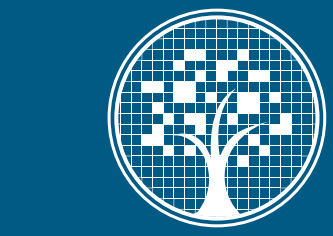

HEALTHCARE COST AND UTILIZATION PROJECT

HCUP Methods Series

Using the HCUP National Inpatient Sample to Estimate Trends (Revised 12/15/15)

Report # 2006-05

Agency for Healthcare Research and Quality

U.S. Department of Health and Human Services
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Recommended Citation: Houchens RL, Ross D, Elixhauser A. *Using the HCUP National Inpatient Sample to Estimate Trends*. 2015. HCUP Methods Series Report # 2006-05 ONLINE. January 4, 2016. U.S. Agency for Healthcare Research and Quality. Available: http://www.hcup-us.ahrq.gov/reports/methods/methods.jsp.

TABLE OF CONTENTS

INDEX OF TABLES

INDEX OF FIGURES

EXECUTIVE SUMMARY

The National (Nationwide) Inpatient Sample (NIS) is an annual database of hospital inpatient stays. The NIS is part of the Healthcare Cost and Utilization Project (HCUP), which is sponsored by the Agency for Healthcare Research and Quality (AHRQ). Researchers and policymakers use the NIS to identify, track, and analyze national trends in health care utilization, access, charges, quality, and outcomes. This report is intended to aid analysts who wish to estimate trends or conduct other analyses using multiple years of the NIS. Several revisions were made to the 1998 and 2012 NIS sample designs, and analysts who want to use the NIS to estimate trends in patient and hospital outcomes may need to adjust for these changes. In this report we enumerate the important revisions to the NIS sample design between 1988 and 2012, suggest ways to manage these changes, and offer advice on statistical methods that may be useful for investigating trends. In addition, we refer to the 1993–2011 NIS Trend Weights, which can be used to adjust for the effects of the redesign on estimated trends that cross the 1998 or 2012 data year. [1]

The NIS contains all-payer data on hospital inpatient stays from States participating in HCUP. Prior to the 2012 NIS, the NIS included *all* discharges from a stratified sample of approximately 20 percent of U.S. community hospitals. Beginning with the 2012 NIS, the NIS includes a stratified sample of approximately 20 percent of discharges from all U.S. community hospitals. Table 1 of the Introduction 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 2013.

Since its inception several revisions have been made to the NIS sample design that affect estimates calculated from the NIS. 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 that these changes have on estimates of numbers of discharges and other key variables, and contains recommendations for handling these and other issues when doing trend analyses.

The following changes affected the NIS over time:

- Changes in States in the sampling frame. 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 2012 NIS was drawn from a frame of 44 States representing 96 percent of the U.S. population.
- Changes in sample design 1998.
    - Excluded short-term rehabilitation hospitals from the target universe.
    - Changed the method for estimating discharges in the universe.
    - Discontinued the preference for NIS hospitals that were in the sample in prior years.
    - Redefined the hospital stratification variables for sampling.
- Changes in sample design in 2012.
    - Excluded long-term acute care hospitals from the target universe.
    - Defined hospital entities on the basis of SID identifiers for hospitals in the frame.
    - Calculated discharge weights on the basis of SID discharge counts rather than AHA survey discharge counts for hospitals in the frame.

[1] For trend analyses, we do not recommend using NIS data prior to 1993.

    - Drew a sample of discharges from all frame hospitals rather than from all discharges within a sample of frame hospitals.
    - Stratified the sample using the nine census divisions rather than the four census regions.
- Changes in data element names and values. For example, diagnosis codes, procedure codes, and diagnosis-related groups changed annually. In addition, beginning with the 2012 NIS, data elements on the NIS were restricted to those available from all participating states and certain data elements such as State were no longer included.

Those issues with the greatest impact on estimates are summarized below. (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.

States Added to or Subtracted From the Sampling Frame. Perhaps the most significant change to the NIS over time involved the list of States in the sampling frame. As shown in Table 1 below, States were frequently added to the sampling frame although others were deleted, usually temporarily. Consequently, the NIS increasingly covers a greater percentage of the hospital discharge population, which makes this database increasingly representative through the years. ***On the basis of these considerations of coverage, we recommend that trend analyses begin no earlier than 1993.*** The six States that were added to the NIS in the 1993 data year, including New York, tipped the sampling frame over the 50 percent mark in terms of population covered. In recent years of the NIS, the sampling frame covers 95 percent of the U.S. population.

1998 NIS Changed the Method for Estimating Discharges in the Universe. One of the most important changes to the 1998 NIS sample design was the change from the use of AHA-reported *total* discharges to the use of AHA-reported *hospital* discharges to estimate NIS discharge weights. The number of total discharges often was greater than the number of hospital discharges because it included patients from units such as skilled nursing facilities and long-term rehabilitation. Consequently, the NIS sample discharge weights used from 1993 through 1997 tended to be larger than the weights used from 1998 through 2011. ***This definitional change caused a "discontinuity" between 1997 and 1998 in estimates of trends in totals, such as total discharges, which can be corrected using trend weights available on the HCUP Web site*** **(https://www.hcup-us.ahrq.gov/db/nation/nis/trendwghts.jsp).** Importantly, this discontinuity had little effect on the estimated trends of means and rates with discharges as the denominators.

1998 NIS Redefined the Hospital Stratification Variables for Sampling. The NIS hospital stratification scheme also was altered beginning with the 1998 data year. We found that these changes to strata definitions had 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 did not allow the release of hospital identifiers, and providing stratum definitions that were consistent across time could have resulted in the identification of specific institutions. Therefore, ***analysts must acknowledge the potential impact of such changes on their conclusions, or they must find another method for consistently defining hospital characteristics over time.*** For example, hospital size could be measured in terms of total discharges instead of total beds.

2012 NIS Excluded Long-term acute care Hospitals. Long-term acute care hospitals were excluded from the hospital universe and sampling frame in 2012 because their inclusion in the sampling frame was inconsistent across States. This modification resulted in an estimated 0.7 percent overall decline in the estimated number of discharges nationally. The removal of long-term acute care hospitals also decreased estimates for average lengths of stay by 1.5 percent, average charges by 0.7 percent, and hospital mortality by 2.0 percent (from an overall mortality rate of 1.91 percentage points to 1.87 percentage points). All of these changes were expected given the characteristics of patients in long-term acute care hospitals.

2012 NIS Calculated Discharge Weights on the Basis of SID Discharge Counts. NIS sample discharge weights are calculated by dividing the estimated number of universe discharges by the number of sampled discharges within each hospital stratum. Prior to the 2012 NIS, the number of universe discharges had been estimated solely on the basis of data from the AHA annual hospital survey. In particular, the total number of discharges in the universe was estimated by the sum of births and admissions contained in the AHA annual survey for all hospitals in the universe. However, AHRQ analysts and HCUP contributors now consider the observed SID discharge counts to be more accurate than estimated AHA discharge counts. Therefore, given that HCUP Partners now supply over 95 percent of discharges nationwide, in 2012 we began using the actual count of discharges contained in HCUP data to estimate the count of discharges in the universe within each stratum; and we used adjusted AHA counts for non-HCUP hospitals. This change resulted in about a 4 percent decline between 2011 and 2012 in the estimate of discharges in the universe. Although the effects of this change were substantial for estimates of discharge counts, the effects were negligible for estimates of means and rates. ***Use of the trend weights file available on the HCUP Web site (https://www.hcup-us.ahrq.gov/db/nation/nis/trendwghts.jsp) will compensate for this change.***

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 renamed *DISCWT* in later files (1998 onward). Such alterations are handled easily with simple programming statements. Second, ICD-9-CM diagnosis and procedure codes have changed annually to account for new diseases and treatments. These changes can make it difficult to classify patients consistently over time. A conversion table that maps code changes between 1986 and later years is available online (http://www.cdc.gov/nchs/icd/icd9cm_addenda_guidelines.htm). ***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, which is available on their Web site (http://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp). However, 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.

NIS 1993–2011 Trend Weights Adjust for Design Changes. To adjust for changes to the NIS design in 1998 and 2012, ***we recommend that users employ "trend" discharge weights for 1993–2011 NIS files to minimize the effects of the redesign on estimated trends that cross the 1998 or 2012 data year.*** For years prior to 2012, the trend weight (*TRENDWT*) should be used in place of the original discharge weight (*DISCWT*) to create national estimates for trend analysis that are consistent with 2012 data onward. The new trend weights are available for download (https://www.hcup-us.ahrq.gov/db/nation/nis/trendwghts.jsp) page on the HCUP-US Web site.

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 ignore the sampling design might be acceptable for point estimates. However, estimates of standard errors will likely be too small, which could lead to incorrect inferences concerning statistical significance and reliability.

Tools available on the HCUP Web site are designed to aid researchers in using the NIS for trend analysis (http://www.hcup-us.ahrq.gov/db/nation/nis/nistrends.jsp). The 1993-2002 Nationwide Inpatient Sample (NIS) Supplemental Discharge-Level File provides additional data elements that were added for NIS data years through 2002. The 1993-2011 Trend Weight File facilitates analysis using multiple years of NIS data by providing new discharge weights.

INTRODUCTION

The National (Nationwide) Inpatient Sample (NIS) is an annual database of hospital inpatient stays. The NIS is part of the Healthcare Cost and Utilization Project (HCUP), which is sponsored by the Agency for Healthcare Research and Quality (AHRQ). Researchers and policymakers use the NIS to identify, track, and analyze national trends in health care utilization, access, charges, quality, and outcomes. The NIS has been available since the 1988 data year.

This report is intended to aid analysts who wish to estimate trends or conduct other analyses using multiple years of the NIS. Several changes have occurred over time that should be taken into account in most trend analyses:

1. 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 2012 NIS was drawn from a frame of 44 States representing 96 percent of the U.S. population.
2. Beginning with the 1998 data year, NIS sampling methods changed to provide a better reflection of the cross-sectional population of hospitals and discharges. The hospital stratification variables were redefined, rehabilitation facilities were dropped from the target universe, and sampling preference was no longer given to NIS hospitals that were in the sample in prior years.
3. Beginning with the 2012 data year, the sampling unit became discharges rather than hospitals, the sample was stratified by nine census divisions rather than four census regions, long-term acute care facilities were dropped from the target universe, hospital entities were defined by hospital identifiers in HCUP State Inpatient Databases (SID) rather than identifiers reported by the annual American Hospital Association (AHA survey, and discharge weights were calculated on the basis of SID discharge counts rather than counts reported by the AHA survey.
4. The definitions and availability of NIS database variables changed over time. For example, diagnosis codes, procedure codes, and diagnosis-related groups changed annually. In addition, beginning with the 2012 NIS, data elements on the NIS were restricted to those available from all participating states and certain data elements such as State were no longer included.

Analysts who want to use the NIS to estimate trends in patient and hospital outcomes may need to adjust for these changes. At a minimum, analysts need to keep these changes in mind as potential confounders in explaining trends. In this report we enumerate the important revisions to the NIS sample design between 1988 and 2012, suggest ways to manage these changes, and offer advice on statistical methods that may be useful for investigating trends. In addition, we refer to the 1993–2011 NIS Trend Weights Files and the 1993–2002 NIS Supplemental Discharge-Level Files. These files provide trends weights and data elements that are defined consistently through 2002 and are intended to simplify trend analysis using the NIS.

HISTORICAL OVERVIEW OF THE NIS

The NIS contains all-payer data on hospital inpatient stays from States participating in HCUP. Each year the NIS provides information on 5 to 8 million discharges. Table 1 shows the participating States, the percentage of the U.S. population covered by these States, the number of hospitals, and the number of discharges for each NIS year. Prior to 2012, the NIS included

all discharges from a sample of as many as 1,056 hospitals (2008 NIS). Beginning in 2012, the NIS included a sample of discharges from all hospitals in the sampling frame (4,378 hospitals, 2012 NIS).

Table 1. National (Nationwide) Inpatient Sample States in the Sampling Frame, 1988–2013

				2012 Redesign		1998 Design	
Year	NIS States	Number of NIS States	U.S. Population Covered, %	Number of NIS Hospitals	Number of NIS Discharges	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, CA, CO, FL, IL, IA, MA, NJ, PA, WA, WI	11	40			882	6,067,667
1990	AZ, CA, CO, FL, IL, IA, MA, NJ, PA, WA, WI	11	40			871	6,156,638
1991	AZ, CA, CO, FL, IL, IA, MA, NJ, PA, WA, WI	11	40			859	5,984,270
1992	AZ, CA, CO, FL, IL, IA, MA, NJ, PA, WA, WI	11	40			856	6,008,001
1993	AZ, CA, CO, CT, FL, IA, IL, KS, MA, MD, NJ, NY, OR, PA, SC, WA, WI	17	54	902	6,529,283	913	6,538,976
1994	AZ, CA, CO, CT, FL, IA, IL, KS, MA, MD, NJ, NY, OR, PA, SC, WA, WI	17	54	894	6,375,443	904	6,385,011
1995	AZ, CA, CO, CT, FL, IA, IL, KS, MA, MD, MO, NJ, NY, OR, PA, SC, TN, WA, WI	19	58	925	6,699,089	938	6,714,935
1996	AZ, CA, CO, CT, FL, IA, IL, KS, MA, MD, MO, NJ, NY, OR, PA, SC, TN, WA, WI	19	58	896	6,528,449	906	6,542,069
1997	AZ, CA, CO, CT, FL, GA, HI, IA, IL, KS, MA, MD, MO, NJ, NY, OR, PA, SC, TN, UT, WA, WI	22	62	997	7,129,491	1,012	7,148,420
1998	AZ, CA, CO, CT, FL, GA, HI, IA, IL, KS, MA, MD, MO, NJ, NY, OR, PA, SC, TN, UT, WA, WI	22	62	984	6,827,350	984	6,827,350
1999	AZ, CA, CO, CT, FL, GA, HI, IA, IL, KS, MA, MD, ME, MO, NJ, NY, OR, PA, SC, TN, UT, VA, WA, WI	24	64	984	7,198,929	984	7,198,929
2000	AZ, CA, CO, CT, FL, GA, HI, IA, IL, KS, KY, MA, MD, ME, MO, NC, NJ, NY, OR, PA, SC, TN, TX, UT, VA, WA, WI, WV	28	77	994	7,450,992	994	7,450,992
2001	AZ, CA, CO, CT, FL, GA, HI, IA, IL, KS, KY, MA, MD, ME, MI, MN, MO, NC, NE, NJ, NY, OR, PA, RI, SC, TN, TX, UT, VA, VT, WA, WI, WV	33	84	986	7,452,727	986	7,452,727
2002	CA, CO, CT, FL, GA, HI, IA, IL, KS, KY, MA, MD, ME, MI, MN, MO, NC, NE, NJ, NV, NY, OH, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV	35	87	980	7,846,038	995	7,853,982
2003	AZ, CA, CO, CT, FL, GA, HI, IA, IL, IN, KS, KY, MA, MD, MI, MN, MO, NC, NE, NH, NJ, NV, NY, OH, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV	37	91	984	7,971,043	994	7,977,728
2004	AR, AZ, CA, CO, CT, FL, GA, HI, IA, IL, IN, KS, KY, MA, MD, MI, MN, MO, NC, NE, NH, NJ, NV, NY, OH, OR, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV	37	88	983	7,992,257	1,004	8,004,571
2005	AR, AZ, CA, CO, CT, FL, GA, HI, IA, IL, IN, KS, KY, MA, MD, MI, MN, MO, NC, NE, NH, NJ, NV, NY, OH, OK, OR, RI, SC, SD, TN, TX, UT, VT, WA, WI, WV	37	86	1,018	7,974,844	1,054	7,995,048
2006	AR, AZ, CA, CO, CT, FL, GA, HI, IA, IL, IN, KS, KY, MA, MD, MI, MN, MO, NC, NE, NH, NJ, NV, NY, OH, OK, OR, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV	38	89	993	8,041,841	1,045	8,074,825

