covered by NIS States, by Region

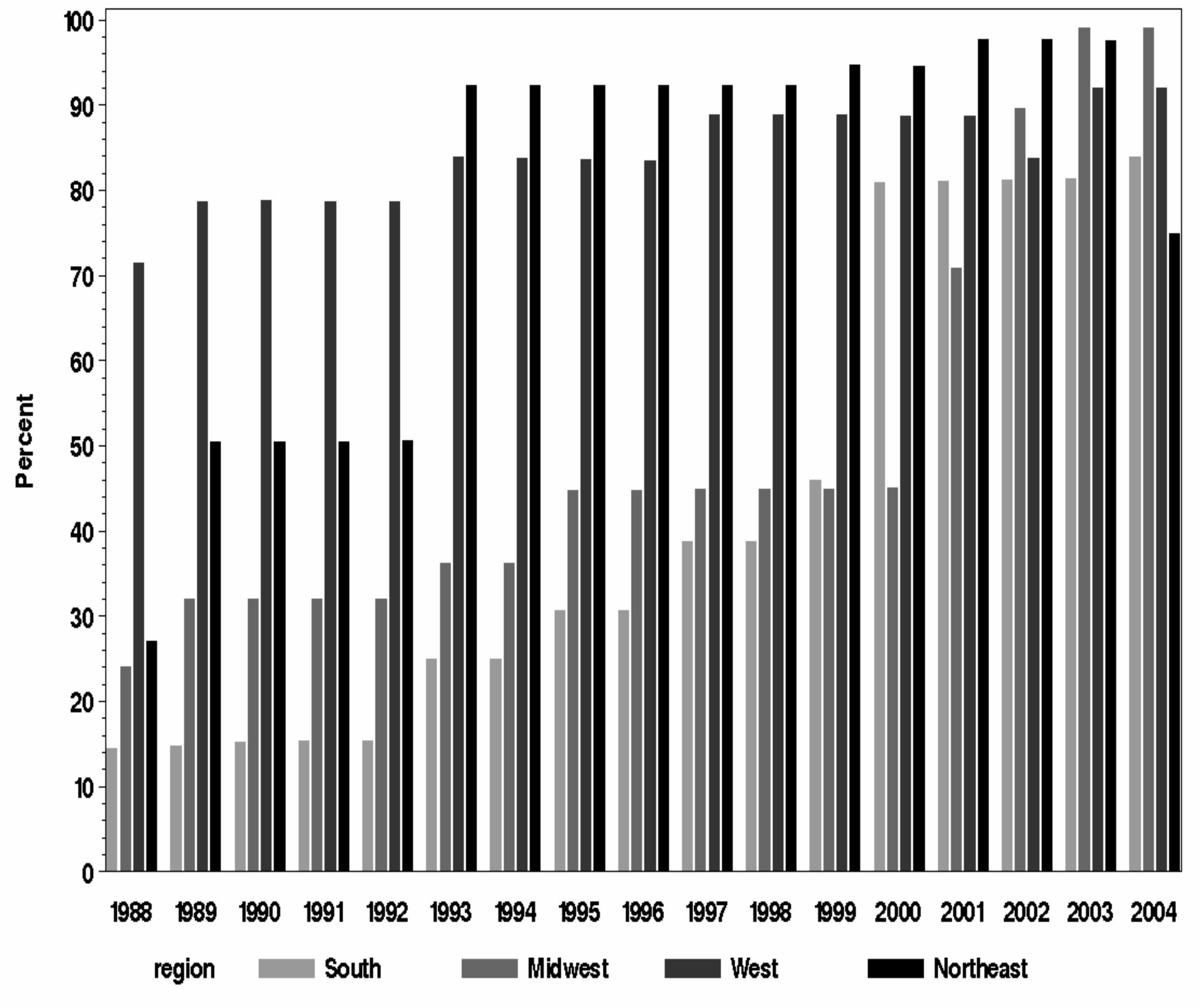
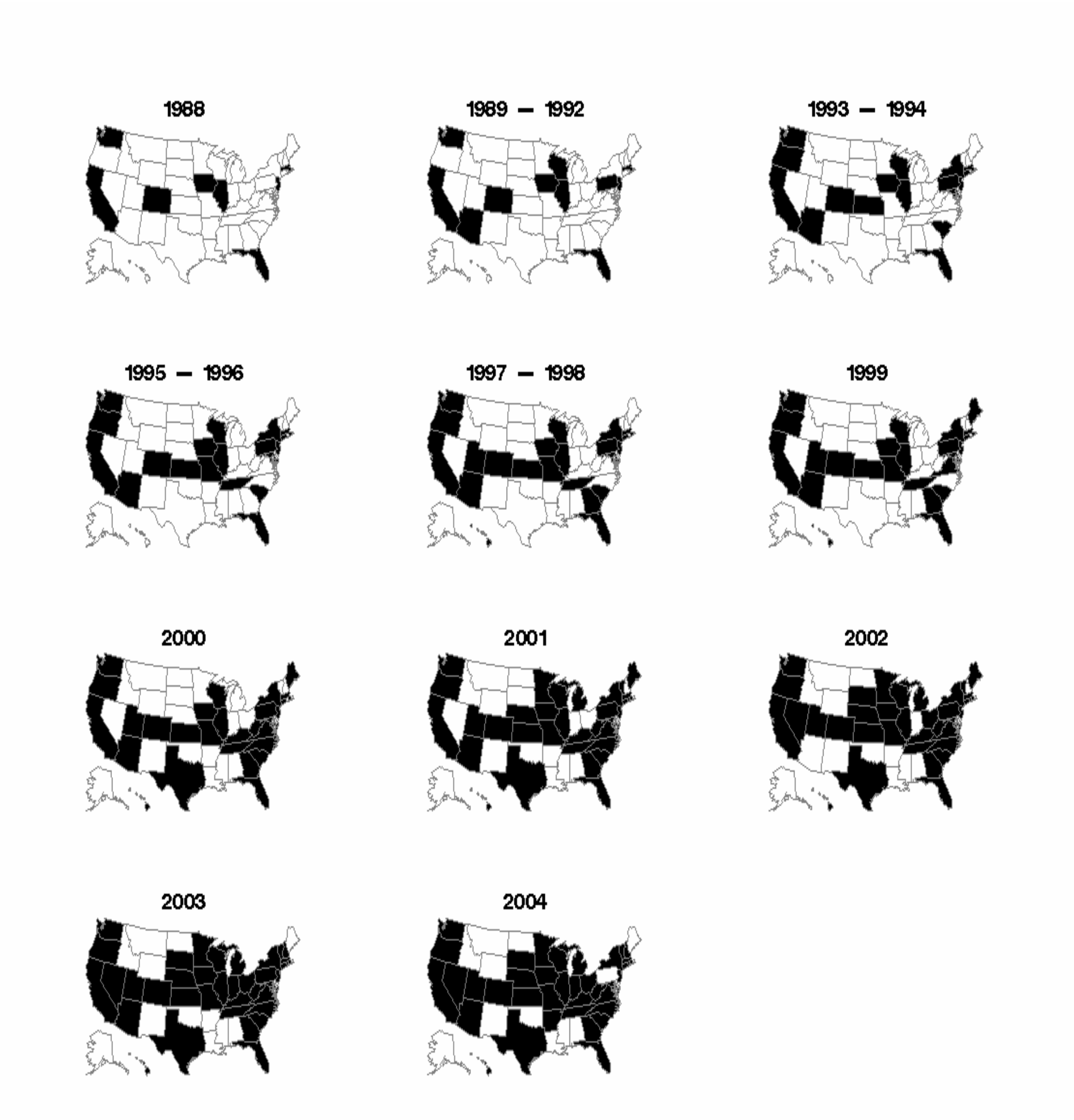


Figure 4: States in the NIS Sampling Frame



For each change to the sampling frame, AHQR compared individual years of the NIS with the corresponding National Hospital Discharge Survey (NHDS) and with the Medicare Provider Analysis and Review file (MedPAR). (*HCUP Nationwide Inpatient Sample Comparison Report* available on the AHRQ Website: http://www.hcup-us.ahrq.gov/db/nation/nis/nisrelatedreports.jsp.) These cross-sectional comparisons indicate that NIS statistics tend to be consistent with those generated by the other two databases.

It is instructive to also compare *trends* in outcomes calculated from the NIS to those calculated from the NHDS. While the sampling frame for the NHDS is unrestricted and contains hospitals from all states, the NHDS sample is much smaller. Thus a potential advantage of the NIS over the NHDS for trend analyses is the larger NIS sample, which results in more precise estimates. A potential disadvantage of the NIS is the restricted sampling frame, which could cause estimates to be biased.

As an example, Figure 5 compares the trends for in-hospital mortality rates between the NIS and the NHDS for each geographic region. The trend lines tend to be slightly smoother for the NIS as compared to the NHDS.

To further compare the precision of estimates from the NHDS and the NIS, Figures 6 and 7 display trends for three condition-specific average lengths of stay calculated from the NHDS and NIS, respectively. The conditions were chosen to compare the relative variation exhibited for diabetes (principal diagnosis = 250.xx—a high-frequency diagnosis), duodenal ulcers (principal diagnosis = 532.xx—a medium-frequency diagnosis), and splenectomy (principal procedure = 41.5—a low-frequency procedure). The smoothness of the trends correlates with the frequencies of the conditions, and the NIS trends exhibit less year-to-year variation compared to the NHDS trends for each condition because the NIS sample sizes are 20 to 25 times larger than the corresponding NHDS sample sizes. The estimates from the two sources are of similar magnitudes.