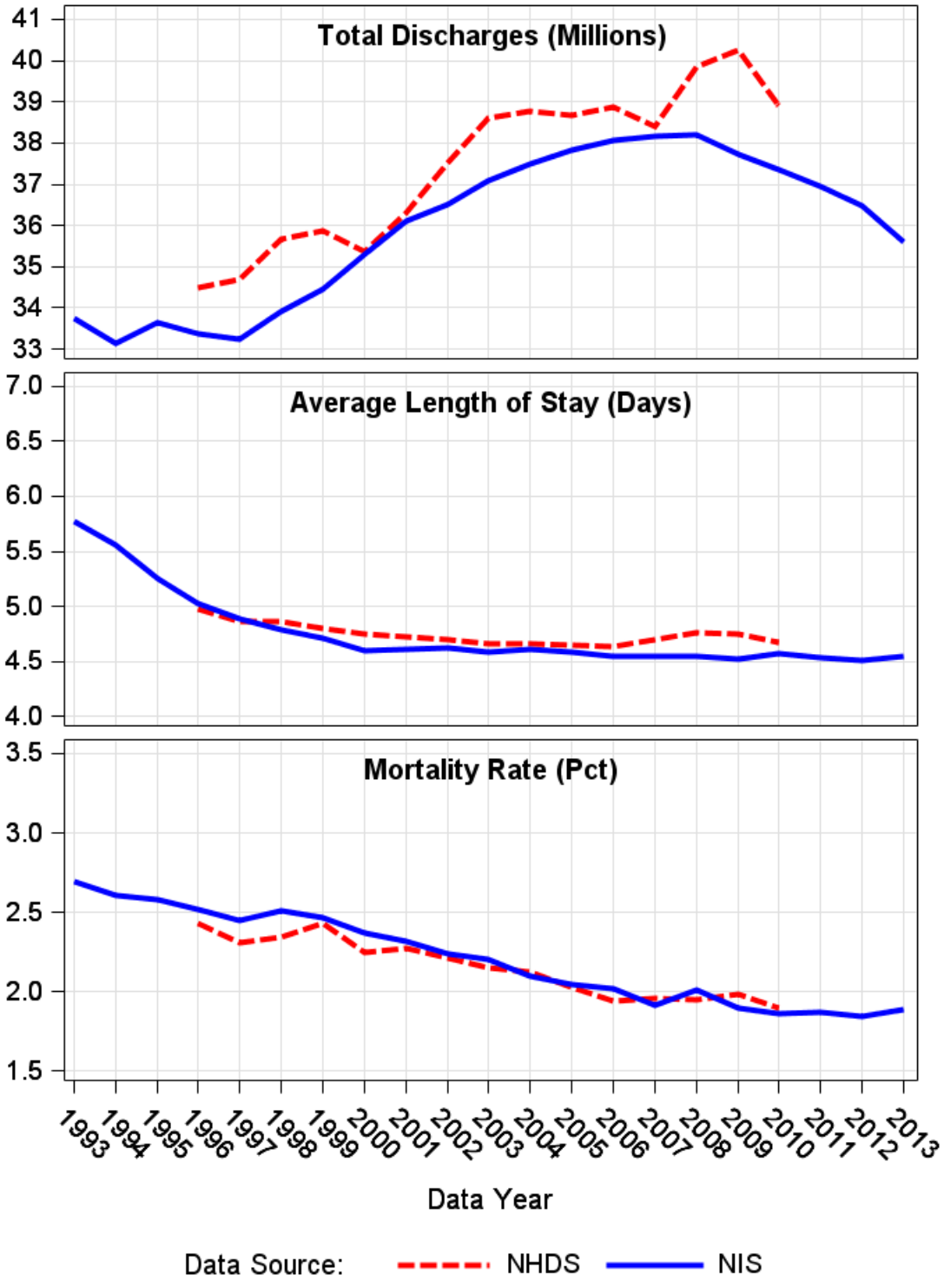
				2012 Redesign		1998 Design	
Year	NIS States	Number of NIS States	U.S. Population Covered, %	Number of NIS Hospitals	Number of NIS Discharges	Number of NIS Hospitals	Number of NIS Discharges
2007	AR, AZ, CA, CO, CT, FL, GA, HI, IA, IL, IN, KS, KY, MA, MD, ME, MI, MN, MO, NC, NE, NH, NJ, NV, NY, OH, OK, OR, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY	40	90	999	8,024,448	1,044	8,043,415
2008	AR, AZ, CA, CO, CT, FL, GA, HI, IA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, NC, NE, NH, NJ, NV, NY, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY	42	95	1,011	8,138,741	1,056	8,158,381
2009	AR, AZ, CA, CO, CT, FL, GA, HI, IA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MT, NC, NE, NH, NJ, NM, NV, NY, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY	44	96	996	7,741,390	1,050	7,810,762
2010	AK, AR, AZ, CA, CO, CT, FL, GA, HI, IA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, MT, NC, NE, NJ, NM, NV, NY, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY	44	96	969	7,678,418	1,051	7,800,441
2011	AK, AR, AZ, CA, CO, CT, FL, GA, HI, IA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NJ, NM, NV, NY, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY	45	96	971	7,893,587	1,049	8,023,590
2012	AK, AR, AZ, CA, CO, CT, FL, GA, HI, IA, IL, IN, KS, KY, LA, MA, MD, MI, MN, MO, MT, NC, ND, NE, NJ, NM, NV, NY, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY	44	96	4,378	7,296,968		
2013	AR, AZ, CA, CO, CT, DC, FL, GA, HI, IA, IL, IN, KS, KY, LA, MA, MD, MI, MN, MO, MT, NC, ND, NE, NJ, NM, NV, NY, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY	44	96	4,363	7,119,563		
				27,207	155,910,891	23,190	171,461,632

Abbreviation: NIS, National (Nationwide) Inpatient Sample

To facilitate the production of national estimates discharge weights are provided for each of the NIS databases along with the information needed 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 shows that the trends in total discharges, average length of stay (ALOS), and in-hospital mortality rate estimated from the NIS are similar to those estimated from available years of the National Hospital Discharge Survey.[2]

[2] Also see the NIS Comparison Reports available as Methods Series Reports on the HCUP web site: http://www.hcup-us.ahrq.gov/reports/methods/methods_topic.jsp#nis

Figure 1. Trends in Estimated Total Discharges, ALOS, and In-Hospital Mortality Rate, NIS Versus NHDS, 1993–2013



Abbreviations: ALOS, average length of stay; NHDS, National Hospital Discharge Survey; NIS, National (Nationwide) Inpatient Sample; Pct, Percentage

Each NIS record contains the patient-level clinical and resource use information that is included in a typical discharge abstract. Prior to 2012, NIS records for States that allowed the release of hospital identifiers 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's Bureau of Health Professions Area Health Resource File, and to ZIP Code–level data from the U.S. Census Bureau or private vendors. (County and ZIP Code information pertains to the hospital, not to the individual discharges.) Beginning with the 2012 NIS, hospital identifiers were removed from the NIS.

The NIS is designed to approximate a 20 percent sample of discharges from U.S. community hospitals, defined by the AHA to be "all nonfederal, short-term, general, and other specialty hospitals, excluding hospital units of institutions." Community hospitals include public hospitals and academic medical centers as well as specialty hospitals such as orthopedic, pediatric, obstetrics-gynecology, and ear-nose-throat institutions. Facilities that are excluded include short-term rehabilitation hospitals (beginning in 1998), long-term acute care hospitals (beginning in 2012), psychiatric hospitals, and alcoholism/chemical dependency treatment facilities. However, rehabilitation, psychiatric, and substance abuse discharges from community hospitals are included.

Prior to 2012, the NIS was a stratified probability sample of hospitals in the frame, with sampling probabilities resulting in 20 percent of the U.S. community hospitals in each stratum. Beginning in 2012, the NIS was a stratified systematic random sample of patients with sampling probabilities resulting in 20 percent of the patients in each stratum. The 2012 sampling frame was limited by the availability of inpatient data from the data sources. The sampling strata were based on five hospital characteristics obtained from the AHA annual survey each year: ownership/control, bed size, teaching status, urban/rural location, and U.S. Census Bureau region or division.

To improve the representativeness of the NIS, the sampling and weighting strategy was modified twice—first with the 1998 NIS and later with the 2012 NIS. This change is especially important for trend analyses that include 1997 and 1998 data or 2011 and 2012 data, because these design changes might be confounded with other changes between those years. Full descriptions of these changes can be found in special reports (Houchens, Elixhauser, Sommers, 2002; Houchens, Ross, Elixhauser, et al., 2014), which are available on the HCUP User Support Web site (Houchens, Elixhauser, Sommers, 2002, Houchens, Ross, Elixhauser, et al. 2014).

A brief discussion of the 1998 and 2012 sampling and weighting modifications is provided below.

Zero-Weight Hospitals

Prior to 1992, hospitals that resulted from a split or a merger involving one or more NIS sample hospitals were added to the NIS file to enhance researchers' ability to study the effects of such splits and mergers. However, unless those hospitals were selected as a part of the regular NIS sample, they were assigned a sampling weight of zero. Also, NIS hospitals that closed (according to the AHA) were retained in the NIS file but were assigned a sample weight of zero if they were not selected for the regular NIS sample in the year that they closed.

Beginning in 1993, we stopped including these zero-weight hospitals in the NIS. Unless a study is concerned with hospital splits and mergers occurring 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 and therefore have no effect on weighted estimates. We excluded all discharges from zero-weight hospitals for the analyses in this report.

Longitudinal Cohort (1988-1998)

To maintain a longitudinal cohort, the pre-1998 sampling plan ensured that hospitals drawn for the sample in 1 year had a high probability of being drawn for the sample in the following year. This method 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 resulted in certain cross-sectional biases in 1 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 shifted the average for some variables only slightly and tended to increase variation around the estimated mean.

Stratification Variables (1998 and 2012)

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 United States). 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 HCUP hospitals in the Northeast and West, which 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 ALOSs 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 (i.e., 4 regions × 3 ownership categories × 3 location/teaching categories × 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 step reduced the potential number of NIS strata from 108 to 60.

The only change to the stratification for 2012 was to stratify hospitals by the nine census divisions rather than the four census regions. This resulted in 196 strata for the 2012 NIS.

Redefining the bed size strata (1998). One reason for small cell sizes 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 urban teaching hospitals located in the West were designated as "large" hospitals (500+ beds). In contrast, about 33 percent of urban teaching hospitals located in the South were designated as large hospitals. Consequently, we redefined small, medium, and large bed size categories nested within both the region and location/teaching categories to ensure that approximately one-third of the hospitals would be allocated to each bed size category.

Redefining the ownership strata (1998). 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 was 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 nonteaching 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 hospital strata (1998). Finally, beginning in 1998, we redefined teaching hospitals. Prior to 1998, a hospital was designated as a teaching hospital only if it had interns or residents and either was a member of the Council of Teaching Hospitals and Health Systems or had a residency program that was approved by the American Medical Association. The new definition still defined these hospitals as teaching hospitals, but it also included hospitals that had a ratio of interns and residents to beds of 0.25 or higher. This intern-to-bed ratio was similar to the definition of teaching hospitals used by the Centers for Medicare & Medicaid Services (CMS).

Elimination of Rehabilitation Hospitals (1998)

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 ALOSs than patients in other types of community hospitals. (Long-term rehabilitation hospitals have 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).

Elimination of Long-Term Acute Care Hospitals (2012)

Long-term acute care hospitals are classified as community hospitals by the AHA if they have an ALOS of fewer than 30 days. However, during the most recent analyses, we determined that this variable was not uniformly available from all States participating in HCUP, and the ALOS of long-term acute care hospitals was over 25 days (compared with 4.5 days for other community hospitals). Thus, long-term acute care hospitals were eliminated beginning with the 2012 NIS.

Changes to Counts of Discharges in the Universe (1998 and 2012)

Prior to 1998, we calculated the number of discharges in the universe as the sum of births and *total facility discharges* 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 hospital discharges, a number that is more consistent with the number of discharges provided by the

State data sources. However, we substituted total facility discharges if the number of hospital discharges was missing.

Beginning in 2012, we estimated the universe count of discharges within each stratum using the actual number of discharges contained in HCUP data. We used the AHA counts only for non-HCUP hospitals in the universe. There were several reasons for switching to the HCUP count of discharges:

- In 2012, the actual count of discharges was available from a sampling frame that covered 96 percent of the population. Earlier years represented a much smaller percentage of the population for which actual discharge counts were available.
- Beginning in 1994, the AHA survey asked for the count of *admissions* rather than the count of *discharges*. The State Inpatient Databases (SID) yield *discharge* counts, and NIS inferences are intended for the universe of *discharges* rather than admissions.
- The estimate of discharges from the AHA survey is the sum of reported admissions and reported births. Summing these two values results in a double count of newborns in neonatal intensive care units (NICUs) because they appear in births as well as in admissions. We estimated that this resulted in an overcount of approximately 0.5 percent for the universe of discharges.
- Compared with SID data, AHA survey admission counts may include long-term care and swing bed admissions more frequently. Using supplemental 2010 data from the Illinois Department of Public Health, we confirmed that the AHA survey count for Illinois included long-term and swing bed admissions, whereas the HCUP SID data for Illinois did not. The SID discharge count agrees with counts from the health department's data after the double counts of newborns in NICUs and the long-term care and swing bed admissions are eliminated. Although these results were for Illinois, we assume that this finding applies to many other states as well.
- More than 50 percent of AHA respondents report statistics for fiscal years, which often end in June or September, rather than for calendar years. The SID files used for the NIS always span a calendar year for each hospital. Although the totals are likely be similar, there would be some difference between fiscal year and calendar year discharge totals.
- AHA survey admission counts are missing approximately 17 percent of the time, and the AHA uses an undocumented regression equation to impute admission counts for these missing values.
- In a survey of HCUP Partners, most of the respondents stated that they believe that the SID data provide more reliable discharge counts than those contained in the AHA survey data.

Use of State Hospital Identifiers Rather Than AHA Hospital Identifiers (2012)

A logical corollary of switching from AHA discharge estimates to SID discharge counts was that we could distinguish unique hospitals using the SID hospital identifiers rather than the AHA hospital identifiers. For the vast majority of hospitals, the SID hospital identifiers have a one-to-one correspondence with the AHA hospital identifiers. However, about 10 percent of the AHA identifiers actually correspond to two or more hospitals in the SID that have common ownership within a hospital system. The numbers of estimated discharges and hospital beds under these single AHA hospital identifiers represent the sums of discharges and beds, respectively, for all of the hospitals that are combined under a given identifier. As a result, some or all of these

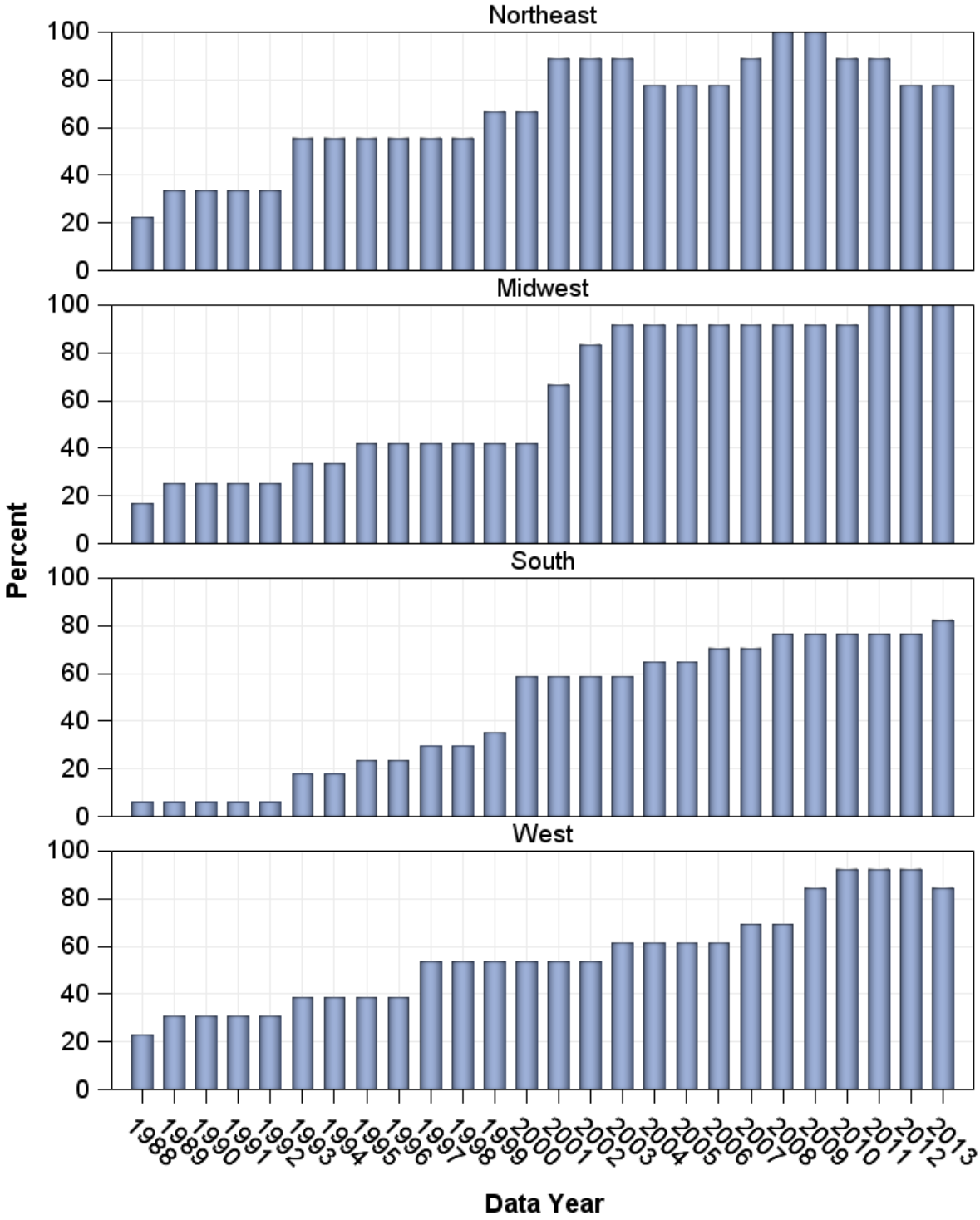
combined hospitals could have been allocated to the wrong bed size stratum in the sample design. Also, the between-hospital variance was combined with the within-hospital variance for these combined hospitals.

In some States, the SID hospital identifiers demonstrate the same weakness as the AHA hospital identifiers. Although those hospitals remain combined, use of the SID hospital identifiers disaggregate the previously combined hospitals in many other States, which is likely to improve the classification of hospitals and improve variance estimates.

NIS REPRESENTATIVENESS AND CHANGES TO THE SAMPLING FRAME

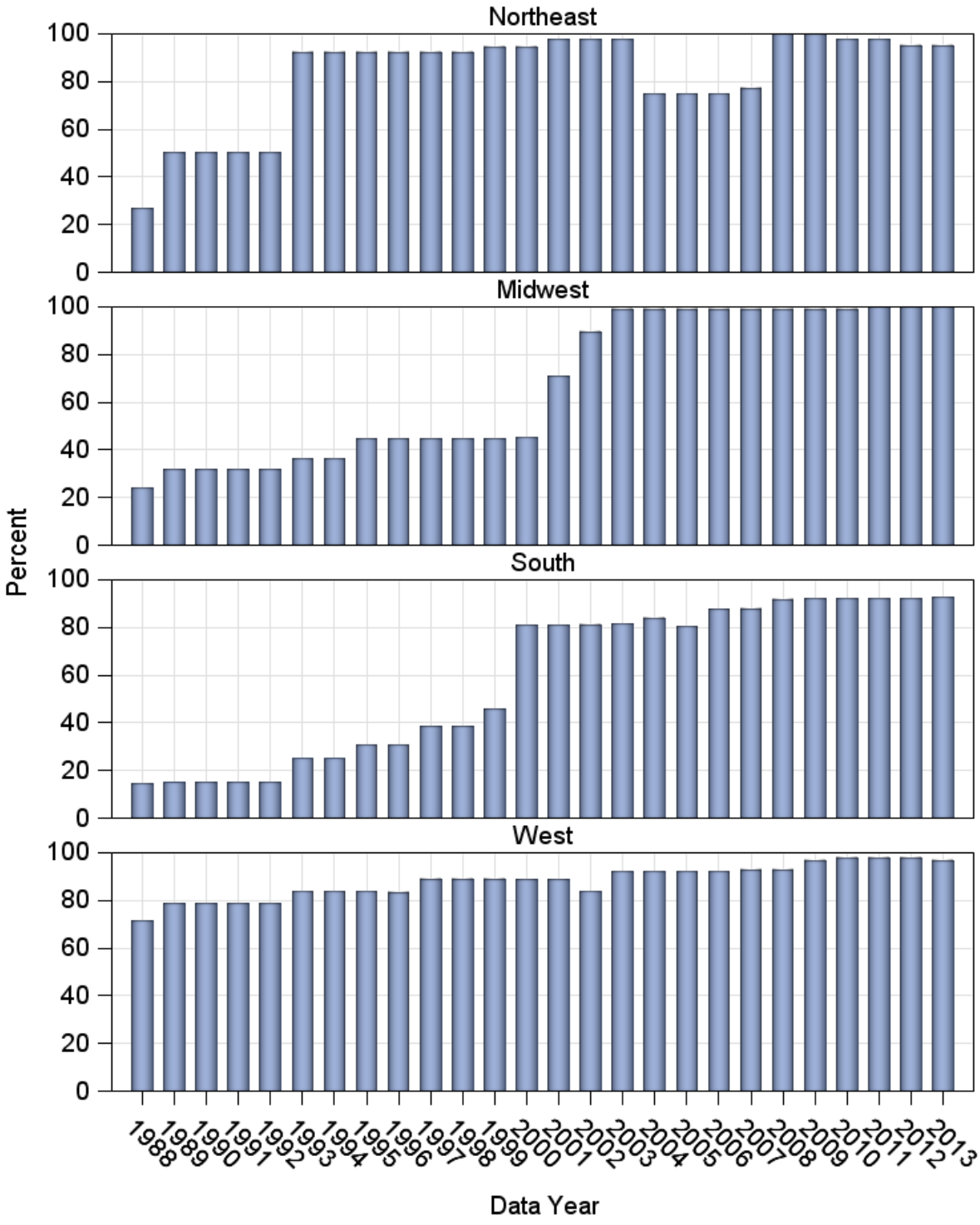
Longitudinally, the representativeness of the NIS increased as new States were added to the sampling frame. This development, which is quantified in Table 1, is illustrated in Figures 2 and 3, which show the regional trend in the percentage of U.S. States and the percentage of the U.S. population covered by the NIS, respectively. The growth in the South and Midwest was more gradual than the growth in the West and Northeast. Figure 4 illustrates the geographic distribution of States in the sampling frame over time. By 2012, the sampling frame for the NIS comprised 88 percent of States and 96 percent of the U.S. population.

Figure 2. Percentage of States Covered by the NIS by Region, 1988–2013



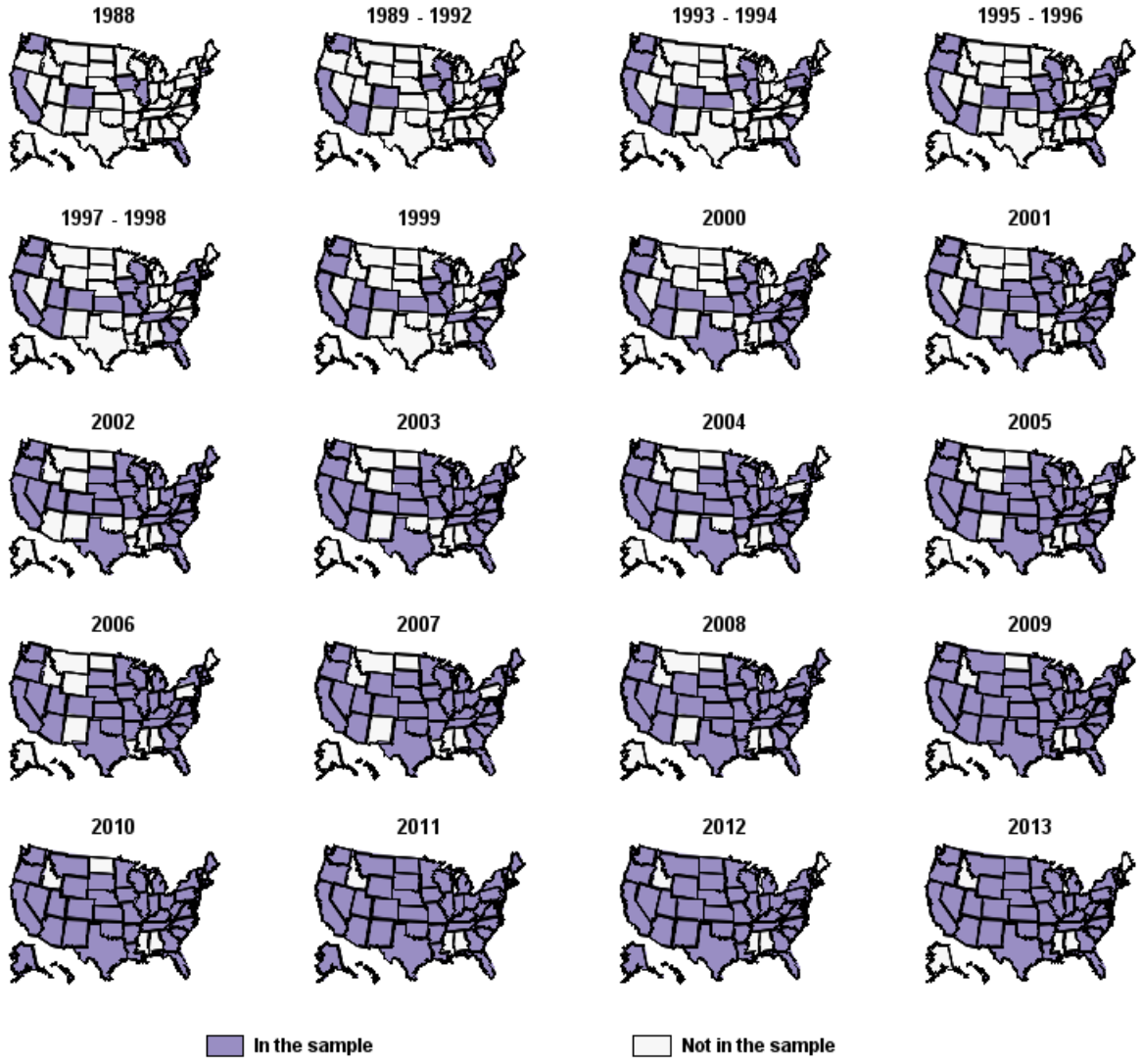
Abbreviation: NIS, National (Nationwide) Inpatient Sample

Figure 3. Percentage of U.S. Population Covered by the NIS by Region, 1988–2013



Abbreviation: NIS, National (Nationwide) Inpatient Sample

Figure 4. States in the NIS Sampling Frame by Year, 1988–2013



Abbreviation: NIS, National (Nationwide) Inpatient Sample

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

The 1998 sample design generated four modifications that should be considered in research designs that include data before and after these changes were incorporated:

1. Excluded short-term rehabilitation hospitals
2. Changed the method for estimating discharges
3. Discontinued the preference for NIS hospitals included in prior samples
4. Redefined the hospital stratification variables for sampling

Most of these revisions have been addressed in the previous sections. The sections that follow further describe the changes and discuss their implications for trend analyses. Because the first two modifications affect discharge counts in the universe, we address their effects together.

Excluding Rehabilitation Hospitals and Changing the Count of Discharges (1998)

As illustrated in Figure 5, the weighted number of NIS discharges decreased 1.5 percent from 35,408,207 in 1997 to 34,874,001 in 1998, a difference of 534,206. This abrupt decline is associated with two changes to the NIS design in 1998. First, community, short-term rehabilitation hospitals were excluded from the hospital universe. Second, the calculation of discharges in the universe for the sample weights was changed 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) using 1997 data.

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

American Hospital Association Survey Discharge Count	**Short-Term Rehabilitation Hospitals**	
	Included	**Not included**
Using the total facility count of discharges	***35,408,207***	35,193,196
Using the hospital count of discharges only	34,883,387	***34,680,628***

The sum of discharge weights was 35,408,207 when short-term rehabilitation facilities were included and the 1997 definition of total facility discharge counts was used for the universe, compared with 34,680,628 when these facilities were excluded and the 1998 definition of hospital counts was used for the universe. The difference is 727,579 discharges, a 2.1 percent reduction resulting from these two changes. After these changes were implemented, 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 shows the effects of these changes on 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 with 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 percent). 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.

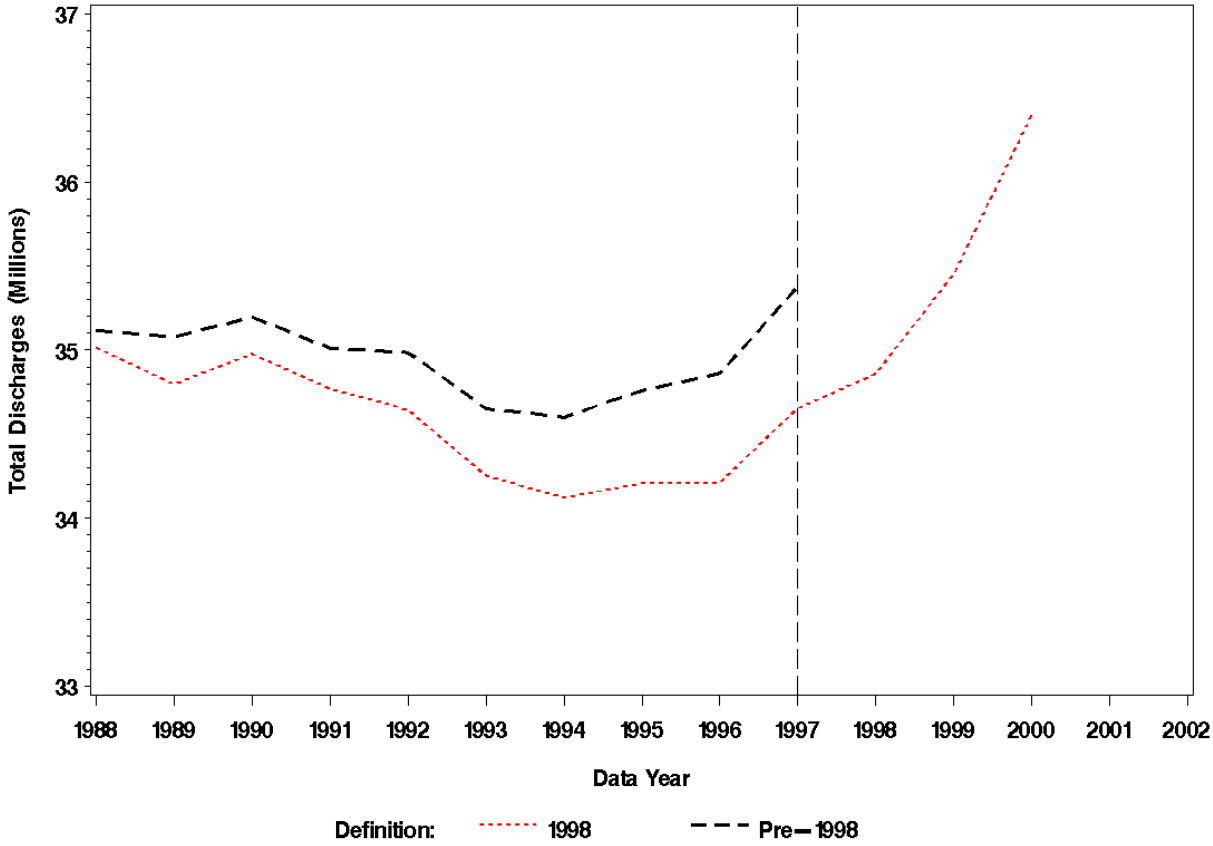
Table 3. 1997 NIS Estimates: Weights Based on 1997 Universe Compared to Weights Based on 1998 Universe