Figure 5: Trends for In-hospital Mortality Rate 1988 – 2004, NIS vs. NHDS

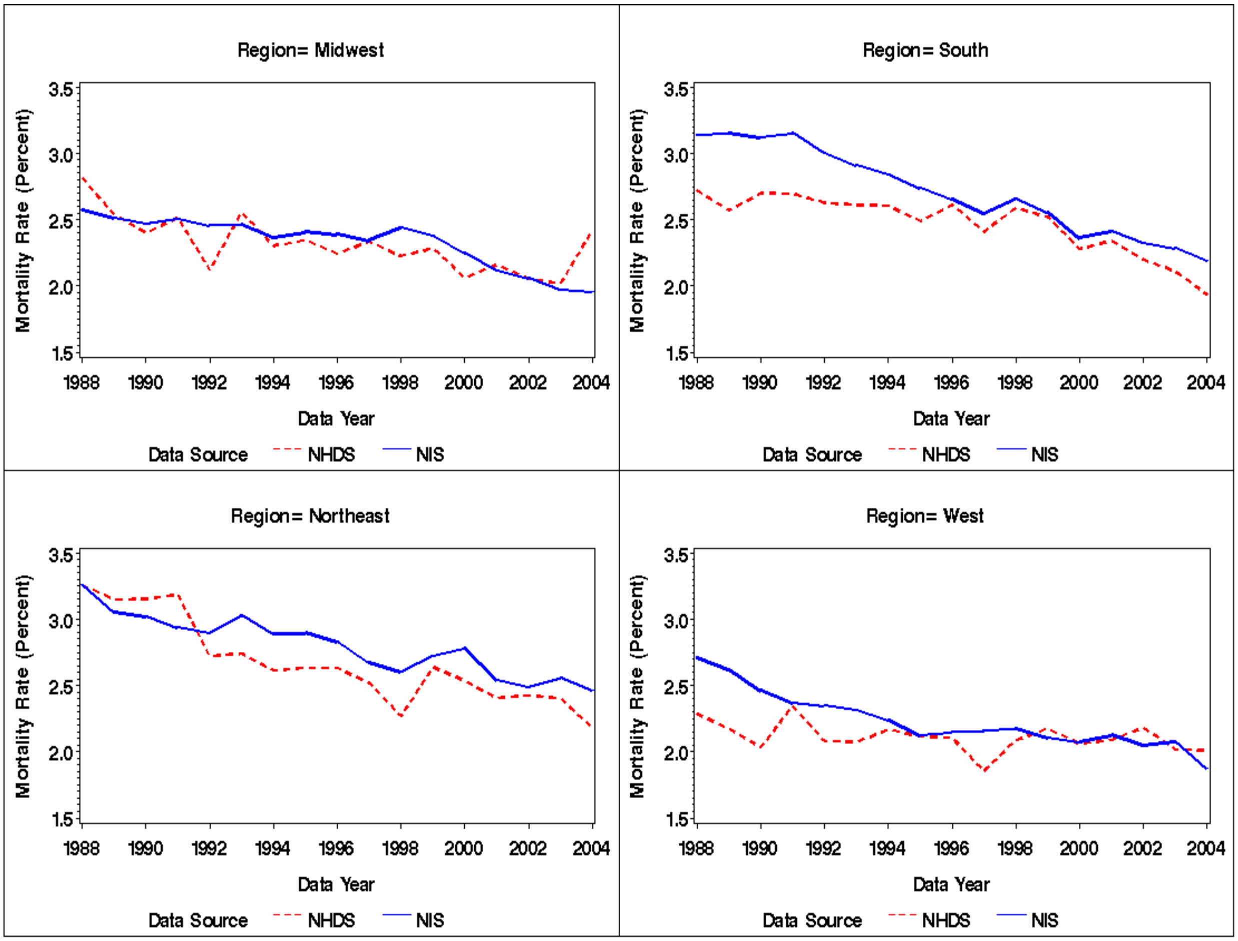


Figure 6: NHDS Trend in Average Length of Stay for Selected Conditions

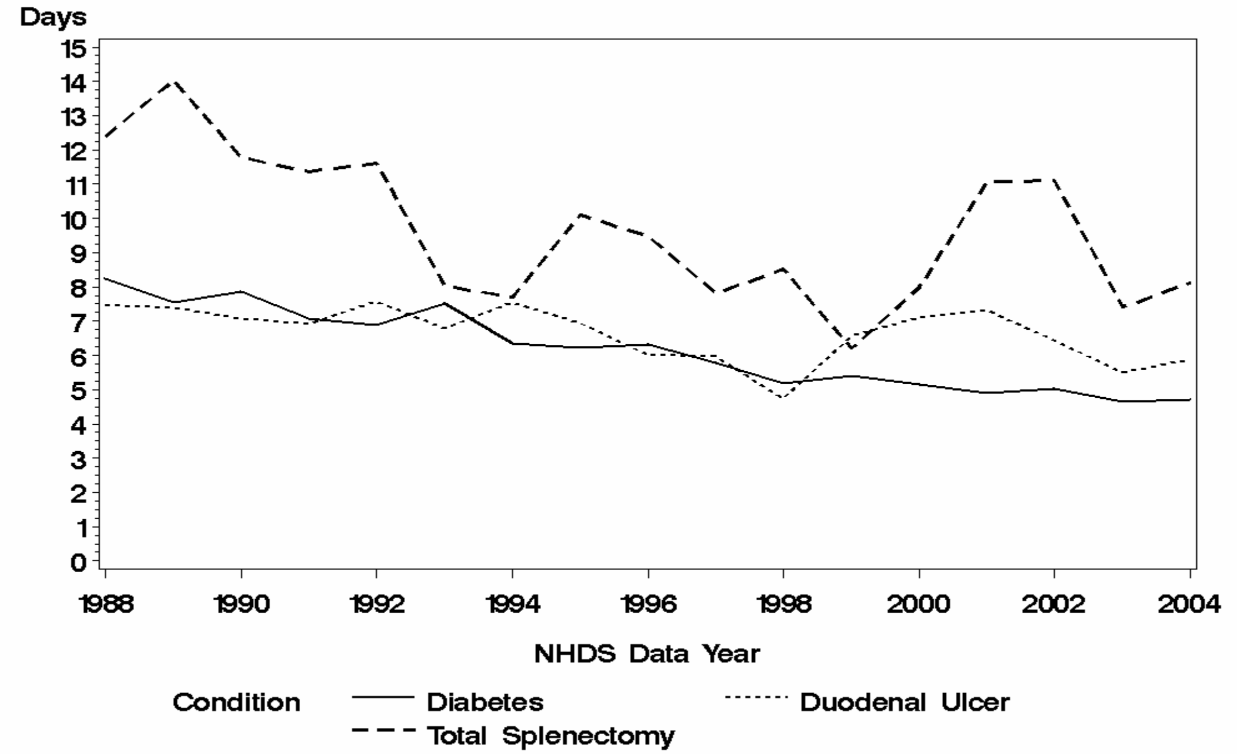
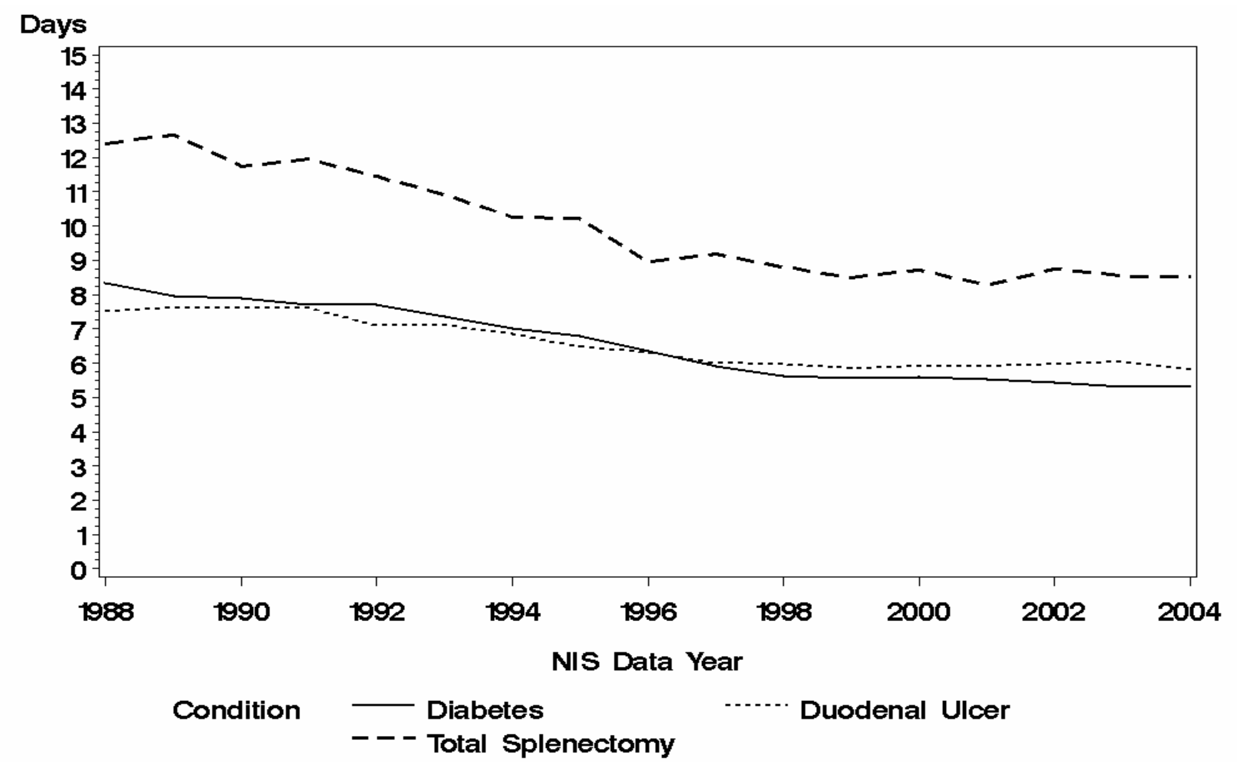


Figure 7: NIS Trend in Average Length of Stay for Selected Conditions



EFFECTS OF THE 1998 SAMPLE DESIGN REVISIONS ON TRENDS THAT SPAN 1998

The 1998 sample design generated four modifications that should be considered. We:

1. Excluded rehabilitation hospitals.
2. Changed the count of population discharges.
3. Discontinued the preference for prior year NIS hospitals.
4. Redefined the hospital stratification variables.

Most of these revisions have been previously addressed. The sections that follow further describe them and discuss their implications for trend analyses. The first two modifications both affect discharge counts in the universe. Therefore, the first section addresses their effects together.

Excluding Rehabilitation Hospitals and Changing the Count of Discharges

The weighted number of NIS discharges decreased from 35,408,207 in 1997 to 34,874,001 in 1998, a difference of 534,206 (1.5%, see Figure 1). This abrupt decline is associated with two changes to the NIS design in 1998: the exclusion of community, short-term rehabilitation hospitals from the hospital universe, and a change to the calculation of discharges in the universe for the sample weights from the total facility discharges to the hospital discharges.

Table 2 shows the effects of removing the short-term rehabilitation facilities and the effects of using the AHA hospital discharge count on the estimated total U.S. discharge count (sum of discharge weights).

Table 2: Estimate of Total U.S. Discharges, 1997

	Include Short-term Rehabilitation Hospitals?	
AHA Survey Discharge Count	**Yes**	**No**
Total Facility Count	***35,408,207***	35,193,196
Hospital Count	34,883,387	***34,680,628***

The bold number in the upper left corner of this table shows the sum of discharge weights presently in the 1997 NIS, including rehabilitation facilities and using total facility discharge counts for the universe. The bold number in the lower right corner shows the sum of discharge weights that would have been obtained for 1997 using the 1998 definition of the count of discharges in the universe and eliminating rehabilitation facilities. The difference is 727,579 discharges (a 2.1 percent reduction resulting from both changes). The total discharge estimate for 1998 was 34,874,001. Therefore, if the 1998 definitions had been in effect in 1997, the estimated number of U.S. discharges would have *increased* from 1997 to 1998 by 193,373 (0.6 percent increase) instead of *decreasing* by 534,206 (1.5 percent). It appears that the method of counting discharges in the universe (differences between rows) had a greater effect than the elimination of short-term rehabilitation facilities (differences between columns). In fact, in the 1997 AHA survey, only about 3.4 percent of all community hospitals and 0.6 percent of all discharges were associated with short-term rehabilitation facilities.

Table 3 indicates the effects of these changes on average lengths of stay (ALOS) and in-hospital mortality rates. The ALOS tends to be a little longer using the 1997 universe, which includes rehabilitation facilities and uses total facility counts, compared to using the 1998 universe, which excludes rehabilitation facilities and uses hospital counts. The largest difference is for ALOS in the Northeast, where the ALOS estimate decreased by almost one-tenth of a day (1.6 %). The differences in ALOS make intuitive sense because stays at rehabilitation facilities tend to be longer. However, the changes in the NIS universe have little impact on overall mortality estimates. The effects of these modifications in the NIS sampling and weighting could be more substantial for subsets of the NIS containing patients that tend to be treated in rehabilitation facilities.

Table 3: 1997 NIS Estimates: Weights Based on 1997 Universe vs. 1998 Universe

Location	Average Length of Stay (Days)		In-Hospital Mortality Rate (%)	
	1997 Universe	**1998 Universe**	**1997 Universe**	**1998 Universe**
Northeast	5.80	5.71	2.67	2.69
Midwest	4.81	4.76	2.35	2.35
South	4.78	4.77	2.55	2.55
West	4.43	4.41	2.16	2.16
Total U.S.	4.94	4.90	2.45	2.46

Figures 8, 9, and 10 illustrate the effects of the population definitions on NIS estimates of trends in total discharges, average length of stay, and mortality rate, respectively. For total discharges, the difference widened between 1988 and 1997, as significant numbers of hospitals and hospital beds steadily converted from non-acute care to long term care. Therefore, it may be important to use weights based on the 1998 discharge population definition for all estimates of totals. The effects are minimal on overall average lengths of stay and on overall in-hospital mortality rates. While the change in the sampling design could have contributed to the 1998 increase in the overall mortality rate, it is not apparent from comparisons to the NHDS (see Figure 5). Moreover, the pre-1998 mortality trends are nearly identical for the two population definitions.