	Average Length of Stay (Days)		In-Hospital Mortality Rate (%)	
Location	**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

Abbreviation: NIS, National (Nationwide) Inpatient Sample

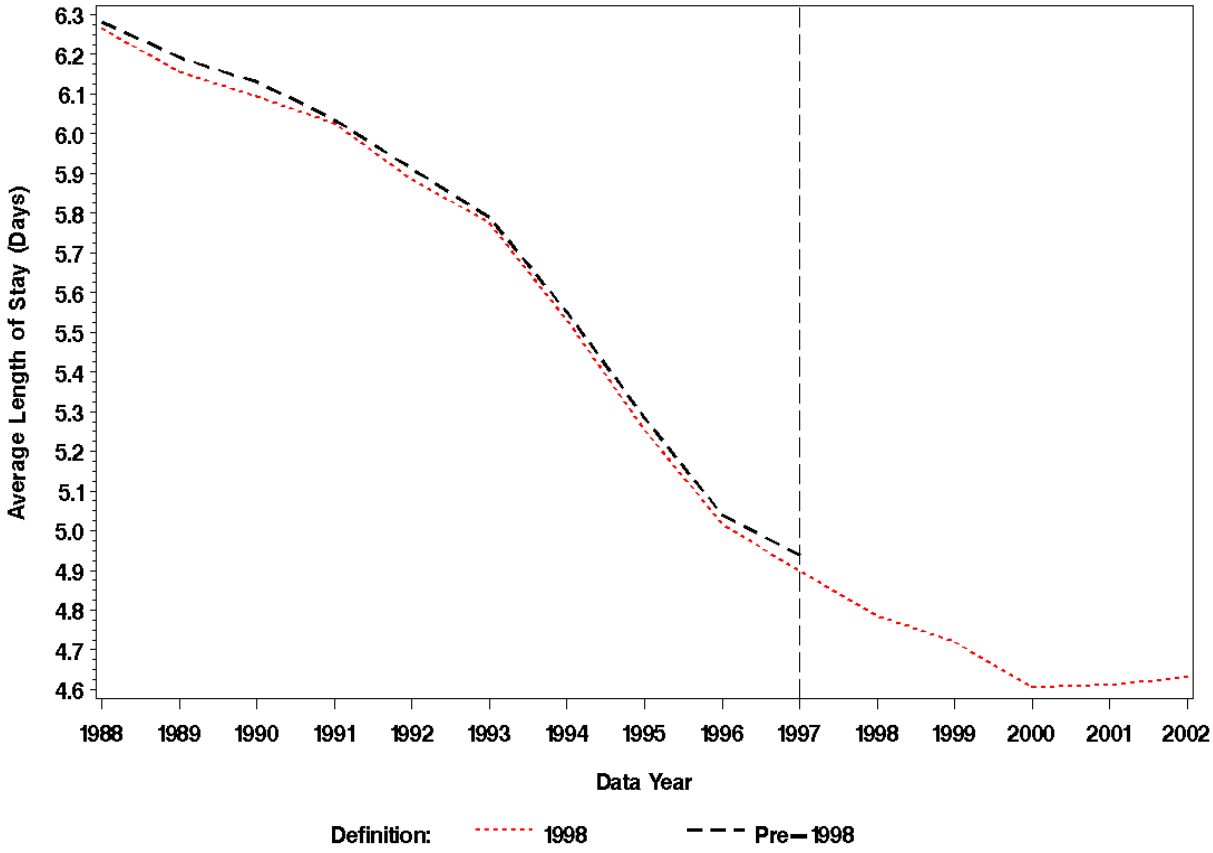
Figures 5, 6, and 7 illustrate the effects of the changes to the universe definition on NIS estimates of trends in total discharges, ALOS, and mortality rate, respectively. The pre-1998 universe *includes* rehabilitation facilities and counts discharges in the universe using AHA survey *total facility* discharge counts. The 1998 universe *excludes* rehabilitation facilities and counts discharges in the universe using AHA survey *hospital* discharge counts. For total discharges, the difference widened between 1988 and 1997, as significant numbers of hospitals and hospital beds steadily converted from acute care to long-term care. Therefore, it may be important to use weights based on the 1998 discharge universe definition for all estimates of totals. The effects are minimal on overall ALOSs and on overall in-hospital mortality rates.

Figure 5. NIS Trends in Total Discharges, by Universe Definition



Note: The 1998 discharge universe excludes rehabilitation facilities and uses AHA survey hospital discharge counts.
Abbreviation: NIS, National (Nationwide) Inpatient Sample

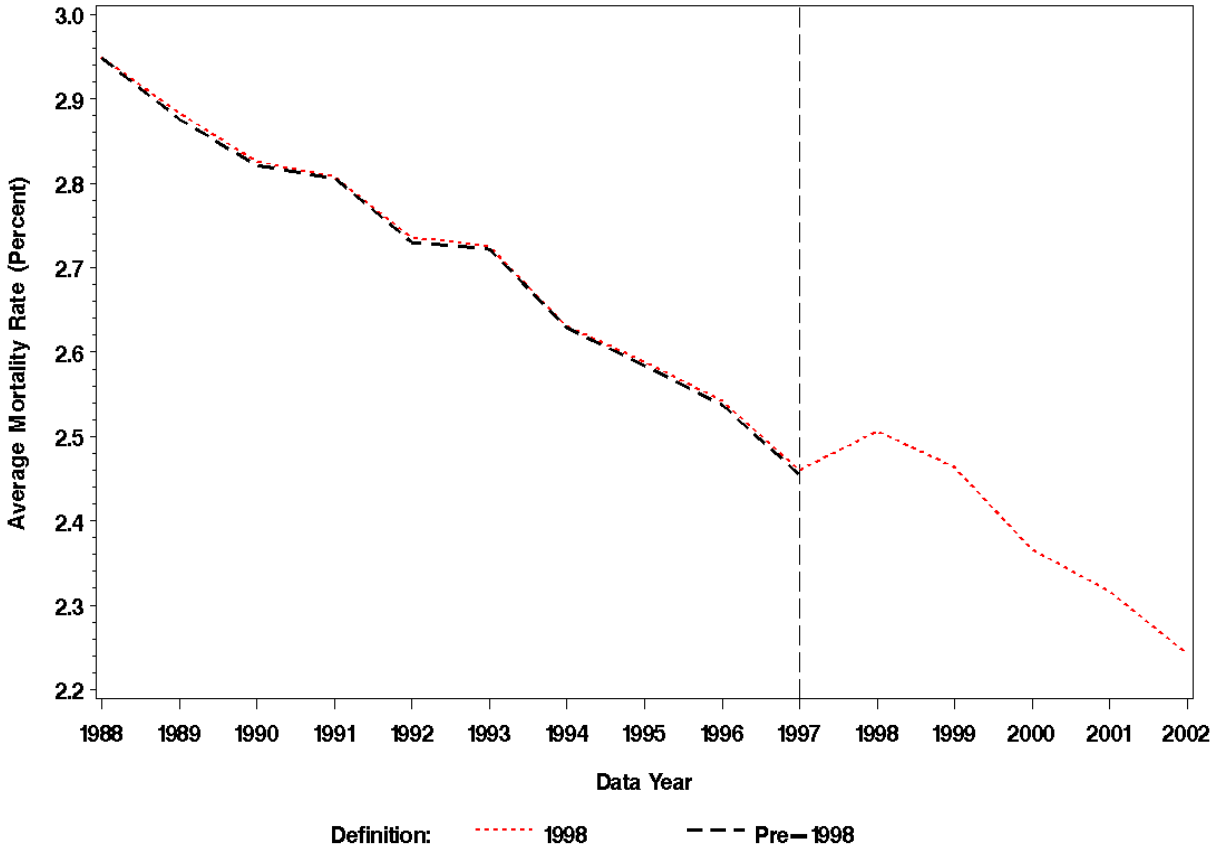
Figure 6. NIS Trends in Average Length of Stay, by Universe Definition



Note: The 1998 discharge universe excludes rehabilitation facilities and uses AHA survey hospital discharge counts.

Abbreviation: NIS, National (Nationwide) Inpatient Sample

Figure 7. NIS Trend in Mortality Rate, by Universe Definition



Note: The 1998 discharge universe excludes rehabilitation facilities and uses AHA survey hospital discharge counts.
Abbreviation: NIS, National (Nationwide) Inpatient Sample

Discontinuing the Preference for Prior Year NIS Hospitals (1998)

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 1988–1992 period, each unique hospital appears an average of 3.7 times in the five NIS files. In contrast, during the 1998–2004 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 Hospital Appearances in the NIS

5-Year Period	Mean No. of Appearances in NIS
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

Abbreviation: NIS, National (Nationwide) Inpatient Sample

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* (Houchens, Elixhauser, Sommers, 2002) indicate that the specific effect of dropping the longitudinal component on estimated averages is slight.

Adjustments to the Stratification Variables (1998)

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 universe discharge counts using 1998 criteria for both sets of weights to purge the comparisons of those revisions. Therefore, we examined only the effect of changes to the stratification variables.

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

	Average Length of Stay		In-Hospital Mortality Rate, %	
Location	**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

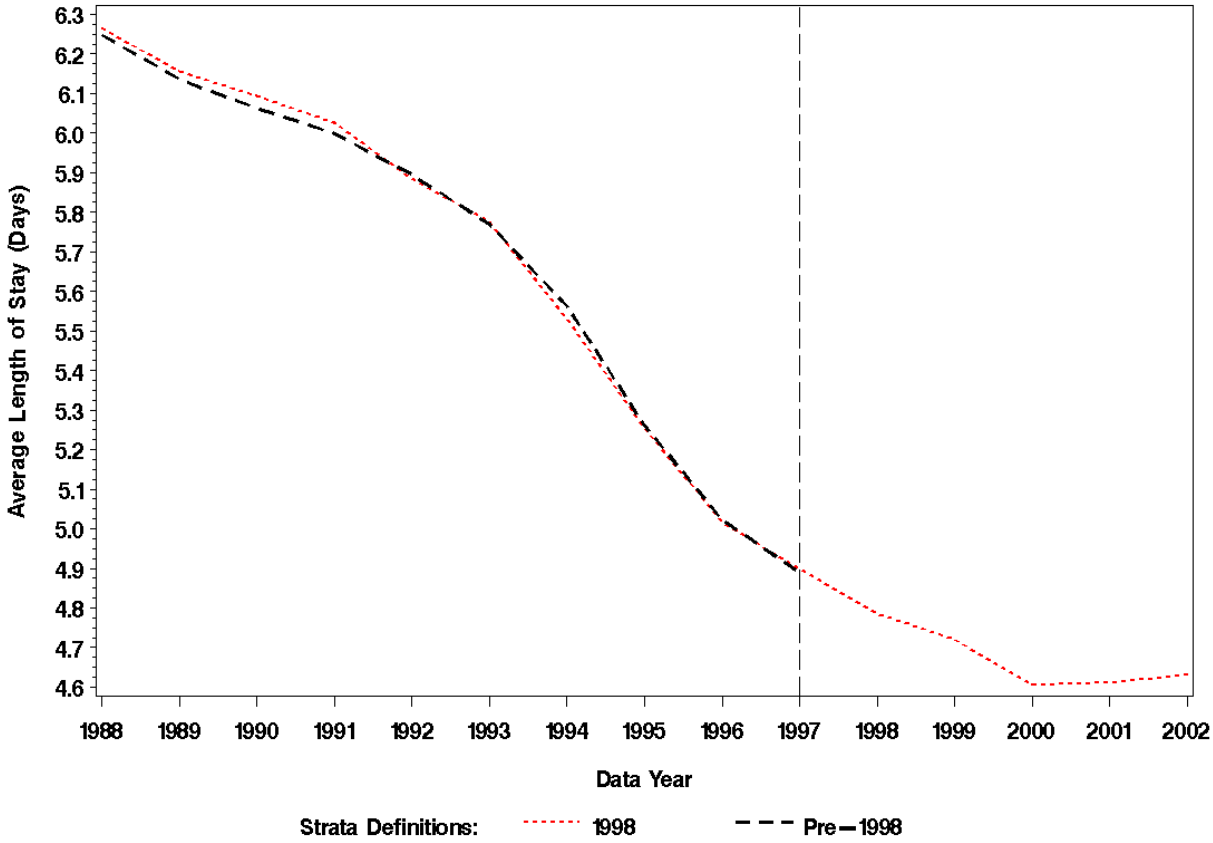
Abbreviation: NIS, National (Nationwide) Inpatient Sample

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) for

each region also would be affected by previously discussed changes affecting discharge counts in the universe. However, the stratification by region was not altered between 1997 and 1998.

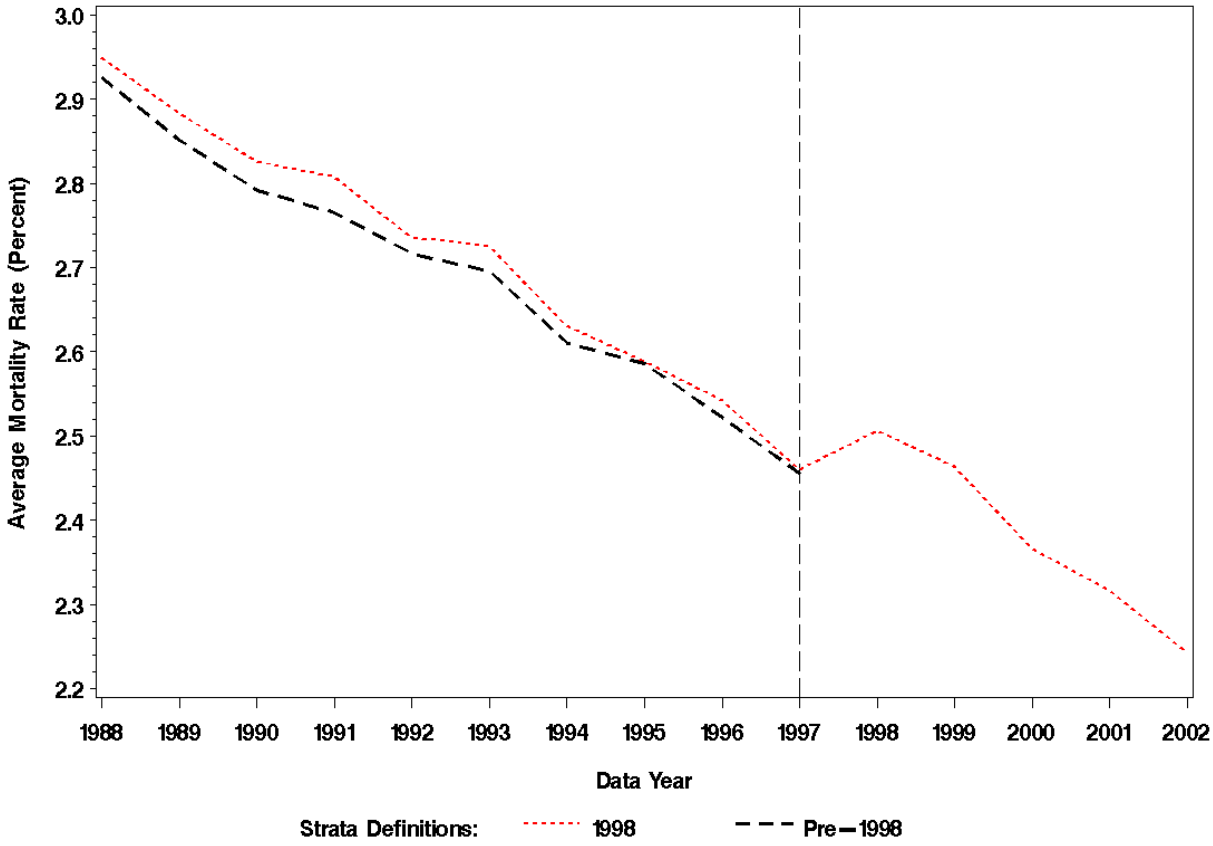
Figures 8 and 9 reinforce that the change to the stratification variables had a negligible impact on overall trends for ALOSs and in-hospital mortality rates, respectively. The differences are quite small. However, the mortality trend slope using 1998 strata definitions is slightly steeper than the mortality 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 8. NIS Trend in Average Length of Stay, by Strata Definition



Abbreviation: NIS, National (Nationwide) Inpatient Sample

Figure 9. NIS Trend in Mortality Rate, by Strata Definition



Abbreviation: NIS, National (Nationwide) Inpatient Sample

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

Change in the Definition of Teaching Hospitals (1998)

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 with 20.1 percent under the 1998 definition. In other words, about 7 percent of nonteaching 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 (1998)

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 cut-off points are shown in Table 6 while
Table 7 contains the new 1998 bed size cut-off points.