Figure 8: NIS Trend in Total Discharges, by Population Definition

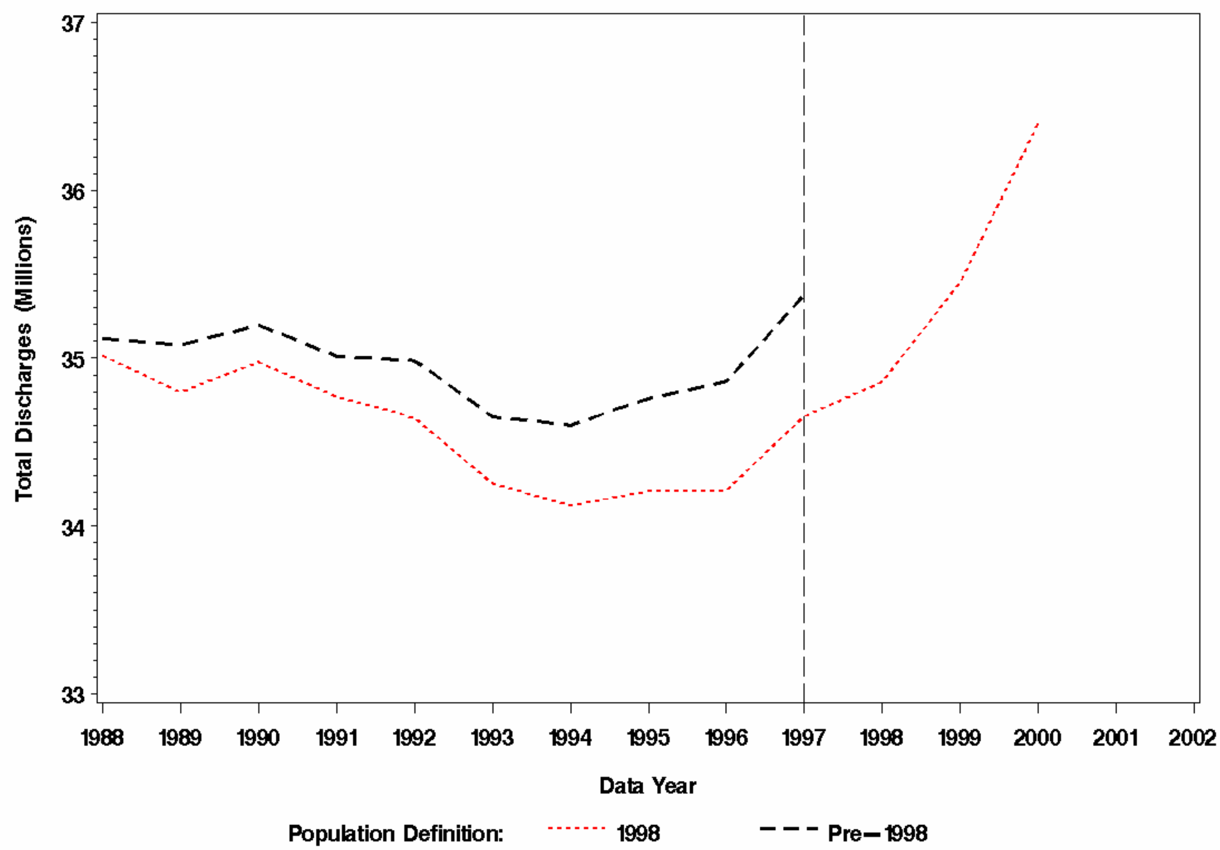


Figure 9: NIS Trend in Average Length of Stay, by Population Definition

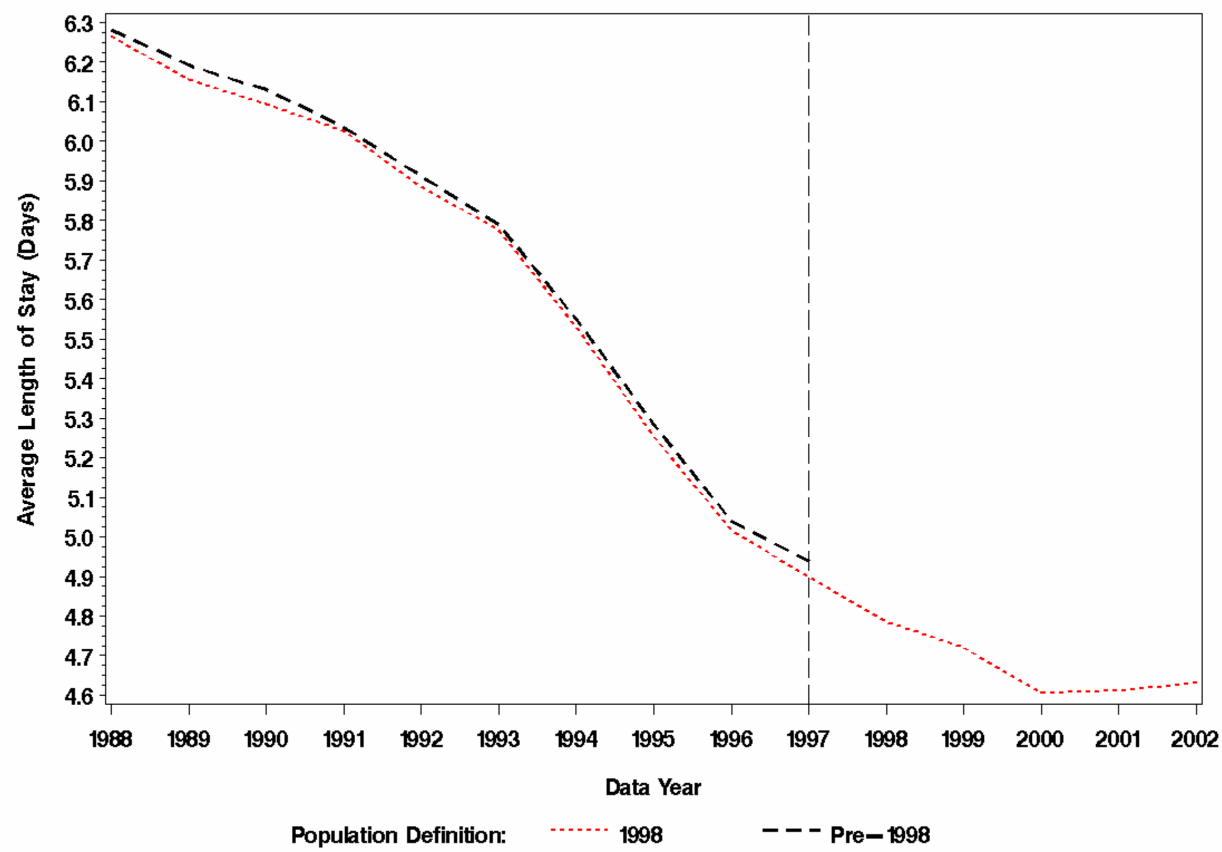
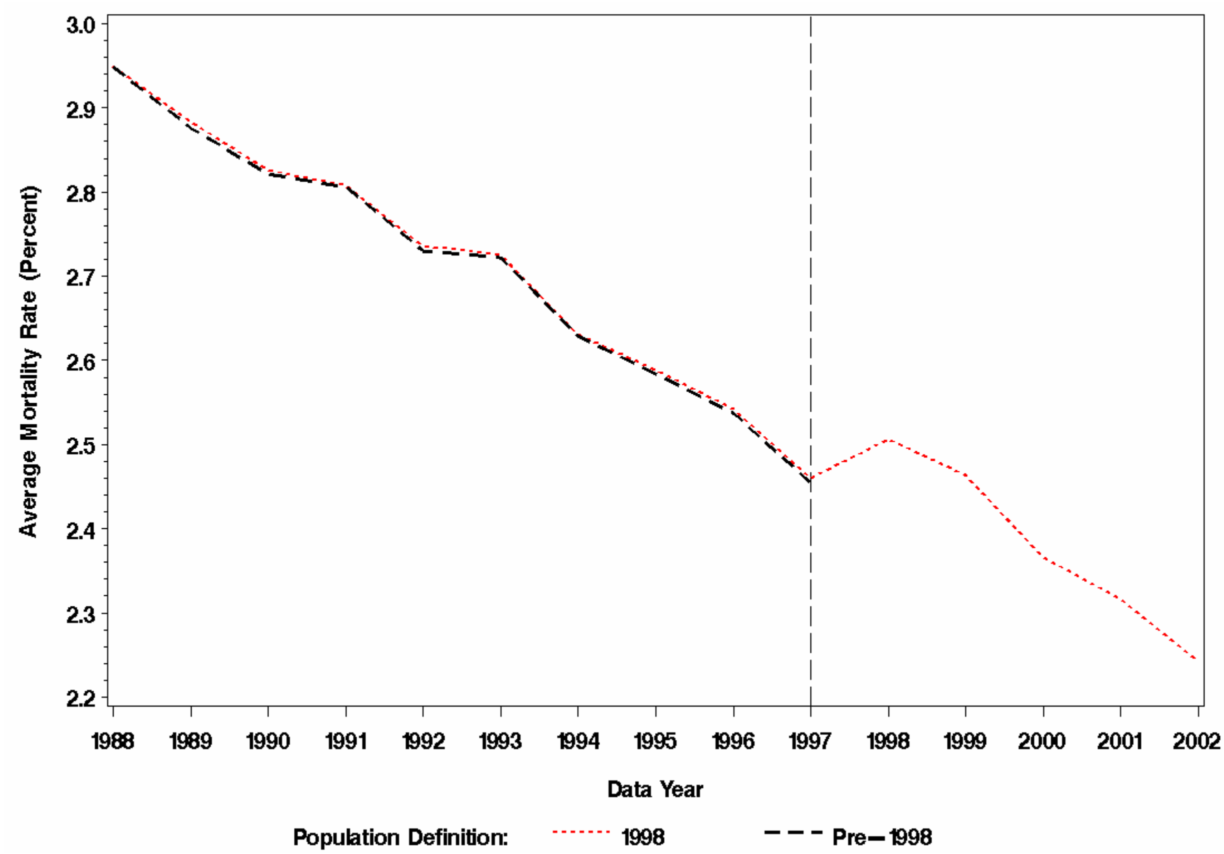


Figure 10: NIS Trend in Mortality Rate, by Population Definition



Discontinuing the Preference for Prior Year NIS Hospitals

This change resulted in fewer hospitals in the longitudinal core sample. Table 4 presents the average number of times that a hospital appears in the NIS during each 5-year period. For example, during the 1988 to 1992 period, each unique hospital appears an average of 3.7 times in the five NIS files. In contrast, during the 1998 to 2004 period, each hospital appears an average of only 1.7 times. This decline in persistence is rooted in two factors. First, the sampling preference for prior year hospitals encouraged persistence before 1998. Second, the number of states in the sampling frame was much smaller for the 1988 – 1992 time frame (8 to 11 states) than it was for the 1998 – 2004 time frame (22 to 37 states). Therefore, hospitals would have repeated more often in the early NIS years even without the preference for prior year hospitals because the pool of available hospitals was much smaller. Nevertheless, the means in Table 3 drop off most quickly for periods that include 1998, the year that the sample design changed.

Table 4: Mean Number of Years a Hospital Stays in the NIS

5-Year Period	Mean Number of Years
1988 – 1992	3.7
1989 – 1993	3.3
1990 – 1994	3.3
1991 – 1995	3.1
1992 – 1996	3.3
1993 – 1997	3.3
1994 – 1998	2.8
1995 – 1999	2.5
1996 – 2000	2.1
1997 – 2001	1.9
1998 – 2002	1.8
1999 - 2003	1.8
2000 - 2004	1.7

To the extent that this aspect of the sample design created a longitudinal component at the expense of cross-sectional representativeness, this design change may have an effect on trends crossing 1998. However, analyses in the report, *Changes in NIS Sampling and Weighting Strategy for 1998,* indicate that the specific effect of dropping the longitudinal component on estimated averages is slight.

Adjustments to the Stratification Variables

In redesigning the sample, we did not simulate NIS samples with and without adjustments to the stratification variables. These revisions are likely to have a very minor impact on most estimates because the same underlying variables were used to construct the strata in both designs and the changes primarily addressed the problem of cells with low hospital frequencies.

However, to assess the impact of changing the stratification variables, we examined two scenarios using the 1997 NIS, as presented in Table 5. First, we used the original weights based on the 1997 strata definitions, and then we recalculated the weights using the 1998 strata definitions. In addition, we eliminated rehabilitation hospitals and defined population discharge counts using 1998 criteria for both sets of weights to purge the comparisons of those revisions. Therefore, we examine only the effect of changes to the stratification variables.

It is important to recognize that, for this exercise, the 1997 sample was *not redrawn* using the 1998 strata definitions. Instead, we merely post-stratified the 1997 sample based on the 1998 strata definitions. Consequently, the 1998 strata weights are more variable than the 1997 strata weights because the 1997 weights were based on a (more uniform) 20 percent hospital sample in each stratum, while the 1998 weights were not. Because standard errors tend to increase as the variation in sample weights increases, we do not calculate and compare standard errors based on the two sets of weights.

Table 5: 1997 NIS Estimates: Weights Based on 1997 Strata vs. 1998 Strata

Location	Average Length of Stay		In-Hospital Mortality Rate (%)	
	1997 Strata	1998 Strata	1997 Strata	1998 Strata
Northeast	5.71	5.66	2.69	2.67
Midwest	4.76	4.76	2.35	2.33
South	4.77	4.77	2.55	2.55
West	4.41	4.41	2.16	2.17
Total U.S.	4.90	4.89	2.46	2.46

The largest discrepancies in Table 5, for ALOS and in-hospital mortality in the Northeast location, are less than 1 percent. The estimated total number of discharges (not shown) is the same for each region because the definitions of the regions were not altered between 1997 and 1998, and the sample is weighted to the same fixed discharge universe in each region.

Figures 11 and 12 reinforce that the change to the stratification variables had negligible impact on overall trends for average lengths of stay and in-hospital mortality rates, respectively. The differences are quite small. However, the mortality trend slope using 1998 strata definitions is slightly steeper than the mortality trend slope using the pre-1998 strata definitions. Of course, the trend in total discharges (not shown) is unaffected by changes in the strata definitions.

Figure 11: NIS Trend in Average Length of Stay, by Strata Definition

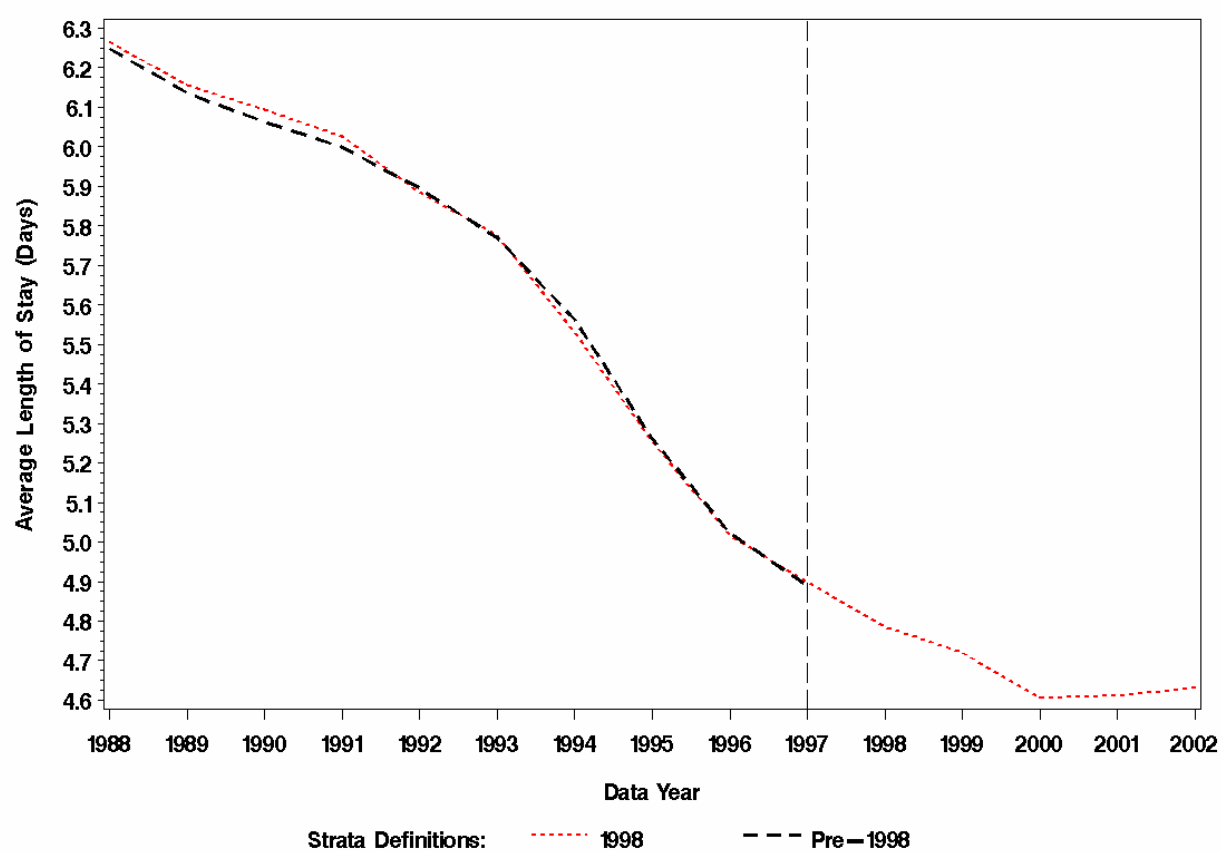
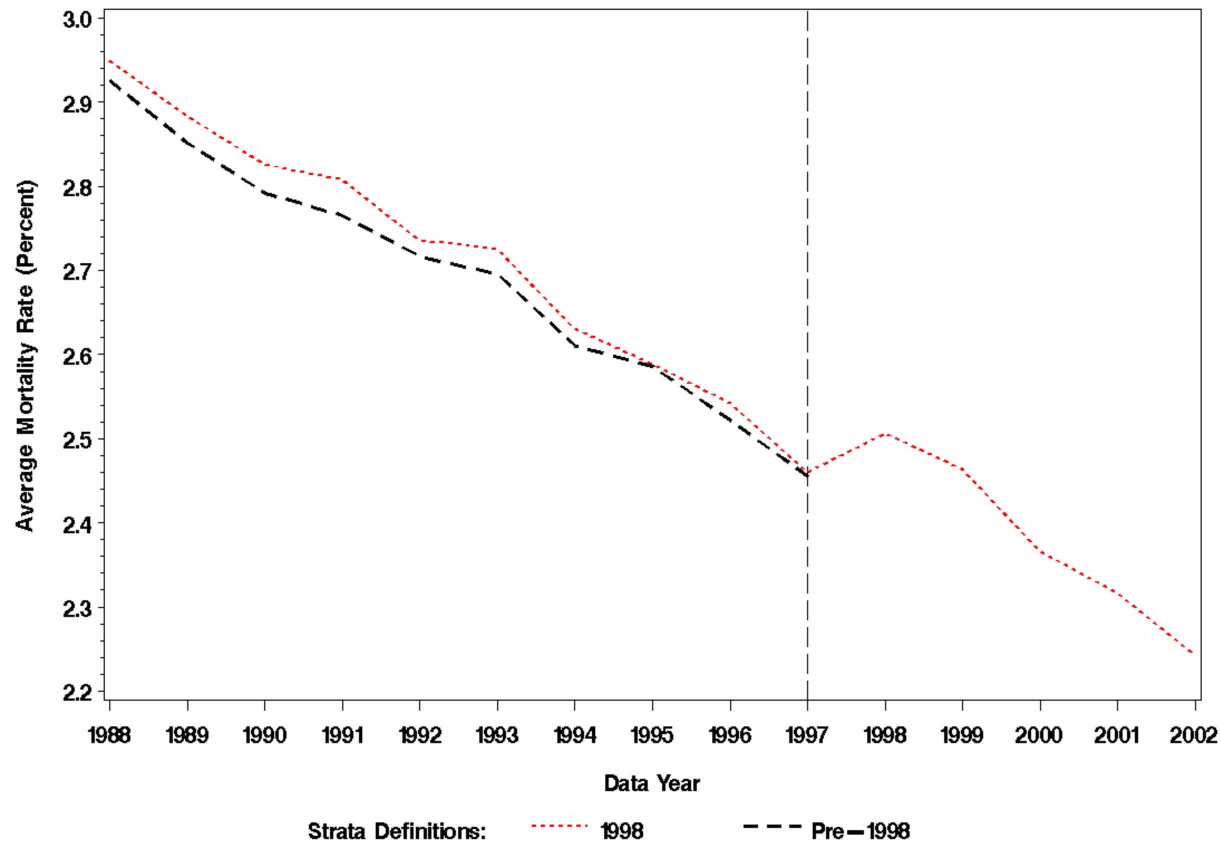


Figure 12: NIS Trend in Mortality Rate, by Strata Definition



Even though the impact of changing the stratification variables was minimal, we will briefly examine each specific change, without estimating their individual effects.

Change in the definition of teaching hospitals

This redefinition caused some hospitals to change strata from non-teaching to teaching. In the 1997 data, 14.3 percent of the hospital sample was designated a teaching hospital under the pre-1998 definition as compared to 20.1 percent under the 1998 definition. In other words, about 7 percent of non-teaching hospitals in 1997 would have been designated teaching hospitals under the 1998 definition. Most likely, the “new” teaching hospitals previously appeared in the sample in proportion to their numbers in the hospital universe within each stratum. Consequently, the effect on sample estimates will be small. This change is most important when the NIS definition of teaching hospitals is used in analyses involving years prior to 1998, for example to estimate the effect of teaching status on an outcome. For such analyses, it would be best to standardize the definition using the 1998 designation.

Change in the bed size categories

This revision caused some hospitals to move from one bed size stratum to another. However, it is expected to have little impact on most analyses. The pre-1998 bed size cutpoints are as follows:

Table 6: Bed Size Categories in the 1988 – 1997 Sample Design

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

The new 1998 bed size cutpoints are:

Table 7: Bed Size Categories in the 1998 – 2004 Sample Design

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+
Midwest	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+

Under the 1998 definitions, the 1,012 hospitals in the 1997 sample would have switched bed size categories as follows:

Table 8: Bed Size Distribution of 1997 NIS Hospitals 1997 Definition vs. 1998 Definition

1997 Definition	1998 Definition		
	Small	Medium	Large
Small	305	133	8
Medium	30	185	101
Large	3	12	235

Consequently, about 28 percent of 1997 sample hospitals would have changed bed size categories under the 1998 classification rules, mostly moving to a higher bed size category. Again, this is probably only important for analyses that involve the NIS definition of bed size categories. For reasons of confidentiality, AHRQ is prevented from releasing each hospital's exact number of beds. Therefore, trend studies crossing 1998 might prefer to employ other measures of hospital size, such as total discharges.

<u>Change in ownership strata</u>

This change caused some hospitals in low-frequency ownership categories to be combined with higher frequency categories. It is expected to have little effect on most analyses, except for the use of ownership categories in analyses. Analysts can collapse the pre-1998 ownership categories to match the 1998 ownership categories. However, the new categories are less refined for some regions than for others. The table below compares the distribution of the 1997 NIS sample hospitals under the two classification schemes.

Table 9: Ownership Distribution of 1997 NIS Hospitals, by Region, 1997 vs. 1998 Categories

1997 Ownership Categories	1998 Ownership Categories				
	Collapsed government or private	Government, nonfederal, public	Private, not for profit, voluntary	Private, investor owned	Collapsed private
Northeast Region					
Public	11	0	0	0	0
Private, not for profit	137	0	0	0	0
Private, for profit	6	0	0	0	0
Midwest Region					
Public	13	69	0	0	0
Private, not for profit	107	0	0	0	99
Private, for profit	9	0	0	0	5
South Region					
Public	9	89	0	0	0
Private, not for profit	35	0	128	0	0
Private, for profit	2	0	0	102	0
West Region					
Public	9	44	0	0	0
Private, not for profit	22	0	50	0	29
Private, for profit	4	0	0	29	4

In the Northeast, only about 10 percent of the 1997 NIS hospitals were other than private non-profit. This is essentially why we did not stratify on ownership in the Northeast after the 1997 sample. However, in other regions, the ownership categories were retained to varying extents. While the 1998 ownership categories are more sensible for the purpose of sampling stratification, the pre-1998 ownership categories are more useful for purposes of hospital analyses because they are consistently defined across all stratification variables, including region. Unfortunately, concerns for hospital confidentiality prevent the release of each hospital's detailed ownership category. Thus, trend studies of hospital ownership that cross 1998 might be better served by data other than the NIS.

Adjustments for 1998 Sample Design Revisions

It appears that many of the "discontinuities" between 1997 and 1998 caused by the 1998 sample redesign can be addressed by removing rehabilitation hospitals and recalculating discharge weights using the 1998 definition of population discharges. The effects of the 1998 sample redesign appear to be largest for estimates of totals and to be relatively minor for estimates of means and rates with discharge denominators.

For analysts who wish to estimate trends in totals prior to 1998, we advise the use of newly-calculated discharge weights using the 1998 definition for the discharge population in the pre-1998 data period. A new weight file is available for this purpose on the AHRQ Website (http://www.hcup-us.ahrq.gov/db/nation/nis/nisdbdocumentation.jsp).

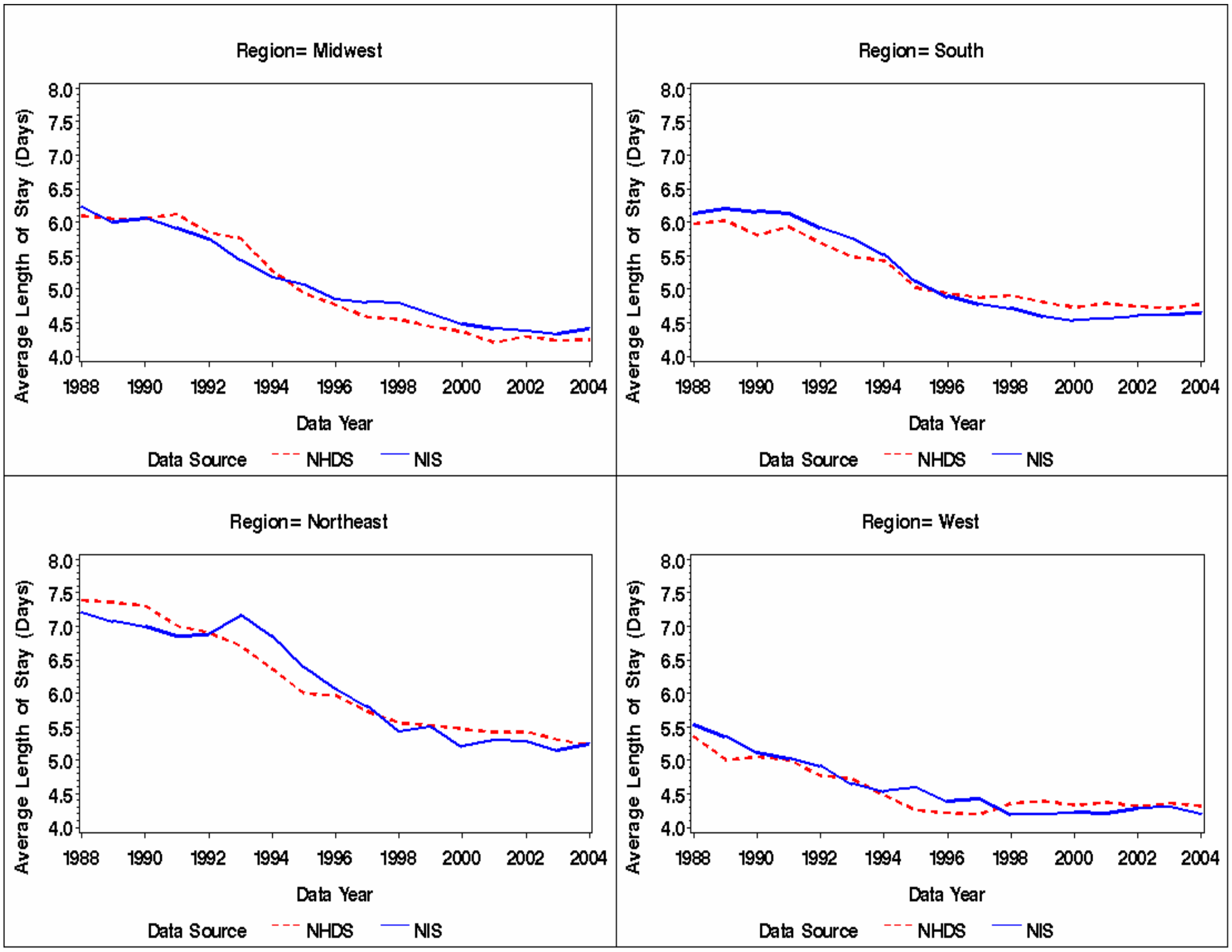
EFFECTS ON TRENDS OF CHANGES TO THE SAMPLING FRAME

While it may be possible to adjust analyses for changes in the 1998 NIS sample redesign, it may be difficult to adjust for major changes in the sampling frame. For example, New York was added to the NIS sampling frame in 1993.

Figure 13 presents estimates from both the NIS and the NHDS for trends in the ALOS for each region. Adding New York to the NIS sampling frame dramatically increased the NIS ALOS estimate in the Northeast region between 1992 and 1993. Ironically, this caused the NIS and the NHDS ALOS trends to diverge sharply for the Northeast region in 1993. A similar pattern is evident for in-hospital mortality rates, previously shown in Figure 5.

However, in the Northeast, the 1993 NIS sampling frame covered more than 90 percent of the population, as compared to roughly 50 percent of the population in 1992 (Figure 3). Thus, NIS estimates for the 1988-1992 period are more likely to be biased compared with NIS estimates for the 1993-2004 period, which should be highly accurate for the Northeast. In addition, we show later (Table 10) that the variance in sample discharge weights decreases by 60 percent between 1992 and 1993, which results in a substantial decrease in the variance of NIS estimates. For this reason, we recommend that most NIS trend analyses should be confined to the 1993-2004 period. It is unclear why the NIS and NHDS estimates are more divergent in 1993 and 1994, given the near complete coverage of the NIS sampling frame in the Northeast during those years.

Figure 13: Estimated Average Length of Stay Trend, by Region and Data Source



Note: Lengths of stay in excess of 180 days were recoded to 180 days in both databases.

HOW SHOULD CHANGES TO DATA ELEMENTS BE ADDRESSED?

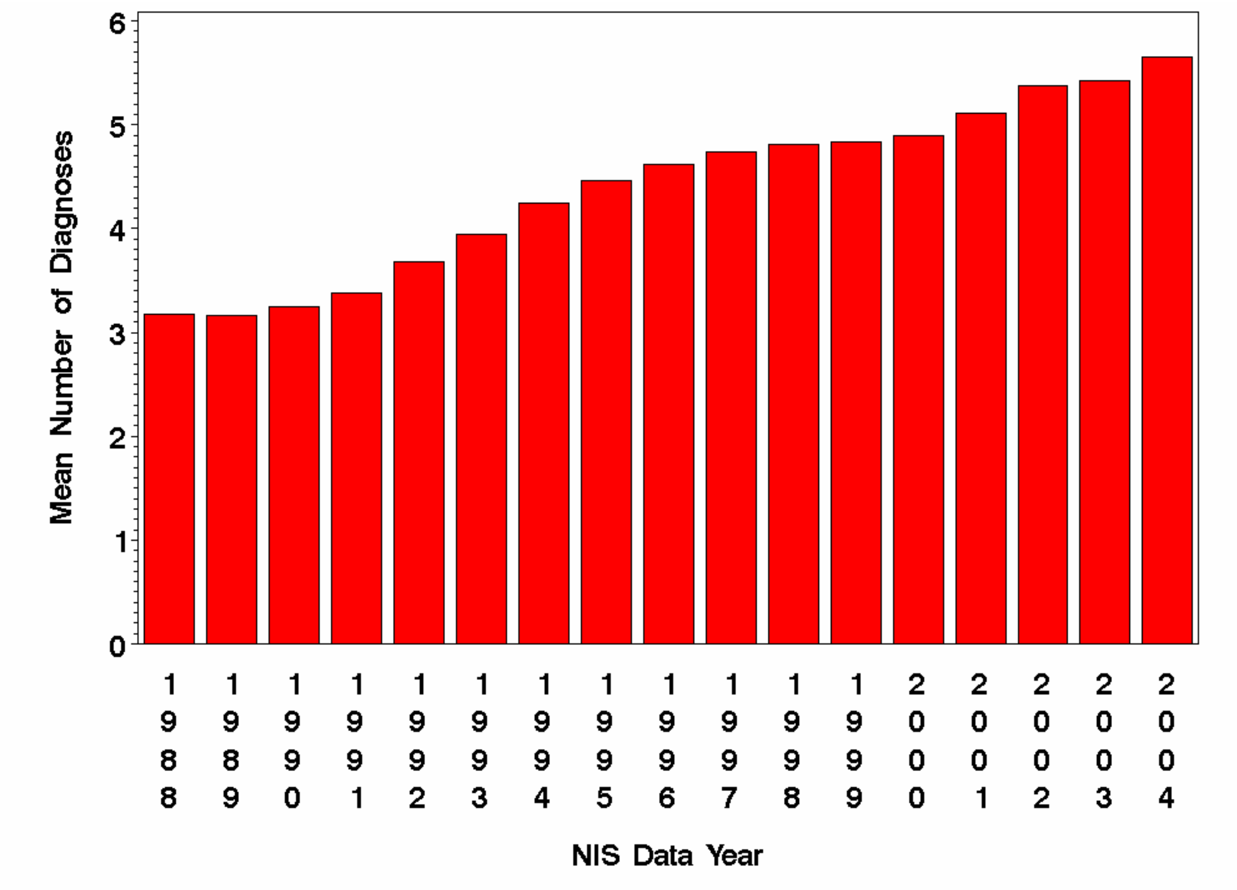
To What Extent Should ICD Coding Issues be Considered?