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

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+

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 Nonteaching	1–124	125–199	200+
	Urban Teaching	1–249	250–424	425+
Midwest	Rural	1–29	30–49	50+
	Urban Nonteaching	1–74	75–174	175+
	Urban Teaching	1–249	250–374	375+
South	Rural	1–39	40–74	75+
	Urban Nonteaching	1–99	100–199	200+
	Urban Teaching	1–249	250–449	450+
West	Rural	1–24	25–44	45+
	Urban Nonteaching	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 shown in

Table 8:

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

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

Abbreviation: NIS, National (Nationwide) Inpatient Sample

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 important only 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 use other measures of hospital size, such as total discharges.

Change in Ownership Strata (1998)

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.

Table 9 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 Versus 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

Abbreviation: NIS, National (Nationwide) Inpatient Sample

Because in the Northeast, only about 10 percent of the 1997 NIS hospitals were other than private nonprofit, 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. Although 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 prevented the release of each hospital's detailed ownership category from 1998 through 2007. Thus, trend studies of hospital ownership that cross 1998 might be better served by data other than the NIS.

EFFECTS OF THE 2012 SAMPLE DESIGN REVISIONS ON TRENDS THAT SPAN 2012

The effects of the 2012 sample redesign are detailed in the *Nationwide Inpatient Sample Redesign Final Report* (Houchens, Ross, Elixhauser, et al., 2014)

The switch from drawing *all discharges from a sample of hospitals* to drawing a *sample of discharges from all hospitals* improved the precision and stability of NIS sample estimates. For example, the margins of error under the 2012 design are expected to be about 53 percent of the 1998 design for ALOS estimates, about 55 percent of the 1998 design for average charge estimates, and about 51 percent of the 1998 design for estimates of hospital mortality.

However, the other sample design modifications affected the values of universe statistics (i.e., the values that sample statistics estimate). In particular, these other modifications had an effect on the numbers and types of discharges in the universe. Using HCUP and AHA annual survey data for 2011, we estimated the effects of the following changes:

1. Switching to the *systematic sample design* from the present NIS sample design[3]
2. Eliminating *long-term acute care* hospitals
3. Using observed *SID discharge counts* in place of estimated AHA discharge counts for estimating the total number of discharges in the universe
4. Using *SID hospital identifiers* in place of AHA hospital identifiers to disaggregate hospitals combined by the AHA hospital identifier.

Table 10 summarizes the effects of these modifications on four universe statistics—discharges, ALOS, average charges, and hospital mortality—obtained from HCUP discharge data and AHA survey data for 2011. The columns are numbered for easy reference. Columns 1 and 2 provide the baseline statistics and describe the universe without any modifications.

Columns 3 and 4 show the effect of excluding long-term acute care hospitals from the universe. The total number of discharges declined from 38,590,733 (column 1) to 38,338,545 (column 3), which represents a 0.7 percent overall decline. This decline was mostly in the older age groups (not shown). The removal of long-term acute care hospitals also decreased ALOS by 1.5 percent, average charges by 0.7 percent, and hospital mortality by 2.0 percent (from a mortality rate of 1.91 percent to 1.87 percent). These changes all are to be expected given the characteristics of patients in long-term acute care hospitals.
Columns 5 and 6 show the effect of replacing AHA discharge counts with SID discharge counts to estimate discharges in the universe (in addition to excluding long-term acute care hospitals). This action had a significant impact on the universe discharge count. The total number of discharges in the universe fell from 38,338,545 (column 3) to 36,935,306 for a further decrease of 3.6 percent and an overall decrease of 4.3 percent, compared with the discharge count in column 1. The incremental impact on ALOS, average charges, and hospital mortality was almost negligible in comparison.

Finally, the incremental effects of switching from the AHA hospital identifier to the SID hospital identifier (columns 7 and 8) were miniscule for all four outcomes.

[3] This includes a revision of the hospital sampling strata to stratify hospitals by the nine census divisions rather than by the four census regions used in the existing NIS design. Switching to the systematic design had no effect on the universe and, therefore, no effect on values of universe statistics.

In sum, the 2012 NIS redesign is expected to provide more stable and precise estimates than previous versions of the NIS. Because long-term acute care hospitals will be excluded and because the accuracy of discharge weights will be improved, NIS users should expect a one-time decrease in historical trends for discharge counts of about 4 percent. They should also expect smaller one-time disruptions to historical trends for rates and means estimated from the NIS, beginning with data year 2012. To address this, we recommend that users employ "trend" discharge weights for historical NIS files to minimize the effects of the redesign on estimated trends that cross the 2012 data year (http://www.hcup-us.ahrq.gov/db/nation/nis/nistrends.jsp).

Table 10. Impact of Incremental Modifications to the Universe on Universe Statistics

	***Old Universe Definition* (1998–2011)**		**Impact of Incremental Modifications to the Universe**					
	Include LTAC Hospitals		**Exclude LTAC Hospitals**					
	Use AHA Discharge Counts		**Use AHA Discharge Counts**		**Use SID Discharge Counts[a]**			
	Use AHA Hospital ID		**Use AHA Hospital ID**		**Use AHA Hospital ID**		***New Universe Definition*** **Use SID Hospital ID**	
	Total Discharges	**Original Discharges, %**	**Total Discharges**	**Original Discharges, %**	**Total Discharges**	**Original Discharges, %**	**Total Discharges**	**Original Discharges, %**
Column Number	1	2	3	4	5	6	7	8
Discharge Count	38,590,733	100.0	38,338,545	99.3	36,935,306	95.7	36,939,183	95.7
ALOS	4.59	100.0	4.53	98.5	4.52	98.5	4.53	98.5
Average Charges	$34,962	100.0	$34,711	99.3	$34,779	99.5	$34,790	99.5
Hospital Mortality	0.01905	100.0	0.01867	98.0	0.01866	97.9	0.01866	98.0

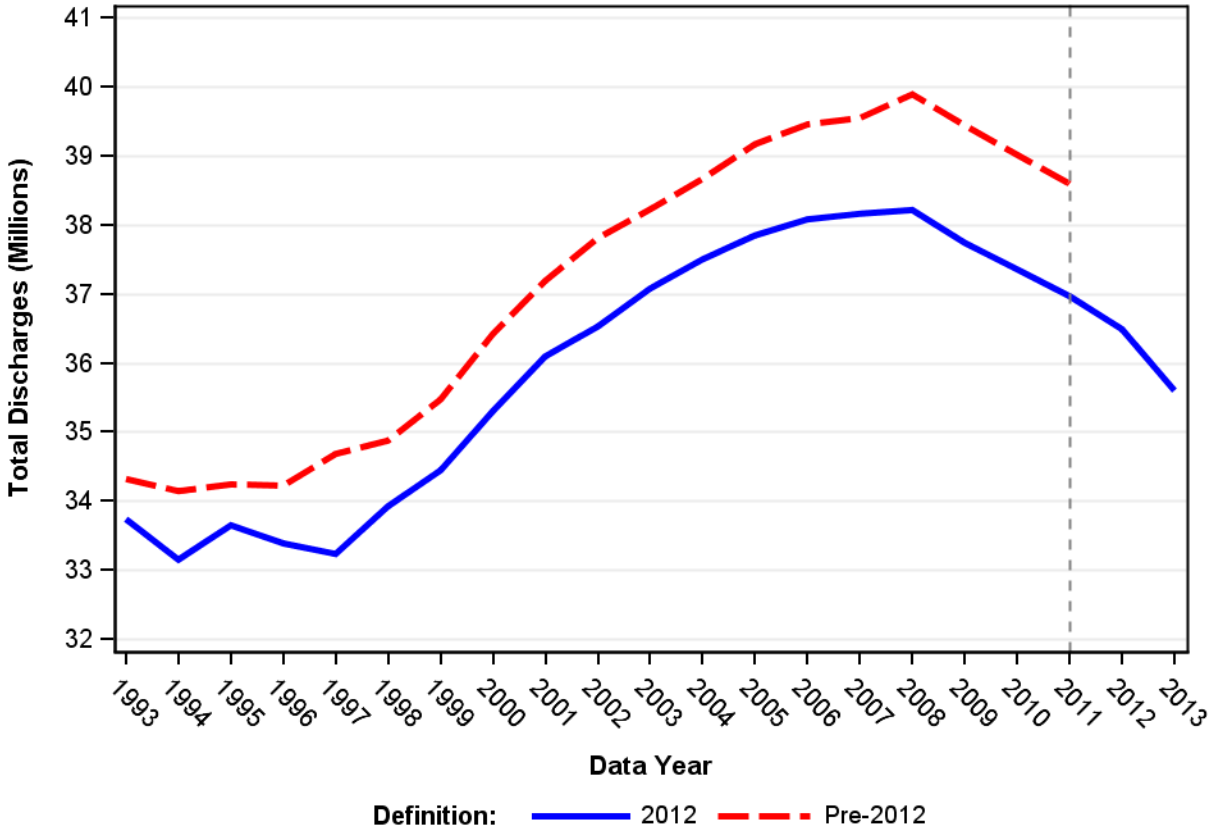
Abbreviations: AHA, American Hospital Association; ALOS, average length of stay; ID, identification number; LTAC, long-term acute care; SID, State Inpatient Databases

[a] When discharge counts or hospital identifiers are not available from the SID, estimates from the AHA will be used. This is expected to affect fewer than 10 percent of hospitals.

Data sources: HCUP State Inpatient Databases (SID) and American Hospital Association (AHA) Survey Data for 2011

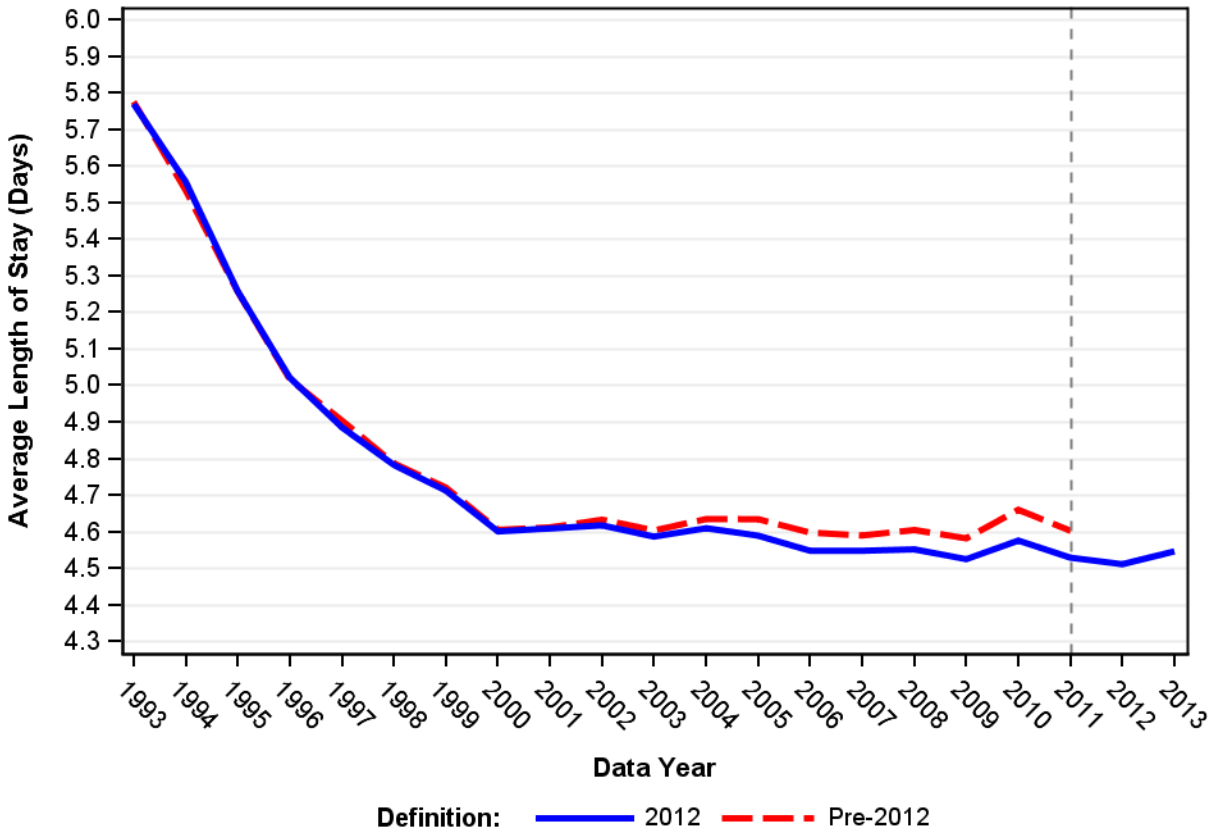
Figures 10, 11, and 12 illustrate the effects of the 2012 change to the universe definitions on NIS estimates of trends in total discharges, ALOS, and mortality rate, respectively. For total discharges, the difference is substantial. Therefore, it will be important to use weights based on the 2012 discharge universe definition for all estimates of totals (http://www.hcup-us.ahrq.gov/db/nation/nis/nistrends.jsp). The effects are much smaller on overall ALOSs and on overall in-hospital mortality rates.