Number of codes

Each NIS record contains up to 15 ICD-9 diagnosis codes and another 15 ICD-9 procedure codes. It is important to recognize that not all state discharge databases contain 15 codes. Some states captured only 5 or 10 codes while other states captured up to 30 codes, and the number of available slots for codes changed over time in some states. In any case, the NIS retains up to 15 of these original codes because analyses demonstrated this captures the vast majority of diagnoses and procedures. For 2004, only about 0.7 percent of the discharges in the NIS originally had more than 15 diagnoses coded. This percentage was even smaller for earlier years.

Figure 14 displays the trend in the average number of diagnoses coded in the NIS from 1988 to 2004. The number grew steadily over this period from 3.2 in 1988 to 5.7 in 2004. The number of codes may be important for some analyses because secondary diagnoses provide information on severity and comorbidities. States (or years) with more codes may appear to have a more complex case-mix than states with fewer codes. Also, conditions that tend to be coded near the end of the vector may occur more frequently in states (or years) with more codes.

Figure 14: Mean Number of Diagnoses Coded, NIS 1988 – 2004



<u>Masking and recoding for cases with sensitive diagnoses and procedures</u>

For completeness, we point out that for records with sensitive diagnoses and procedures (most notably AIDS, alcohol abuse, drug abuse, and induced abortions), some states mask or recode certain data elements, such as ages, dates, and physician identifiers. These recodes are unlikely to affect most analyses. Some states completely exclude records with sensitive diagnoses. For example, beginning in 2001, Iowa excluded records in MDC 25 (HIV infections) and some behavioral health records. For details, see the documentation that accompanies the NIS data files (*Sources of NIS Data and State-specific Restrictions,* and *Description of Data Elements, Nationwide Inpatient Sample*).

<u>Annual ICD-9-CM code changes</u>

On October 1 of each year, ICD-9-CM code changes go into effect, including the introduction of new codes. A conversion table mapping code changes between 1986 and 2004 is available online at http://www.cdc.gov/nchs/data/icd9/icdcnv05.pdf.

Any trend analysis of hospital treatments for specific medical conditions should entail a careful consideration of ICD-9-CM codes for the specific conditions in effect during the study period.

The complete list of changes is too lengthy to include in this report. However, some examples of code changes are:

For diagnosis codes:

- For AIDS (042.x-044.x), fourth digits were first introduced in 1986 and were subsequently removed in 1994 (simplified to 042).
- For diabetes (250.xx), fifth digits of 2 and 3 were added in 1993 to indicate uncontrolled diabetes.
- For AMI (410.xx), fifth digits were added in 1989 to indicate an initial episode of an AMI versus subsequent care.

For procedure codes:

- For different types of bone marrow and stem cell transplants (41.0x), fifth digit codes were added in 2000.
- For angioplasty (36.0x), fourth digit codes were added for more specificity.
- A new code for therapeutic ultrasound for vessels of the head and neck (00.01) was introduced in 2002.

For some analyses, analysts might want to consider grouping discharges into diagnostic or procedure groups, which might be less sensitive to code changes, especially code changes within a specific disease. One such grouper is the Clinical Classification Software (CCS), which is available for download from the AHRQ Web site (http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp).

What Other Coding Issues Should Be Considered?

DRG Changes. The Diagnosis Related Group (DRG) definitions change on October 1 of each year to keep pace with ICD-9-CM code modifications and to reflect developments in medical practice. Many of the changes relate to ICD-9-CM coding revisions, but occasionally cases are reassigned to other DRGs on the basis of cost. A single DRG grouper can be applied to the NIS discharge data by using the ICD-9-CM conversion table cited in the last section to map ICD-9-CM codes to the version suitable for that grouper. For most years, the NIS contains DRG values for the following groupers:

- For every year of the NIS, the grouper in effect on the discharge date.
- For the 1988 – 1999 NIS, grouper version 10 (effective October 1992).
- For the 1998 – 2004 NIS, grouper version 18 (effective October 2000).

Note that all three versions are present for 1998 and 1999. The grouper version may not be an issue for those DRGs that had equivalent definitions over time.

Other Variable Changes. Other variables on the NIS discharge records also have changed over time. For example, the categorical variable "sex" was changed to the indicator variable "female" starting with the 1998 NIS. In addition, variable names and data elements in the hospital-level file changed over time. It is fairly easy to adjust for these revisions through simple computer programming statements. However, NIS supplemental trends files, described next, are available to simplify the process.

NIS SUPPLEMENTAL TRENDS FILES

A new tool is now available to aid researchers in using the NIS for trends analysis. See *User Guide for the 1988-2002 NIS Trends Supplemental Files*, which is available on the HCUP-US website. This tool includes programs and files that provide trend weights and data elements that are consistently defined across data years. It builds on this report by providing files that:

- rename and recode variables from earlier years to their later form (1998 and later),
- add data elements that were added in later years (to the extent possible), and
- provide the recalculated weights for NIS data years 1993-1997.

The NIS Supplemental Trends Files are intended to simplify the steps necessary for using the NIS across data years.

HOW SHOULD HOSPITAL WEIGHTS AND DISCHARGE WEIGHTS BE USED?

When is it Appropriate to Use Hospital Weights Rather than Discharge Weights?

Hospital weights weight the sample of hospitals to the population of hospitals. Discharge weights weight the sample of discharges to the population of discharges. Thus, the selection of weights depends on the level of the analysis. Examples of hospital-level statistics are the average occupancy rate and the average volume of hospital procedures. The average occupancy rate and the average procedure volume would be estimated using a hospital-level file and hospital-level weights. On the other hand, the average length of stay and the total number of procedures performed per discharge are patient-level statistics. The average length of stay and the number of procedures per discharge would be estimated using the discharge-level file and discharge weights.

Should Weights Be Incorporated in Trend Analyses?

Weights are usually required to obtain unbiased estimates of descriptive statistics such as sums, means, and standard errors. In some instances, unweighted means provide good estimates, but they are rarely better estimates (Korn and Graubard, 1999). Obviously, unweighted means are equal to weighted means when the weights are constant. Also, unweighted means nearly equal weighted means on outcomes for which there is little variation.

Table 10 reveals that the variation in NIS discharge weights decreased steadily over the period 1988 to 2004. This decrease is associated with the expanding sampling frame. As more states were added to the frame, more strata included at least 20 percent of the hospital universe, which is the target sample size. Also, consistent with the 20 percent hospital sample size, the average discharge weight decreased to a value near 5 over this period. Therefore, in the NIS, unweighted means tend to be closer to weighted means in later years than they are in earlier years. Nevertheless, we generally recommend the use of weights for descriptive statistics.

Quite often, researchers do not use sample weights in regression analyses, which are used to better understand the relationship between a dependent variable and a set of independent or explanatory variables. There is some debate concerning the use of sample weights in regression analyses (Korn and Graubard, 1999). We will not repeat the arguments here. However, we recommend that the weights be used, if possible. Even in statistical routines that fail to account for the sample design, the sample weights can usually be used, although the analyst might have to normalize the weights to sum to the sample size and provide better estimates of error and statistical significance. That said, some procedures that might be useful for trends analysis do not usually allow the use of sample weights. One example is times series analysis.

Table 10: Mean and Standard Deviation of Discharge Weights, NIS 1988 – 2004

Year	Mean Discharge Weight	Standard Deviation
1988	6.71	4.63
1989	5.79	3.85
1990	5.72	4.08
1991	5.85	3.95
1992	5.83	4.16
1993	5.31	1.65
1994	5.42	1.89
1995	5.18	1.55
1996	5.33	1.63
1997	4.95	1.12
1998	5.11	0.68
1999	4.93	0.52
2000	4.89	0.57
2001	4.99	0.49
2002	4.81	0.57
2003	4.79	0.56
2004	4.83	0.50

WHICH STATISTICAL METHODS SHOULD BE USED FOR NIS TREND ANALYSES?

Various statistical techniques are available to analyze trends or time series depending on the number and spacing of time points and on the outcome or response variable under study. Usually, there is one response variable, such as length of stay, and one or more predictor or explanatory variables.

Descriptive statistics can be analyzed using standard statistical routines for survey data (see Houchens and Elixhauser, 2001). Several types of regression analysis can be conducted, including simple and multiple linear regression for continuous outcomes, logistic and probit regression for binary outcomes, and Poisson or negative binomial regression for count outcomes.

Modules for multiple linear regression incorporating complex survey designs are available using the SAS SURVEYREG procedure (SAS Institute, 2004), the Stata SVYREGRESS command

(StataCorp, 2003), and the SUDAAN REGRESS procedure (Research Triangle Institute, 2004). Logistic and probit regression procedures for binary outcomes that incorporate survey design elements are also available in SAS (SURVEYLOGISTIC procedure), Stata (SVYLOGIT and SVYPROBIT commands), and SUDAAN (LOGISTIC or RLOGISTIC procedure). Procedures for count data, such as Poisson regression and negative binomial regression, which incorporate complex survey design elements are available in SUDAAN (LOGLINK procedure) and Stata (SVYPOISSON, SVYNBREG, and SVYGNBREG commands).

If regressions are performed using only a subset of the NIS, estimated standard errors might be incorrect if the subset does not contain at least one observation from every stratum. The example analysis in the following section illustrates the differences that can occur. For regression procedures, statements for designating subpopulations are available in SUDAAN (SUBPOPN statement) and Stata (SUBPOP option). However, for trend studies that use multiple years of the NIS involving many millions of observations, the analyst might prefer to reduce the size of the analysis file to the subset of interest. It is still possible to get appropriate standard errors by augmenting the subset with "dummy" observations, one for each NIS stratum. This technique is explained in Appendix B of Houchens and Elixhauser (2001).

Hierarchical or multilevel regressions might be appropriate for incorporating hospital characteristics as explanatory variables (Snijders and Bosker, 1999; Singer, 2003). These models are appropriate for nested observations, such as students nested within teachers nested within schools. In the context of NIS trend studies, discharges are nested within hospitals. Some hospitals are contained in multiple years of the NIS. Consequently, the nesting structure could also be characterized as discharges nested within years nested within hospitals (repeated measures on the same hospital).

Hierarchical models account separately for the discharge-level error, the hospital-level error, and the correlation among discharges within hospitals. Also, these models can account for serial correlation over time. Hierarchical models can be fit using SAS PROC MIXED (Singer, 1998), Mplus (Muthen & Muthen, 1998 – 2004), HLM (Raudenbush, Bryk, Chong, and Congdon, 2000), and MLwiN (Rasbash, et al., 2002). These statistical routines allow the use of sample weights. However, they do not account directly for other survey design elements. Instead, the sample design must be modeled. For example, hospital-level variation is modeled separately from discharge-level variation, and hospital stratification variables are often included as independent variables for the hospital-level model.

One explanatory variable that is always of interest in trend analyses is time. How is time measured? NIS trends can be estimated in years (discharge year), quarters (discharge quarter), or months (admission month). The choice of time measure depends on the goals of the study and the nature of the trend. If the analysis is concerned with seasonality, then time should be measured in quarters or months.

Care must be exercised when using the month variable. The NIS contains *admission* month and *discharge* year. The discharge quarter and length of stay can be used to help estimate the admission year corresponding to the admission month. For example, if the admission month is December and the discharge quarter is the first or second quarter, then the admission year is probably one year earlier than the discharge year. However, using admission dates to measure time raises another set of problems because the NIS is a discharge database, not an admissions database.

The analyst could also try to impute the *discharge* month from the combination of admission month, discharge quarter, and length of stay. For example, if the admission month is December, the discharge quarter is January-March, and the length of stay is under 30 days, it would be reasonable to impute a discharge month of January. However, many other combinations are much less clear-cut. For instance, if the length of stay was 45 days in the last example, then the discharge month could be either January or February. For this reason, we recommend using discharge quarter to study seasonality, if that is adequate to the task.

An Example Trend Analysis: Lengths of Stay for Affective Disorders

The analyses here are intended to be illustrative rather than prescriptive. We suggest some steps that analysts can take and suggest some statistical methods that could be useful. However, a variety of other approaches and other methods might be appropriate depending on the goals of the study.

Bao and Sturm (2001) estimated the 10-year trend in the average length of stay (ALOS) for several categories of mental health and substance abuse (MHSA) between 1988 and 1997 using one of the NIS 10-percent samples. We will use the full NIS to examine trends in average length of stay (ALOS) for one of those categories, affective disorders, defined by category number 69 in AHRQ's clinical classification system. Affective disorders have diagnoses of 296.xx, 298.0, 300.4, 301.11, and 301.13. A search of the ICD-9 code conversion table reveals no changes to these codes over the study period. Consequently, this subpopulation of discharges is consistently defined throughout, at least with respect to ICD-9 codes.

As exhibited in Figure 15, each NIS contains a large sample of discharges for affective disorders. Consequently, most statistics for this subpopulation should be fairly precise. The estimated (weighted) number of affective disorders (not shown) also climbed from approximately 401,000 in 1988 to about 709,000 in 2001, then declined to roughly 655,000 in 2001. Taking the growth of the general population into account, Bao and Sturm estimated a 36 percent increase in the *rate* of discharges for affective disorders in the general population between 1988 and 1997.