Figure 10. NIS Trends in Total Discharges, by Universe Definition



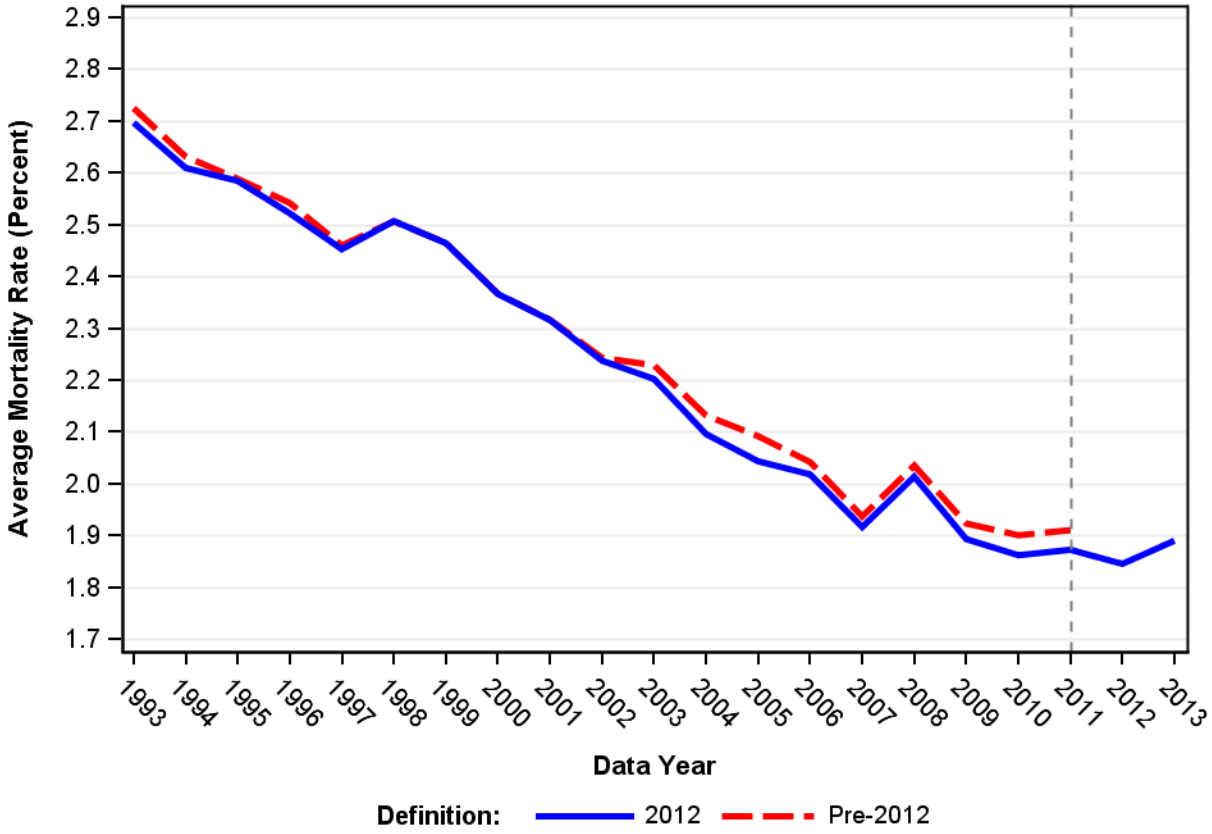
Abbreviation: NIS, National (Nationwide) Inpatient Sample

Figure 11. NIS Trends in Average Length of Stay, by Universe Definition



Abbreviation: NIS, National (Nationwide) Inpatient Sample

Figure 12. NIS Trends in Mortality Rate, by Universe Definition



Abbreviation: NIS, National (Nationwide) Inpatient Sample

NIS 1993-2011 Trend Weights

In order to adjust for changes to the NIS design in 1998 and 2012, we recommend that users employ "trend" discharge weights for 1993–2011 NIS files to minimize the effects of the redesigns on estimated trends that cross the 1998 or 2012 data year. For years prior to 2012, the trend weight (TRENDWT) should be used in place of the original discharge weight (DISCWT) to create national estimates for trends analysis that are consistent with 2012 data onward. The new discharge trend weights replace the earlier NIS Trend Weights that were developed for the 1988–1997 NIS following the 1998 NIS redesign. The new trend weights are available for download under http://www.hcup-us.ahrq.gov/db/nation/nis/nistrends.jsp from the NIS Database Documentation page on the HCUP-US Web site. AHRQ does not advise using data years 1988-1992 for trend analyses. Therefore, the trend weights start with the 1993 data year.

EFFECTS ON TRENDS OF CHANGES TO THE SAMPLING FRAME (1993 ONWARD)

Although it may be possible to adjust analyses for changes in the 1998 and 2012 NIS sample redesigns, 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. Adding New York to the NIS sampling frame dramatically increased the NIS ALOS estimate in the Northeast region between 1992 and 1993 (not shown). For this reason, we recommend that most NIS trend analyses be confined to the 1993 and later period.

HOW SHOULD CHANGES TO DATA ELEMENTS BE ADDRESSED?

To What Extent Should ICD Coding Issues Be Considered?

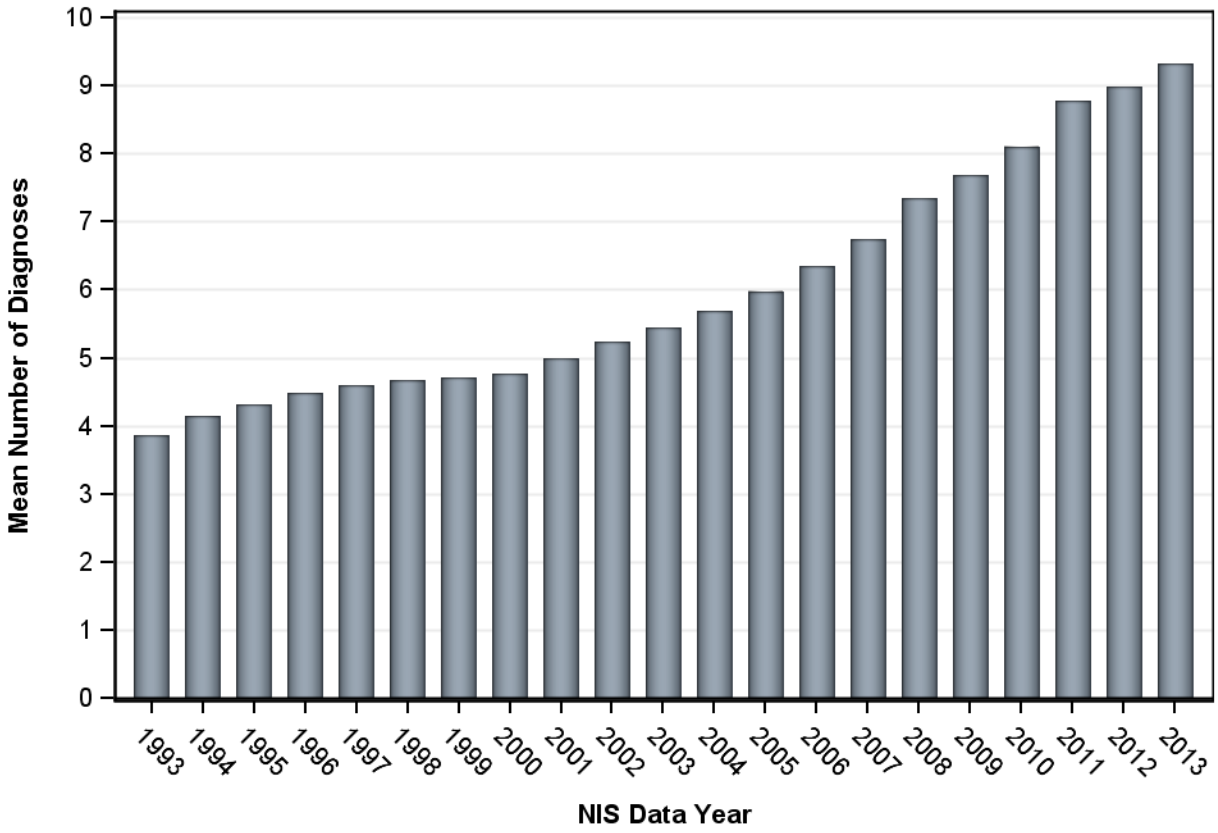
Number of Codes

Each NIS record contains up to 25 ICD-9 diagnosis codes[4] and another 15 ICD-9 procedure codes. It is important to recognize that not all State discharge databases contain 25 diagnosis codes and 15 procedure codes. Some States captured only 5 or 10 codes, whereas other States captured up to 50 codes, and the number of available slots for codes changed over time in some States. In any case, the NIS retains up to 25 of these original diagnosis codes and 15 procedure codes because analyses demonstrated that 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 13 displays the trend in the average number of diagnoses coded in the NIS from 1993 to 2012. The number grew steadily over this period. 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 diagnosis vector may occur more frequently in States (or years) with more codes.

[4] The number of diagnoses was increased from 15 to 25 beginning with 2009.

Figure 13. Mean Number of Diagnoses Coded, NIS 1993–2013



Abbreviation: NIS, National (Nationwide) Inpatient Sample

Masking and Recoding for Cases With Sensitive Diagnoses and Procedures

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 age or exclude records entirely. These recodes are unlikely to affect most analyses.

Annual ICD-9-CM Code Changes

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 later years is available online at http://www.cdc.gov/nchs/icd/icd9cm_addenda_guidelines.htm.

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, the following are some examples of code changes:

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 acute myocardial infarction (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).

ICD-10-CM and ICD-10-PCS

The International Classification of Diseases, Tenth Revision, Clinical Modification/Procedure Coding System (ICD-10-CM/PCS) replaced the ICD-9-CM coding system beginning October 1, 2015. Changes in this new code set allow greater data specificity and provide more future expansion capabilities than were possible with ICD-9-CM:

- Added information relevant to ambulatory and managed care encounters
- Expanded injury codes
- Combined diagnosis and symptom codes to reduce the number of codes needed to fully describe a condition
- Addition of sixth and seventh characters
- Incorporation of common fourth and fifth digit sub-classifications
- Laterality (e.g., designation of left or right side when describing locations of injuries)
- Greater specificity in code assignment.

All HCUP tools have been converted to ICD-10 and ICD-10 codes will appear in HCUP data started with the fourth quarter of 2015 (http://www.hcup-us.ahrq.gov/tools_software.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 new DRG system, called Medicare Severity DRGs (MS-DRGs), became effective with discharges occurring on or after October 1, 2007. CMS replaced 538 DRGs with 745 new MS-DRGs. Every DRG number had a new meaning with the introduction of MS-DRGs (American Health Information Management Association, 2010).

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. 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 1998–2005 NIS, grouper version 18 (effective October 2000)
- For the 2006–2013 NIS, grouper version 24 (effective October 2006)
- For the 2008–2013 NIS, DRG in use on discharge date, calculated without Present On Admission (POA) indicators, which are not available from some States

Note that multiple DRG versions are available for some years. The grouper version may not be an issue for those DRGs that had equivalent definitions over the study period.

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, the 1993–2002 NIS Supplemental Discharge-Level Files, described next, are available to simplify the process.

NIS 1993–2002 SUPPLEMENTAL DISCHARGE-LEVEL FILES

The 1993-2002 Nationwide Inpatient Sample (NIS) Supplemental Discharge-Level Files facilitate analysis using multiple years of NIS data. The 1993-2002 NIS Supplemental Discharge-Level Files provide additional data elements that were added for later data years of the NIS through 2002 as well as updated NIS Trend Weights (http://www.hcup-us.ahrq.gov/db/nation/nis/nistrends.jsp).

SHOULD WEIGHTS BE INCORPORATED IN TREND ANALYSES?

In order to adjust for changes to the NIS design in 1998 and 2012, we recommend that users employ "trend" discharge weights for 1993–2011 NIS files to minimize the effects of the redesign on estimated trends that cross the 1998 or 2012 data year. For years prior to 2012, the trend weight (TRENDWT) should be used in place of the original discharge weight (DISCWT) to create national estimates for trends analysis that are consistent with 2012 data onward. The new trend weights are available for download at http://www.hcup-us.ahrq.gov/db/nation/nis/nistrends.jsp from the NIS Database Documentation page on the HCUP-US Web site.

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 rarely are better estimates (Korn and Graubard, 1999). Obviously, unweighted means are equal to weighted means when the weights are constant, which is a feature of the NIS for 2012 and later. Also, unweighted means nearly equal weighted means on outcomes for which there is little variation.

For example, Table 11 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 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 usually can 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 11. 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

Abbreviation: NIS, National (Nationwide) Inpatient Sample

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 (LOS), and one or more predictor or explanatory variables.

Standard statistical routines for survey data can be used to analyze descriptive statistics. 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 also are 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 (Houchens, et al., 2015). 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 obtain appropriate standard errors by augmenting the subset with "dummy" observations, one for each NIS stratum. This technique is explained in Houchens et al. (2015).

Hierarchical or multilevel regressions might be appropriate for incorporating hospital characteristics as explanatory variables (Snijders and Bosker, 1999; Singer and Willett, 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 also could 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, et al., 2000), and MLwiN (Rasbash, Steele, Browne, 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 often are 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, *discharge* quarter and *discharge* year. The NIS is a discharge file, not an admission file. Some January discharges will have an admission month from the previous December. Therefore, December *admissions* in the NIS are a mix of present year and prior year admissions.

An Example Trend Analysis: Lengths of Stay for Affective Disorders

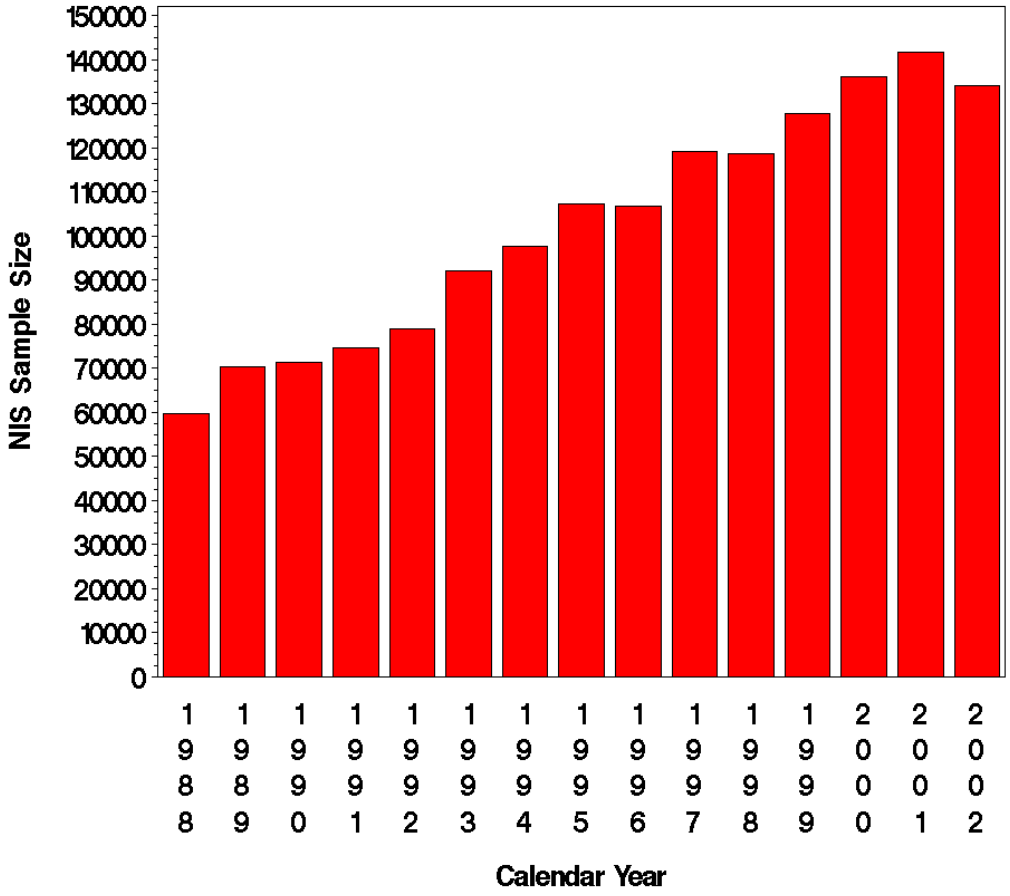
The analyses here are intended to be illustrative rather than prescriptive. We suggest some steps that analysts can take and suggest some statistical methods that could be useful. However, a variety of other approaches and other methods might be appropriate depending on the goals of the study.