Figure 15: NIS Sample Sizes for Affective Disorders, 1988 – 2002

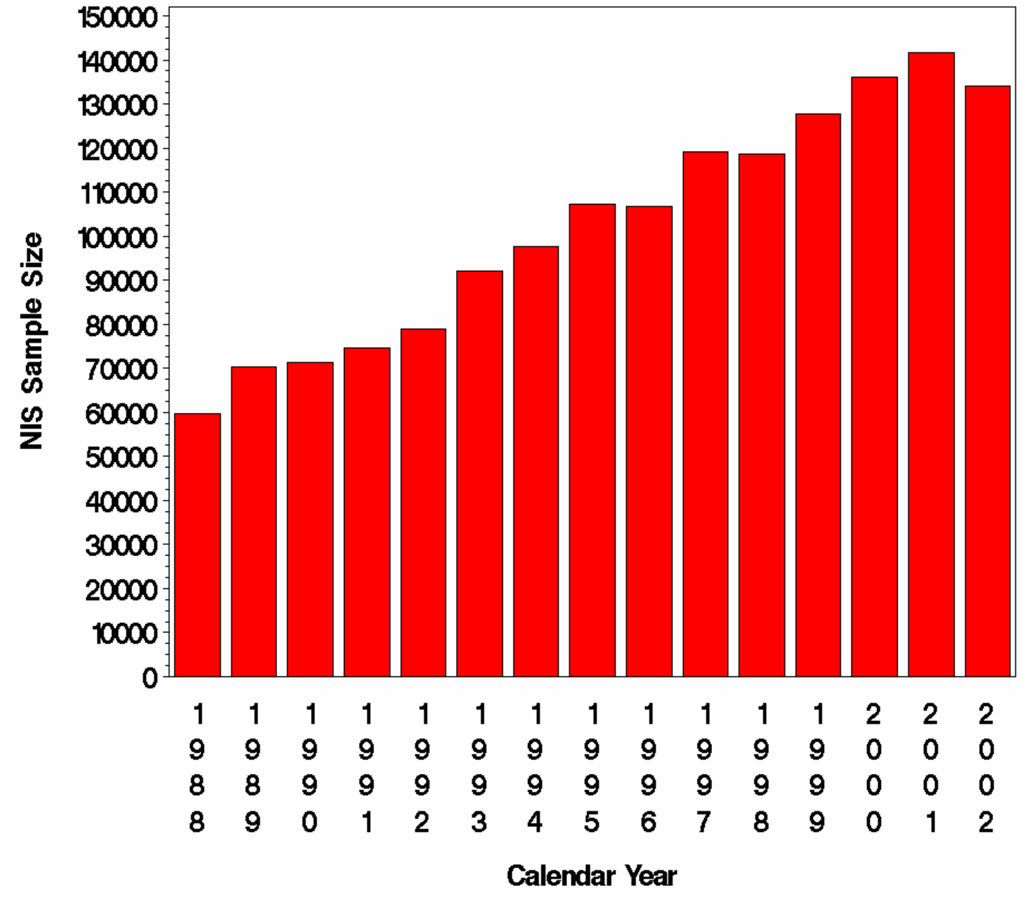
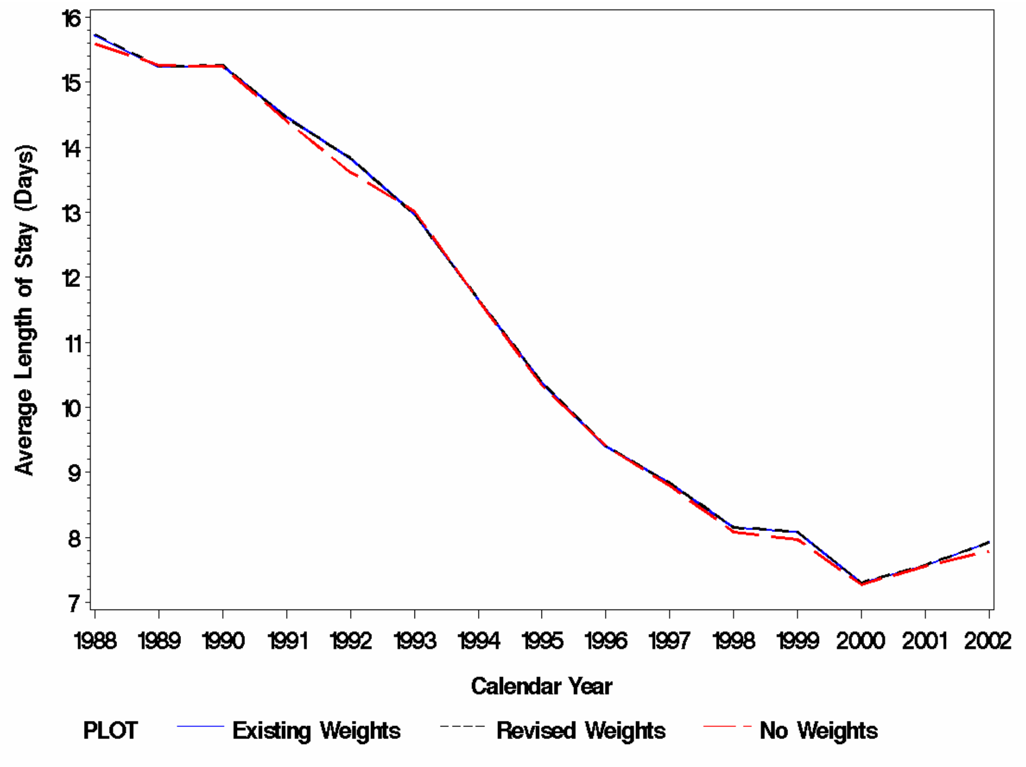


Figure 16 presents the estimated full-sample trend in ALOS for affective disorders extending through 2002. Although only two lines are visible, three lines are plotted corresponding to estimates based on: 1) the existing weights, 2) the revised weights (for years prior to 1998), and 3) no weights. The revised weights exclude rehabilitation hospitals from the universe and weight sample discharges up to the AHA count of hospital discharges (rather than total facility discharges). There is practically no difference between the two weighted estimates. Therefore, these two lines completely overlap on the plot. Moreover, the unweighted trend is barely different from the weighted trends. We use the revised weights throughout these analyses. However, similar results should be obtained with the existing weights.

Figure 16: Trend in ALOS for Affective Disorders, 1988 – 2002 (NIS Full Sample)



The ALOS trend estimated by Bao and Sturm for affective disorders shown in Figure 17, based on the 10-percent sample for the period 1988 to 1997, is very close to that estimated by the full NIS (Figure 16). The outer dashed lines connect the 95 percent confidence limits for each year's ALOS estimate. Bao and Sturm estimated standard errors with the SUDAAN statistical package using the finite population correction (FPC) factor. Their estimates accounted for the finite number of universe hospitals in each stratum for each year.

In our analyses, we will ignore the FPC. Doing so increases the estimated standard errors by about 10 percent, but it allows the results to be generalized beyond the specific hospital universe and each hospital's specific discharge population each year. See the report*, Final Report on Calculating Nationwide Inpatient Sample (NIS) Variances,* for more information on calculating standard errors.

In Figure 17, the confidence limits narrow through time. This narrowing is a result of 1) decreasing LOS variance owing to an increase in cost-containment measures, and 2) increasing numbers of participating HCUP hospitals, which in turn, increased the number of hospitals in the NIS sample. In particular, as the sampling frame increased over time, we were more successful in sampling 20 percent of the U.S. hospitals *in each stratum*. This led to less variation in sample discharge weights across strata, which contributed to smaller estimates of standard error overall.

To statistically test for a significant linear trend, Bao and Sturm fitted a linear regression to the annual ALOS estimates with time as a predictor, using the method of weighted least squares. The weight given each mean was inversely proportional to its estimated variance (square of the standard error). The resulting regression line is shown as a straight dashed line in Figure 18.

Although the observed trend appears to be slightly non-linear, the regression line falls within the individual 95 percent confidence limits for every year, indicating that the year-specific regression predictions are somewhat plausible, although this is not a test of the model's adequacy. This regression indicates an average decline in ALOS of 0.9 days per year for affective disorders during the 10-year period.

In the remainder of this section, we will expand on Bao and Sturm's analysis of ALOS by using the full NIS sample and by extending the timeframe through 2002. While we encourage the use of the 10-percent samples for preliminary analyses, we recommend that final estimates be calculated using the full NIS sample, if possible.

Figure 17: Trend in ALOS for Affective Disorders, 1988 – 1997 (NIS 10% Sample)

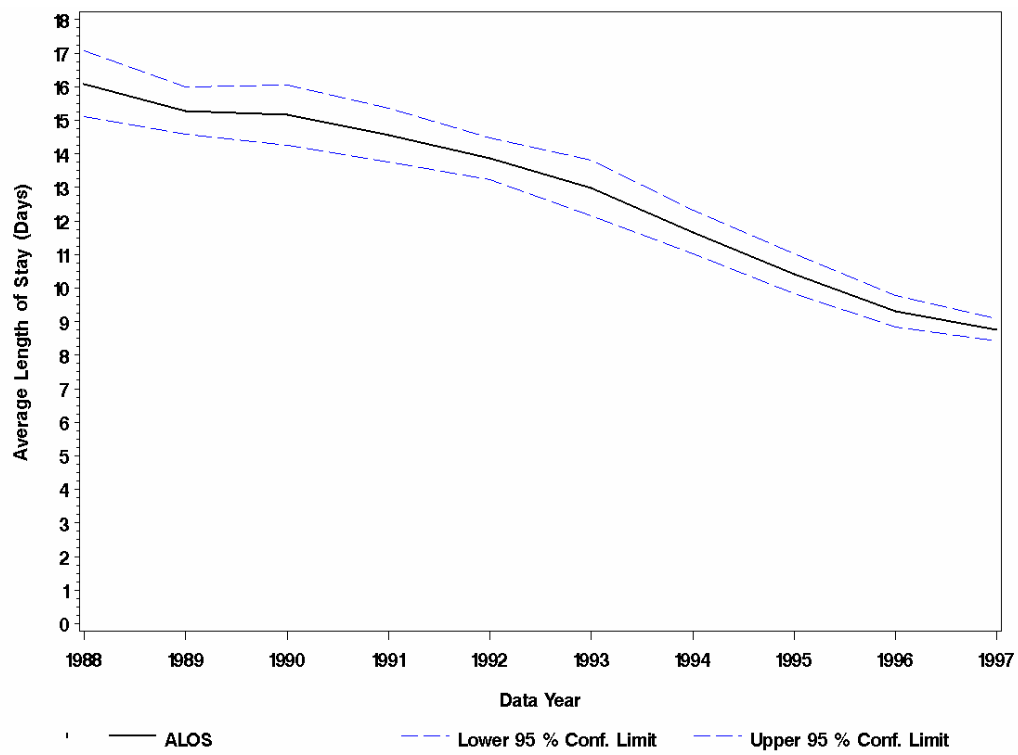
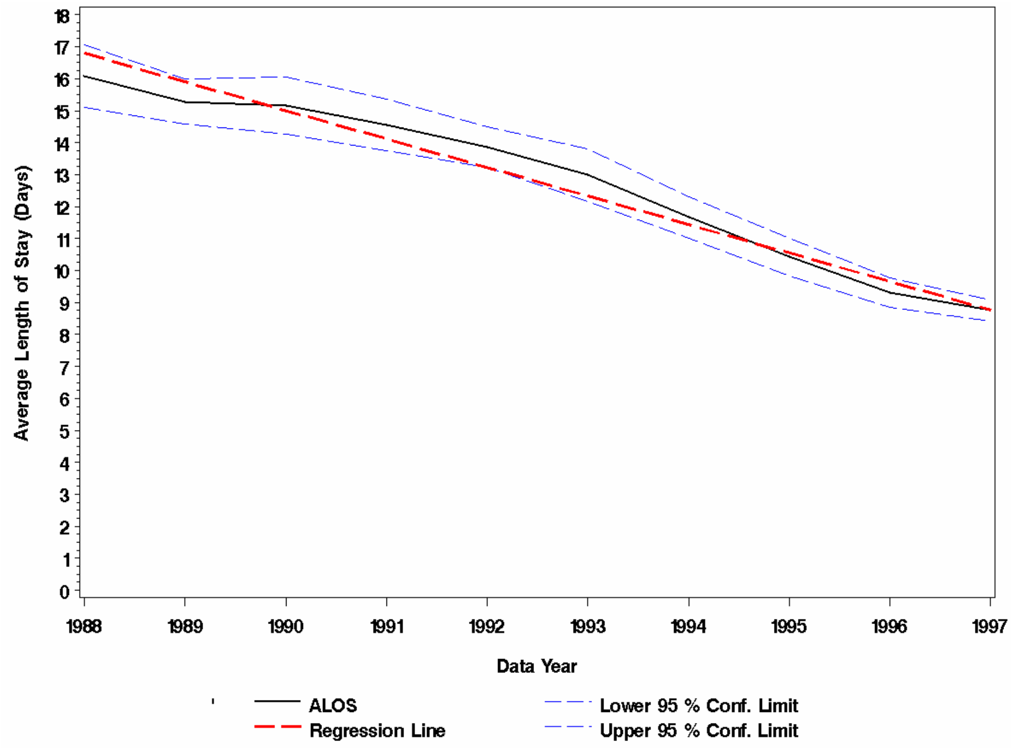


Figure 18: Trend in ALOS for Affective Disorders, 1988 – 1997 (NIS 10% Sample)

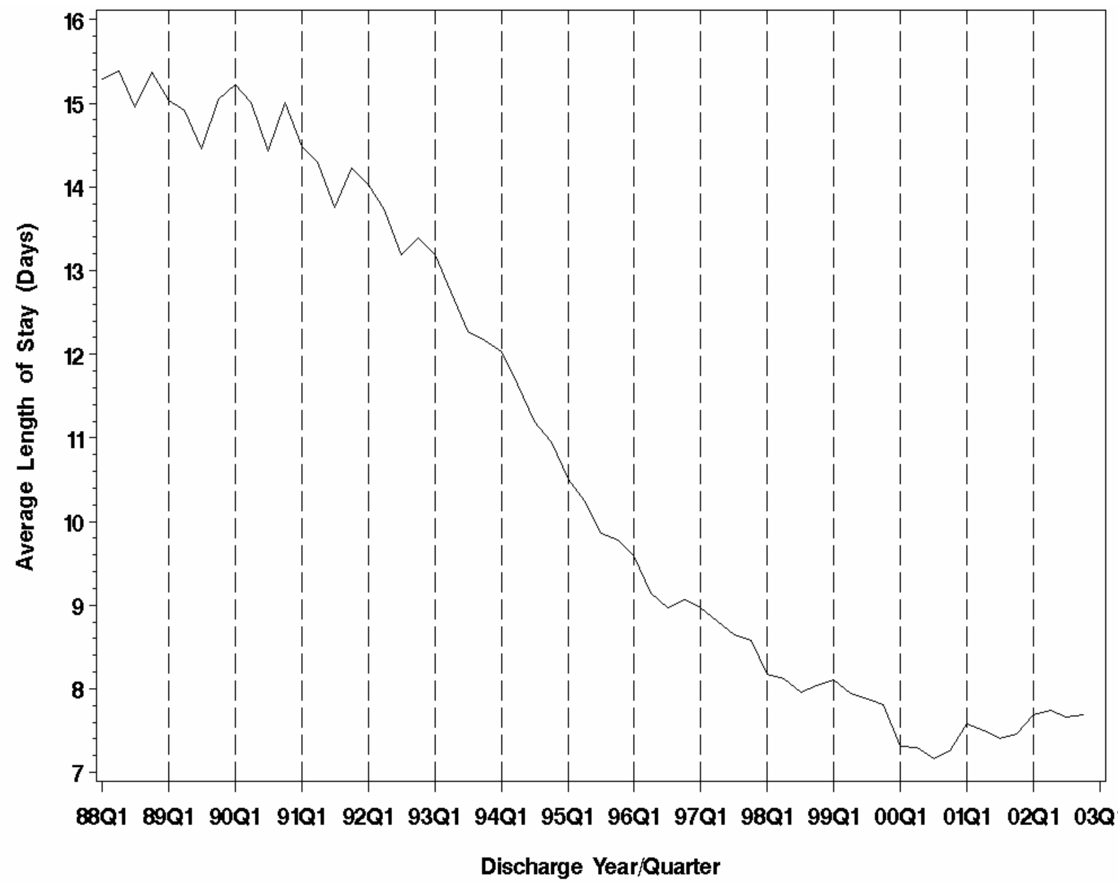


Examining Quarterly Trend Plots

Trend plots often reveal whether the trend is linear or nonlinear, whether there is seasonality, and whether there are any obvious outliers in the data.