The analyses in this section were not updated for the 2012 NIS sample design changes. Consequently, these analyses are illustrated with earlier NIS data. Nevertheless, the methods are applicable to recent NIS data.

Bao and Sturm (2001) estimated the 10-year trend in ALOS for several categories of mental health and substance abuse between 1988 and 1997 using one of the NIS 10 percent samples. We used the full NIS to examine trends in ALOS for one of those categories, affective disorders, defined by category number 69 in the AHRQ 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 revealed 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 14, each NIS contained a large sample of discharges for affective disorders. Consequently, most statistics for this subpopulation were 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 and 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.

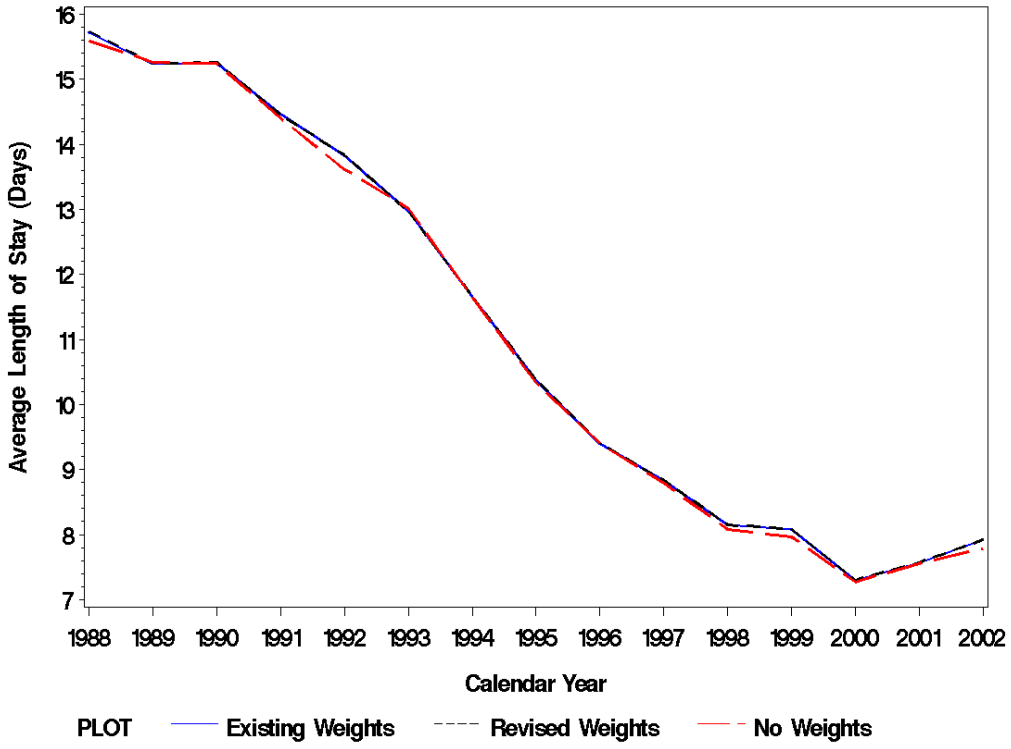
Figure 14. NIS Sample Sizes for Affective Disorders, 1988–2002



Abbreviation: NIS, National (Nationwide) Inpatient Sample

Figure 15 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 15. Trend in ALOS for Affective Disorders, 1988–2002 (NIS Full Sample)



Abbreviations: ALOS, average length of stay; NIS, National (Nationwide) Inpatient Sample

The ALOS trend estimated by Bao and Sturm for affective disorders shown in Figure 16, based on the 10 percent sample for the period 1988 to 1997, is very close to that estimated by the full NIS (Figure 15). 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 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* (Houchens and Elixhauser, 2013)*,* for more information on calculating standard errors.

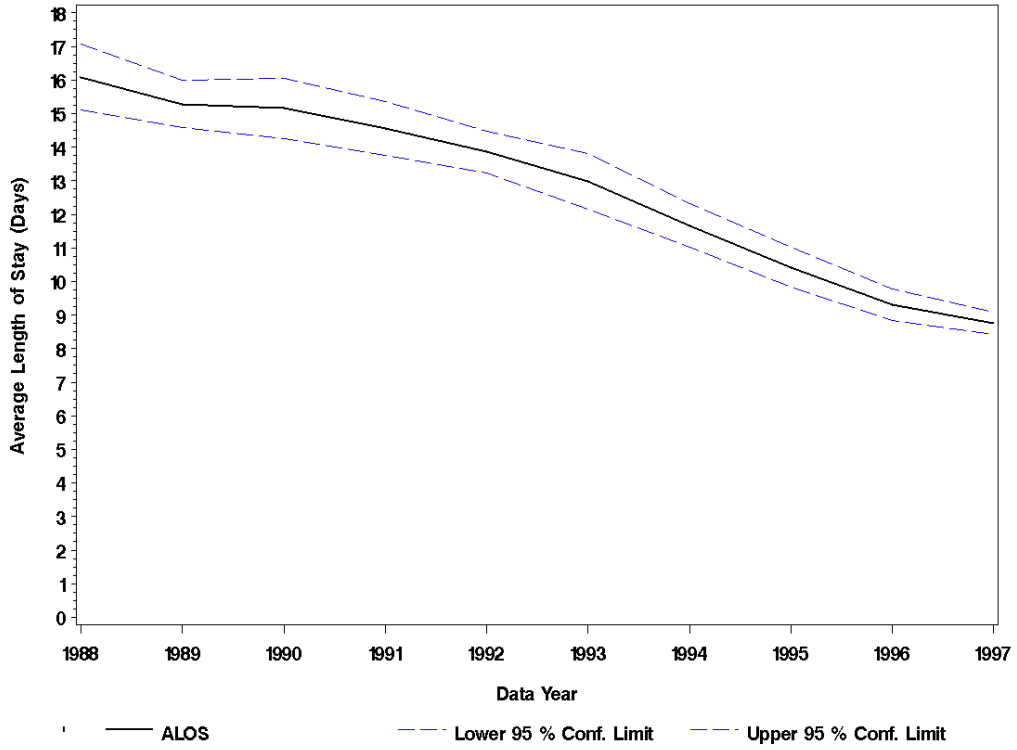
In Figure 16, the confidence limits narrow through time. This narrowing is a result of (1) decreasing LOS variance owing to an increase in cost-containment measures and (2) increasing numbers of participating HCUP hospitals, which in turn, increased the number of hospitals in the NIS sample. In particular, as the sampling frame increased over time, we were more successful at 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 17. Although the observed trend appears to be slightly nonlinear, 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.

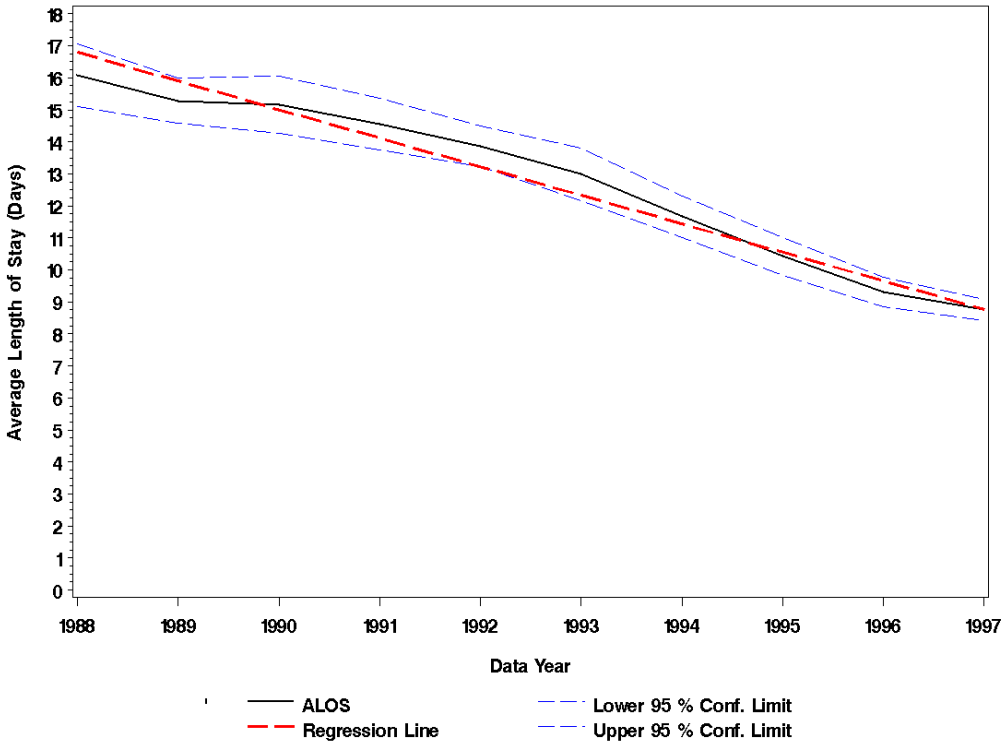
In the remainder of this section, we expand on Bao and Sturm's analysis of ALOS by using the full NIS sample and by extending the timeframe through 2002.

Figure 16. Trend in ALOS for Affective Disorders, 1988–1997 (NIS 10% Sample)



Abbreviations: ALOS, average length of stay; NIS, National (Nationwide) Inpatient Sample

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



Abbreviations: ALOS, average length of stay; NIS, National (Nationwide) Inpatient 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 18 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 analyze the annual trend beginning in 1993 (see Figure 15).

Figure 18. Quarterly ALOS Trend for Affective Disorders, NIS 1988–2002

Abbreviations: ALOS, average length of stay; NIS, National (Nationwide) Inpatient Sample

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.

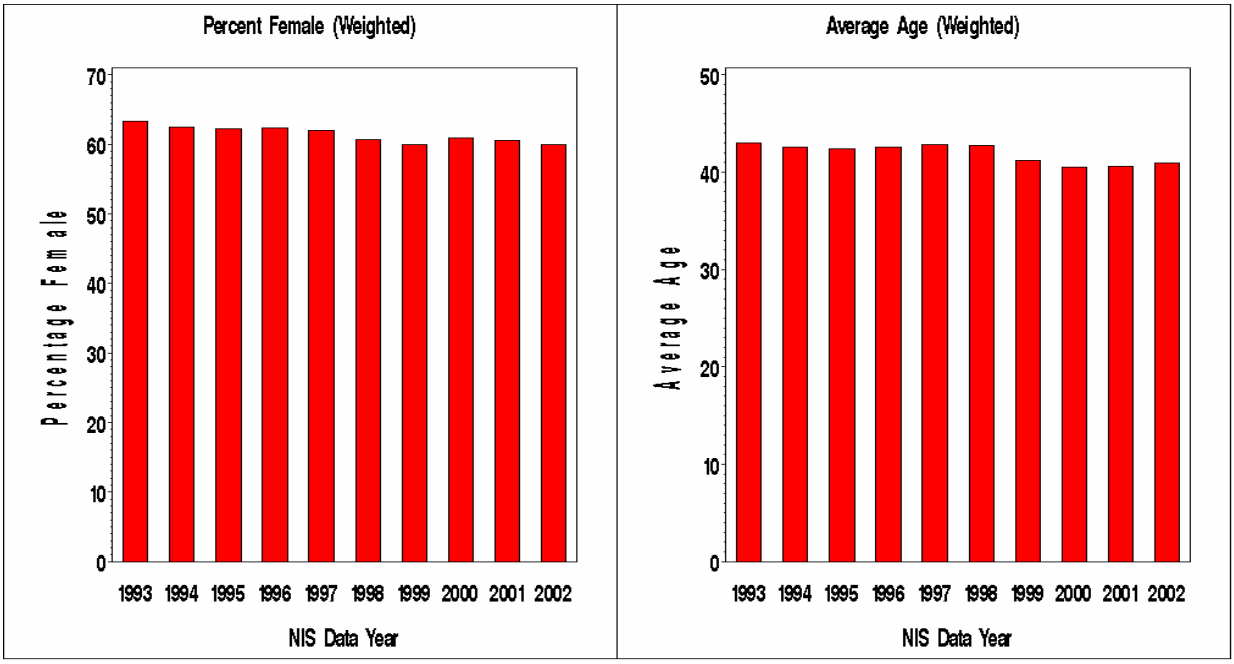
For illustration, we will use only three independent variables: age (0–124 years), sex (male or female), and year (1993–2002). Consequently, the model that we fit omits important predictors. However, these three variables serve adequately for this example. Our goal will be to estimate the trend in ALOS 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. Less than 0.02 percent of the observations were eliminated as result of this exclusion.

Ages ranged from 0 to 124 years. 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 19. 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 19. Sex and Age Trends for NIS Discharges with Affective Disorders, 1993–2002



Abbreviations: NIS, National (Nationwide) Inpatient Sample

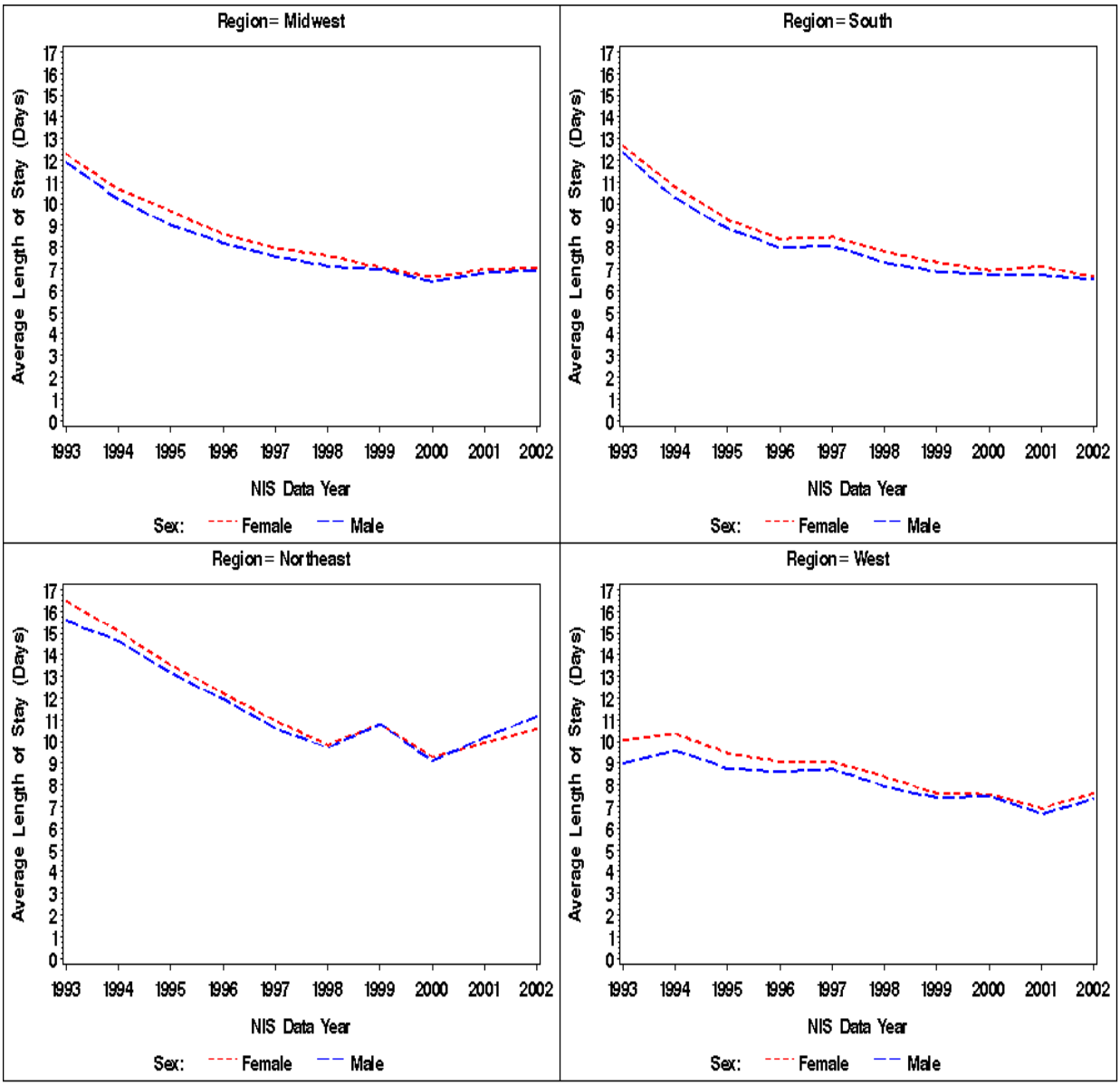
To investigate, we examine plots showing the relationships over time between ALOS and the independent variables (age, sex, and region).