Figure 19 plots the trend using quarterly averages. Between 1988 and 1993 we see a tendency for fourth quarter increases in ALOS. However, between 1993 and 2002 the within-year pattern in ALOS is weak or nonexistent. Therefore, we will analyze the annual trend beginning in 1993 (see Figure 16).

Figure 19: Quarterly ALOS Trend for Affective Disorders, NIS 1988 – 2002



Simple Regression for ALOS

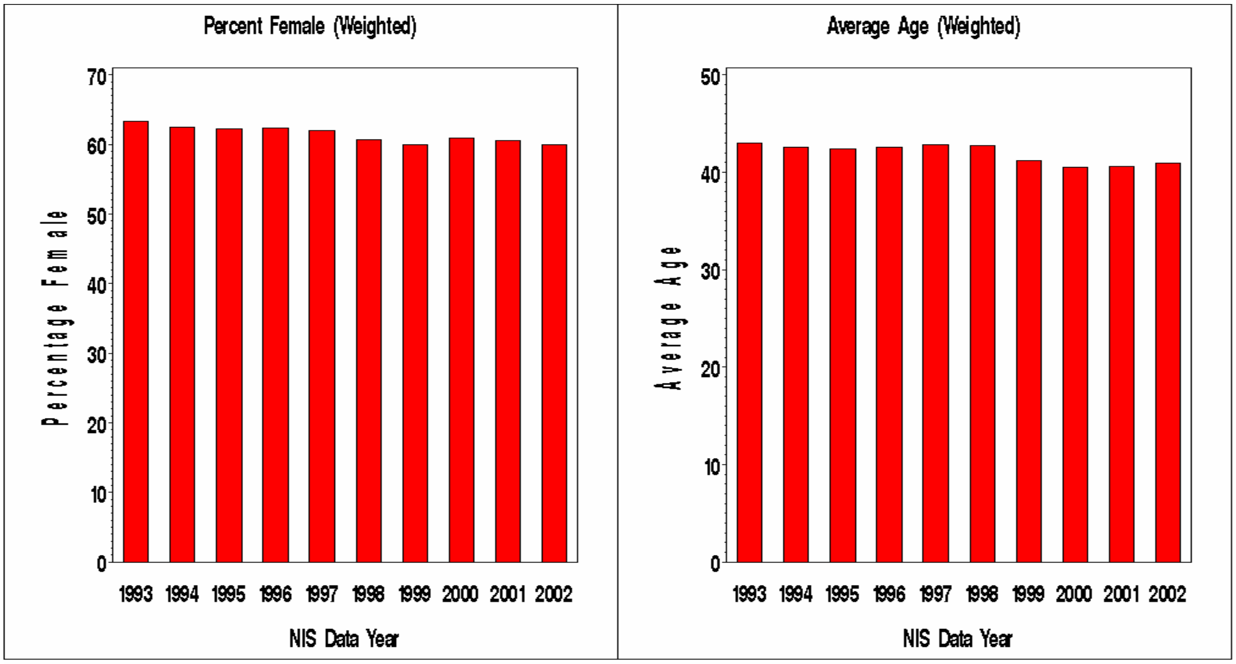
Simple linear regression is perhaps the least analytically demanding method for estimating trends. All statistical models are approximations. We suggest starting with simple models and then moving on to more complicated or sophisticated models only when the simpler models fail.

For illustration, we will use only three independent variables: age (0 – 124), sex (male or female), and year (1993 – 2002). Consequently, the model we fit omits important predictors. However, these three variables serve adequately for this example. Our goal will be to estimate the trend in ALOS conditional on age and sex. Our study period will be the 10-year period 1993 – 2002, consistent with our earlier recommendation to drop NIS years prior to 1993 for trend studies.

We recoded LOS values from 0 to 1 for discharges occurring on the same day as the admission. The minimum LOS in the sample was 1 day and the maximum LOS was 2,344 days (over 6 years). We eliminated as outliers all observations with a LOS over 180 days. Fewer than 0.02 percent of the observations were eliminated as result of this exclusion.

Ages ranged from 0 to 124. Over all 10 years, the average age was 42 and the median age was 39. Overall, females comprised 62 percent of the sample and males comprised the remaining 38 percent. The trends in the percentage of females and the average age are displayed in Figure 20. The percentage female and average age both declined slightly over the study period. Consequently, to the extent that the outcomes are related to age and sex, the trends might be partly explained by the trends in the age and sex distributions.

Figure 20: Sex and Age Trends for NIS Discharges with Affective Disorders, 1993 – 2002



To investigate, we examine plots showing the relationships over time between ALOS and the independent variables (age, sex, and region).

Figure 21 compares the ALOS trend between males and females, by region. The trends are similar in each region, with females tending to have slightly longer average lengths of stay compared to males. The ALOS trend is a little flatter in the West compared to other regions. In the Northeast, the ALOS abruptly rises in 1999 for both males and females.

Figure 22 displays the relationships between ALOS and age, by sex and region. We combined all 10 years of data. We used scatterplot smoothers to generate the line for this plot. The decline in ALOS for the very elderly is based on few cases. Nevertheless, perhaps elderly patients hospitalized for affective disorders tended to be discharged rather quickly to long-term care facilities.

The relationship between ALOS and age appear to be consistent over the four regions. There appears to be an interaction between sex and age, with ALOS lower for females compared to males at lower ages and with ALOS higher for females compared to males at higher ages. Further investigation reveals that these relationships also hold separately for each year in the study period (not shown). One thing is clear: the effect of age on ALOS is non-linear.

Figure 21: ALOS Trends, NIS Discharges with Affective Disorders, Males vs. Females, by Region

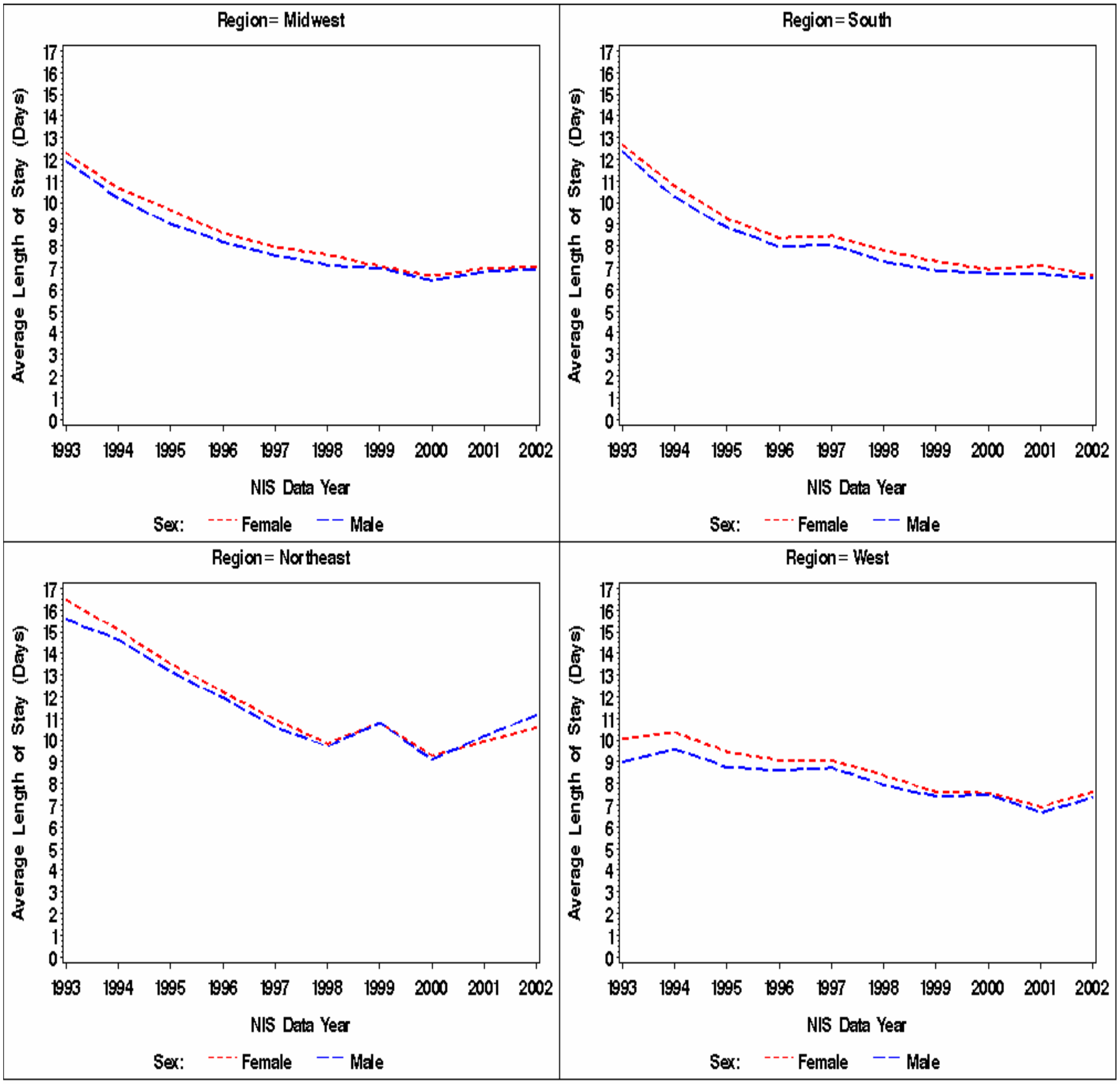
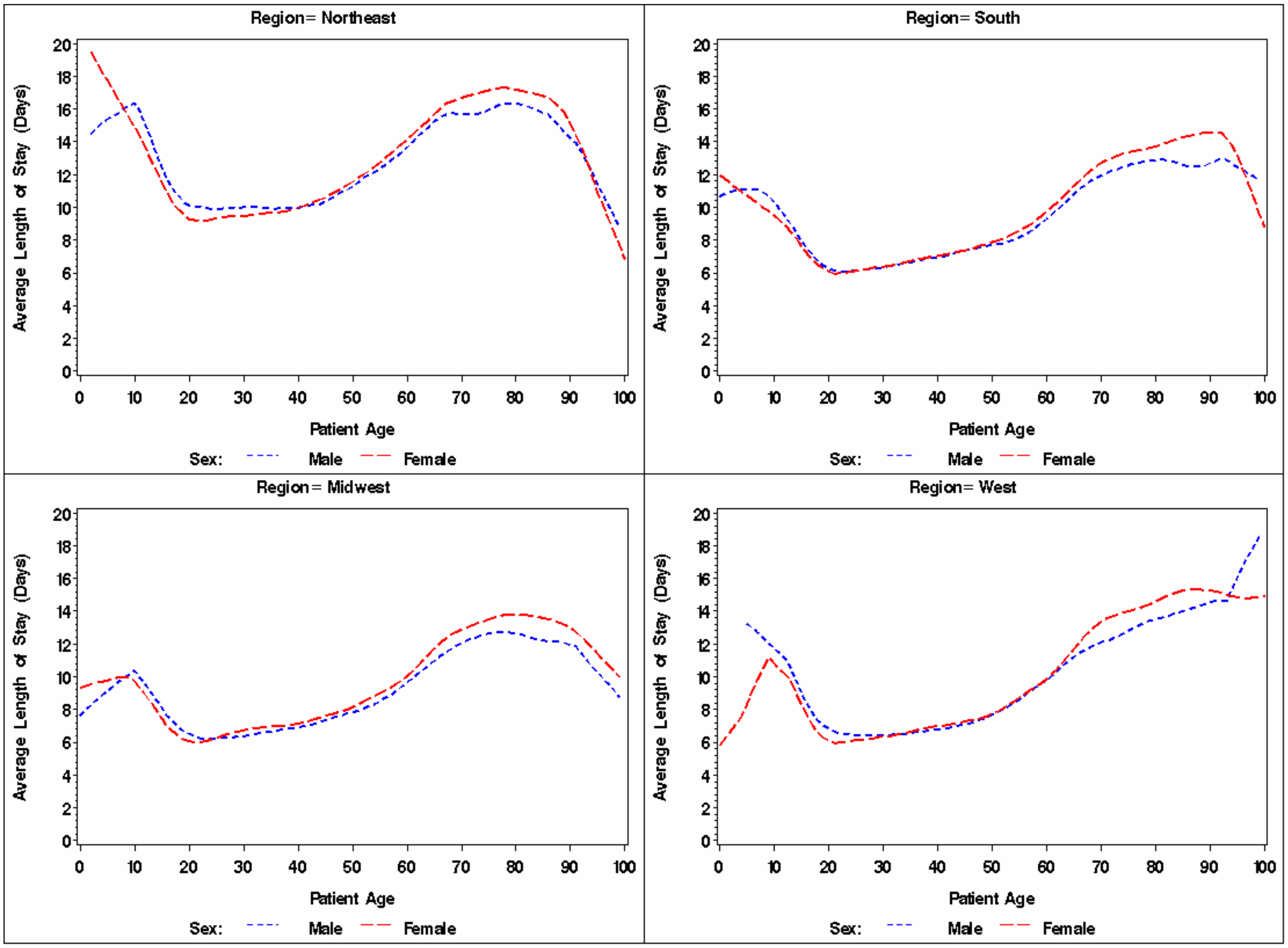


Figure 22: ALOS vs. Age, NIS Discharges with Affective Disorders, 1993 – 2002, Males vs. Females, by Region



The trend is slightly different for each of the regions. To keep it simple, we selected the West region to fit the following regression for affective disorders:

$$
\begin{aligned}
LOS_i = {} & \alpha + \beta_1 * (year_i - 1997) + \beta_2 * (year_i - 1997)^2 \\
& + \beta_3 * female_i + \beta_4 * age_i + \sum_{k=1}^{3} \lambda_k * age_{ik} \\
& + \beta_5 * female_i * (year_i - 1997) + \beta_6 * female_i * (year_i - 1997)^2 \\
& + \beta_7 * female_i * age_i + \sum_{k=1}^{3} \omega_k * female_i * age_{ik} + \varepsilon_i
\end{aligned}
$$

LOS_i is the observed length of stay for patient i in the West. The variable *female* is an indicator equal to one for females and zero for males. We used a restricted cubic spline for age (Harrell, 2001). Spline functions are useful for modeling nonlinear effects like those we see for age in Figure 22. For our spline, age is divided into intervals with endpoints at 18, 31, 41, 53, and 79 years. These five "knots" correspond to the 5th percentile, the 25th percentile, the 50th percentile, the 75th percentile, and the 95th percentile of age. A piecewise cubic polynomial is fit within each interval, except the tails, which are linear. The variables age1, age2, and age3 are terms for the age spline function and λ_1, λ_2, and λ_3 are the corresponding coefficients. We added an interaction term (sex by year) to test the possibility that the trend differs between males and females. We also added an interaction term (sex by age) to test the possibility that the age effects differ between males and females. The error terms are designated ε_i.

We estimated the parameters in this regression using four different methods:

1. REG – used the SAS procedure PROC REG without sample weights (each observation had a weight equal to one).
2. REG (Wt) – used the SAS procedure PROC REG with sample discharge weights.
3. SURVEYREG – used the SAS procedure PROC SURVEYREG with weights and taking into account the sample design effects (stratified cluster sampling).
4. REGRESS – used the SUDAAN procedure REGRESS with weights, sample design effects, and taking into account the effect of subsetting the analysis on a subdomain (affective disorder subgroup).

The resulting estimates are shown in Table 11. The coefficient estimates produced by the four procedures are fairly close in value. However, the survey procedures (SURVEYREG and REGRESS) produced quite different standard errors and t-statistics compared to the nonsurvey procedures (REG and REG(Wt)). The survey procedures generated higher estimates for the standard errors because they took into account the sample design. The SUDAAN procedure REGRESS tended to generate slightly higher standard errors than SAS SURVEYREG because it accounted for the fact that the affective disorder data comprised a subdomain or a subset of the NIS in the West region.

Figure 23 illustrates the estimated ALOS trend for a 40 year old males and females. The estimated trend is nearly linear for males, and slightly curve-linear for females. Figure 24 plots the estimated effects of age on ALOS for males and females. ALOS is U-shaped with respect to age, reaching a minimum near 30 years old. Under the age of 30, males tend to have longer lengths of stay compared to females. After the age of 30, males and females tend to have the similar lengths of stay.

Table 11: Estimated Regression Statistics, ALOS for Affective Disorders, NIS 1993 – 2002

Statistic	Procedure	Inter-cept α	*Year – 1997* β_1	*(Year – 1997)²* β_2	*Fem* β_3	*Age* β_4	*Fem Year* β_5	*Fem Year²* β_6	*Fem Age* β_7	*Age₁* λ_1	*Age₂* λ_2	*Age₃* λ_3	*Fem Age₁* ω_1	*Fem Age₂* ω_2	*Fem Age₃* ω_3
Coef-ficients	REG	11.829	-0.266	0.014	-1.845	-0.200	-0.088	0.020	0.058	1.247	-2.578	1.174	-0.221	0.565	-0.345
	REG (Wt)	11.498	-0.252	0.009	-1.692	-0.189	-0.098	0.020	0.055	1.195	-2.433	1.066	-0.225	0.615	-0.443
	SURVEYREG	11.511	-0.253	0.009	-1.686	-0.190	-0.098	0.020	0.054	1.194	-2.422	1.050	-0.221	0.602	-0.431
	REGRESS	11.710	-0.294	0.001	-1.846	-0.192	-0.057	0.025	0.056	1.147	-2.068	0.570	-0.176	0.279	0.012
Std. Errors	REG	0.299	0.014	0.005	0.386	0.013	0.017	0.006	0.017	0.115	0.411	0.477	0.148	0.526	0.606
	REG (Wt)	0.302	0.013	0.005	0.390	0.013	0.017	0.006	0.017	0.115	0.411	0.475	0.148	0.525	0.604
	SURVEYREG	0.811	0.052	0.018	0.687	0.032	0.023	0.008	0.027	0.222	0.707	0.726	0.201	0.675	0.743
	REGRESS	0.846	0.064	0.018	0.696	0.034	0.045	0.010	0.028	0.265	0.990	1.195	0.238	0.941	1.186
***t*-values**	REG	39.572	-19.432	3.004	-4.779	-15.519	-5.112	3.360	3.482	10.854	-6.278	2.462	-1.494	1.074	-0.569
	REG (Wt)	38.096	-18.794	2.013	-4.340	-14.599	-5.825	3.365	3.256	10.382	-5.926	2.244	-1.521	1.171	-0.733
	SURVEYREG	14.186	-4.843	0.507	-2.454	-6.021	-4.256	2.372	2.003	5.382	-3.426	1.447	-1.103	0.893	-0.580
	REGRESS	13.848	-4.563	0.074	-2.651	-5.738	-1.261	2.587	2.003	4.332	-2.090	0.477	-0.740	0.297	0.010
***p*-values**	REG	<.001	<.001	0.003	<.001	<.001	<.001	<.001	<.001	<.001	<.001	0.014	0.135	0.283	0.569
	REG (Wt)	<.001	<.001	0.044	<.001	<.001	<.001	<.001	<.001	<.001	<.001	0.025	0.128	0.242	0.463
	SURVEYREG	<.001	<.001	0.613	0.014	<.001	<.001	0.018	0.045	<.001	<.001	0.148	0.270	0.372	0.562
	REGRESS	<.001	<.001	0.941	0.008	<.001	0.208	0.010	0.045	<.001	0.037	0.633	0.459	0.766	0.992

Figure 23: Estimated ALOS Trend, Affective Disorders, West Region, For Discharges Age 40 Years

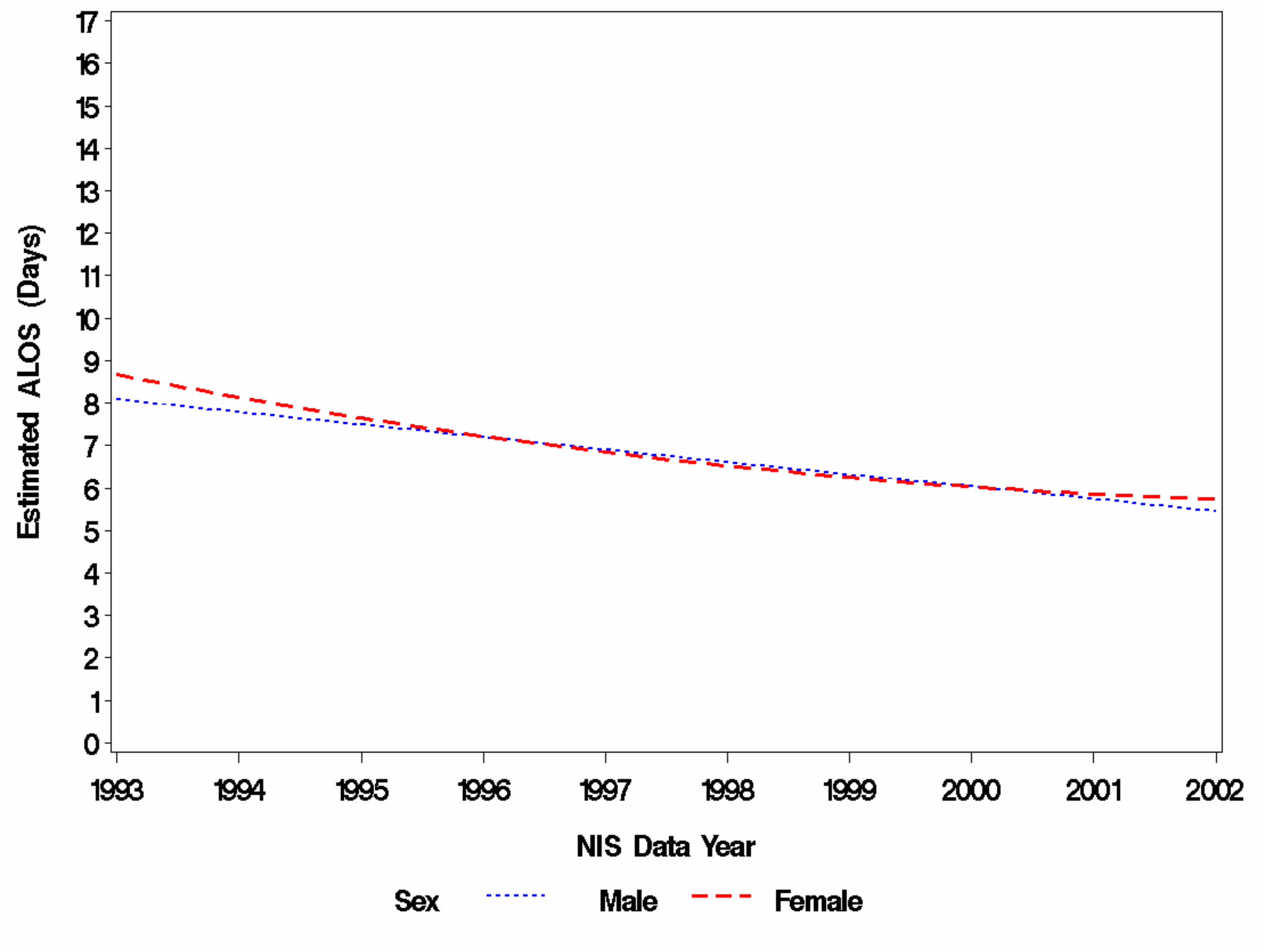
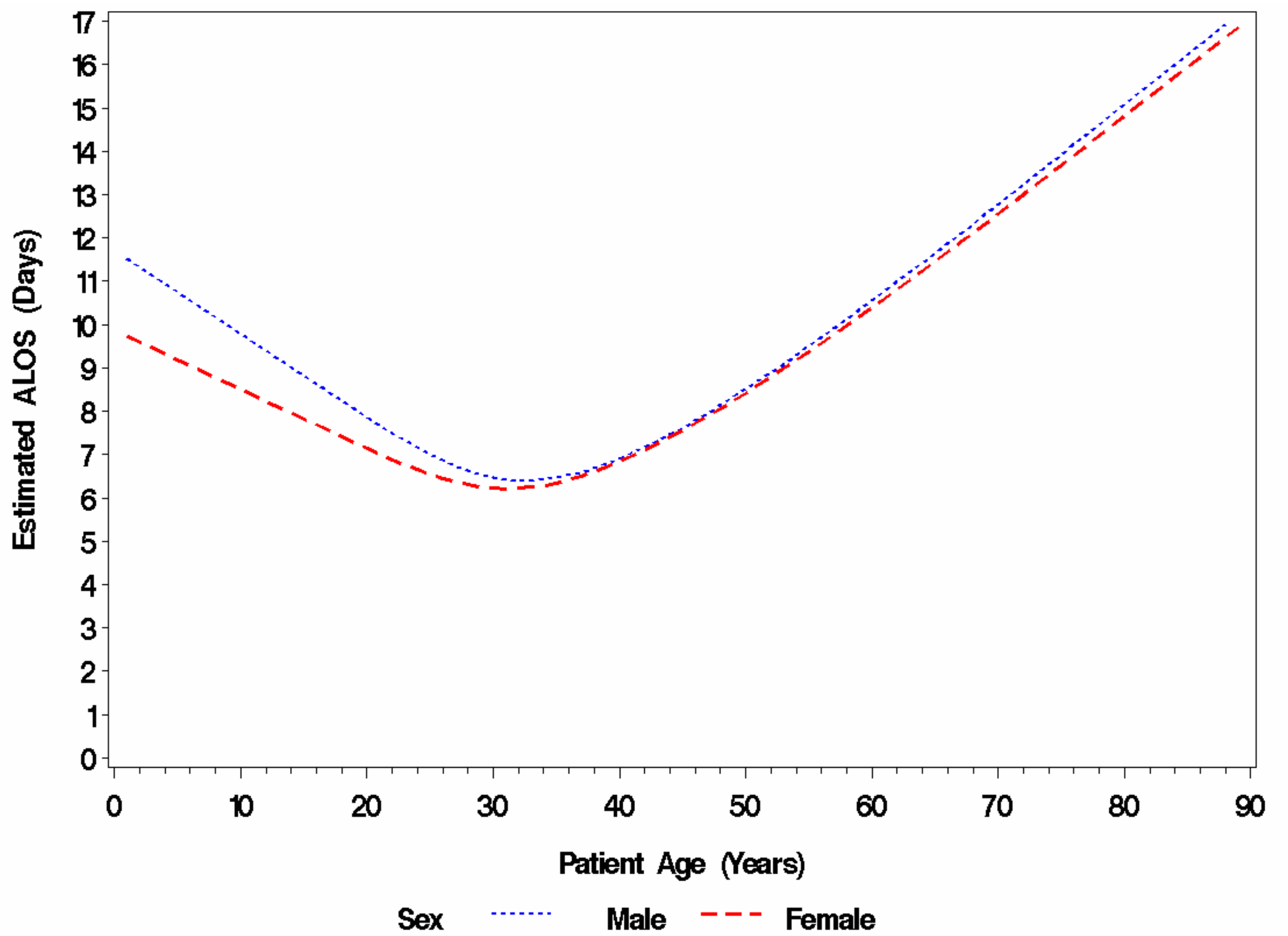


Figure 24: Estimated Effect of Age on ALOS, Affective Disorders, West Region



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