Figure 20 compares the ALOS trend between males and females, by region. The trends are similar in each region, with females tending to have slightly longer ALOSs compared with males. The ALOS trend is a little flatter in the West compared with other regions. In the Northeast, the ALOS abruptly rises in 1999 for both males and females.

Figure 21 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 older adults hospitalized for affective disorders tended to be discharged rather quickly to long-term care facilities.

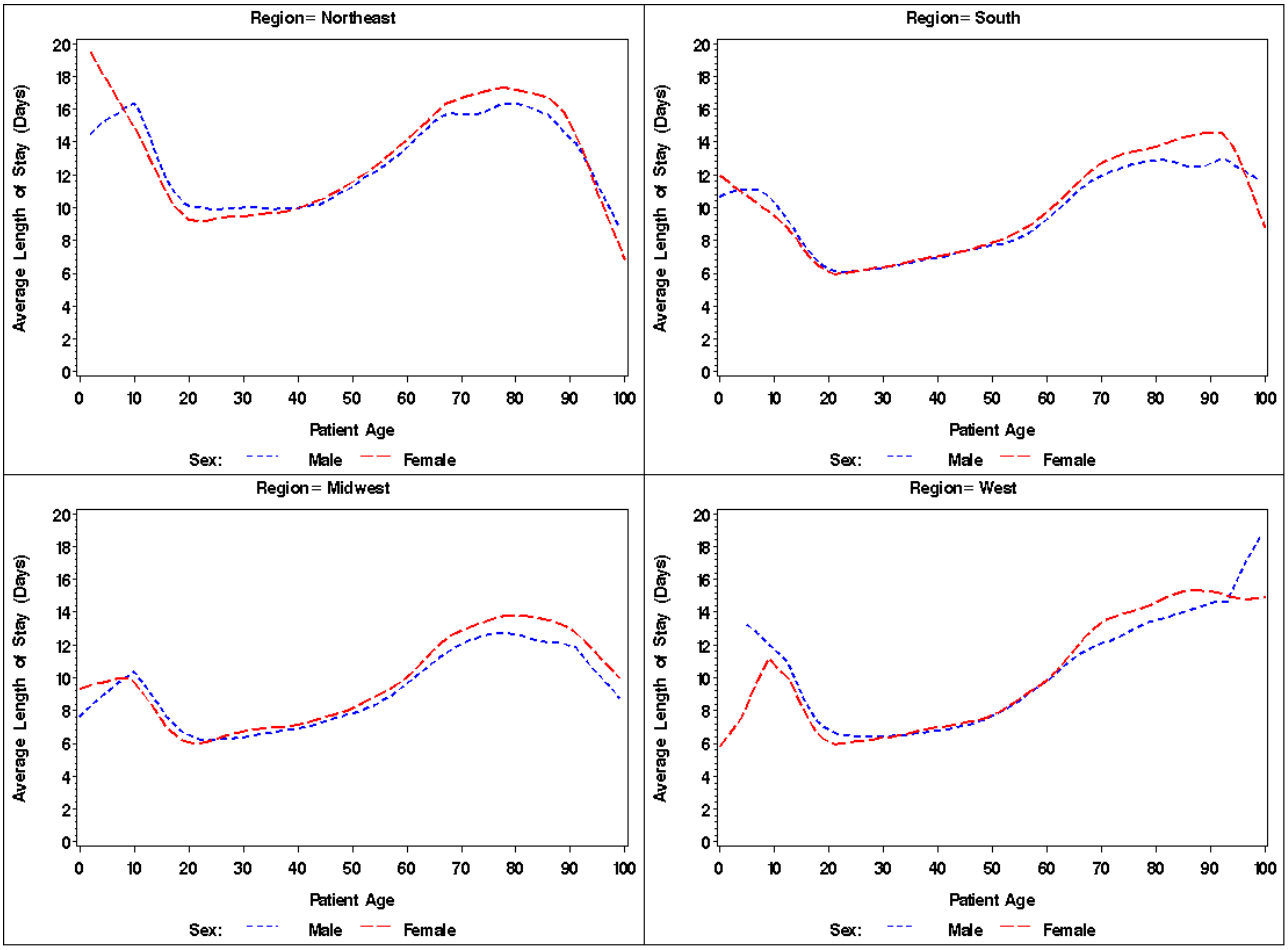
The relationship between ALOS and age appear to be consistent over the four regions. There appears to be an interaction between sex and age, with ALOS lower for females compared with males at lower ages and with ALOS higher for females compared with males at higher ages. Further investigation revealed 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 nonlinear.

Figure 20. ALOS Trends, NIS Discharges With Affective Disorders, Males Versus Females, by Region



Abbreviations: ALOS, average length of stay; NIS, National (Nationwide) Inpatient Sample

Figure 21. ALOS Versus Age, NIS Discharges With Affective Disorders, 1993–2002, Males Versus Females, by Region



Abbreviations: ALOS, average length of stay; NIS, National (Nationwide) Inpatient Sample

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:

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

LOS_i is the observed length of stay for patient *i* in the West. The variable *female* is an indicator equal to 1 for females and 0 for males. We used a restricted cubic spline for age (Harrell, 2001). Spline functions are useful for modeling nonlinear effects like those that we see for age in Figure 23. 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 age_1, age_2, and age_3 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 12. 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 with the non-survey 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.

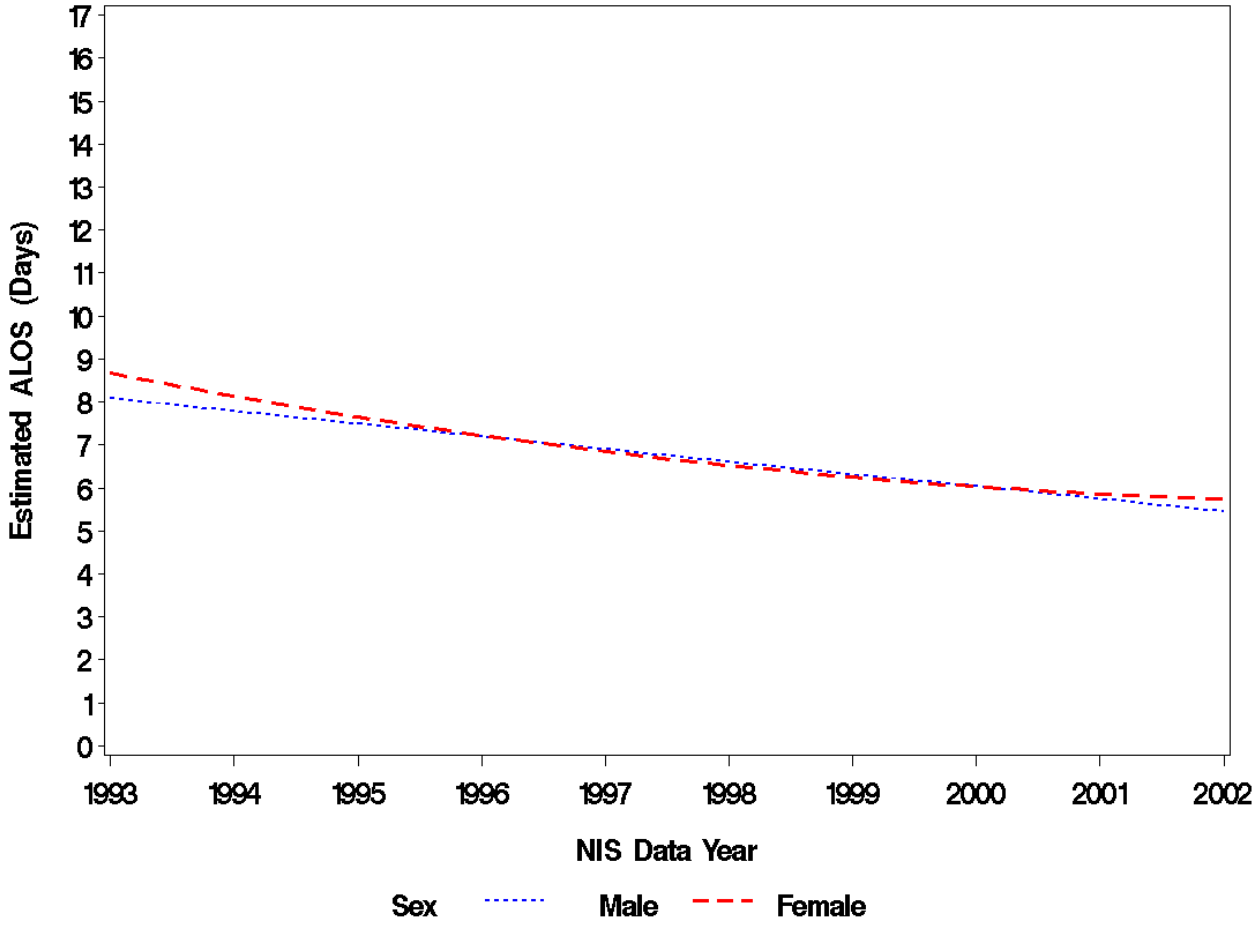
Table 12. Estimated Regression Statistics, ALOS for Affective Disorders, NIS 1993–2002

Statistic	Procedure	Intercept α	Year–1997 β_1	(Year–1997)^2 β_2	Fem β_3	Age β_4	Fem Year β_5	Fem Year^2 β_6	Fem Age β_7	Age$_1$ λ_1	Age$_2$ λ_2	Age$_3$ λ_3	Fem Age$_1$ ω_1	Fem Age$_2$ ω_2	Fem Age$_3$ 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

Abbreviations: ALOS, average length of stay; NIS, National (Nationwide) Inpatient Sample

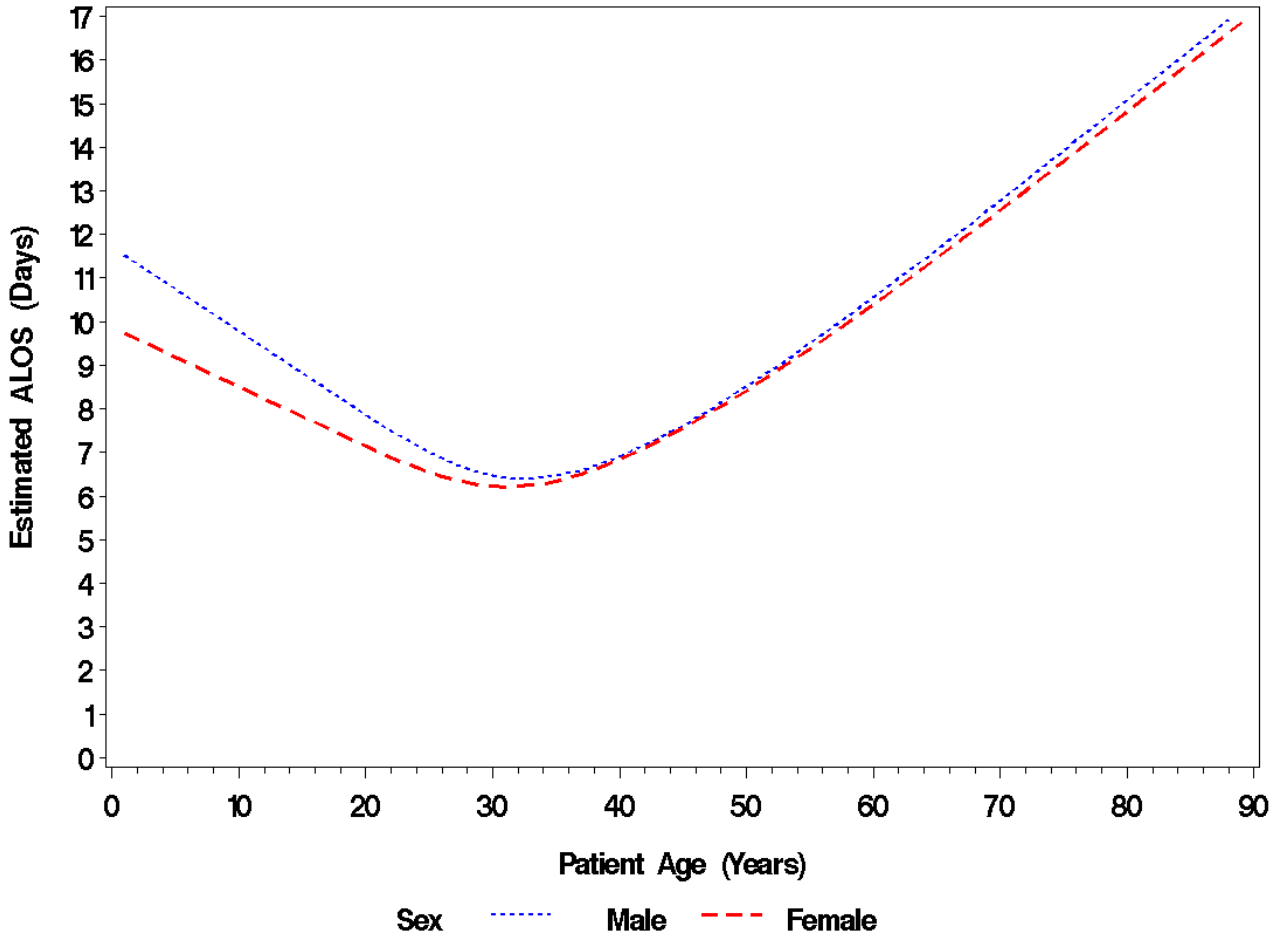
Figure 22 illustrates the estimated ALOS trend for 40-year-old males and females. The estimated trend is nearly linear for males and slightly curve-linear for females. Figure 23 plots the estimated effects of age on ALOS for males and females. ALOS is U-shaped with respect to age, reaching a minimum near age 30 years. Under the age of 30, males tend to have longer LOSs compared with females. After the age of 30 years, males and females tend to have similar LOSs.

Figure 22. Estimated ALOS Trend, Affective Disorders, West Region, for Discharges Aged 40 Years



Abbreviations: ALOS, average length of stay

Figure 23. Estimated Effect of Age on ALOS, Affective Disorders, West Region



Abbreviations: ALOS, average length of stay

CONCLUSIONS

Since its inception several revisions have been made to the NIS sample design that affect estimates calculated from the NIS:

1. 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 2012 NIS was drawn from a frame of 44 States representing 96 percent of the U.S. population.
2. Beginning with the 1998 data year, NIS sampling methods changed to provide a better reflection of the cross-sectional population of hospitals and discharges. The hospital stratification variables were redefined, rehabilitation facilities were dropped from the target universe, and sampling preference was no longer given to NIS hospitals that were in the sample in prior years.
3. Beginning with the 2012 data year, the sampling unit became discharges rather than hospitals, the sample was stratified by nine census divisions rather than four census regions, long-term acute care facilities were dropped from the target universe, hospital entities were defined by hospital identifiers in HCUP State Inpatient Databases (SID) rather than identifiers reported by the annual American Hospital Association (AHA survey, and discharge weights were calculated on the basis of SID discharge counts rather than counts reported by the AHA survey.
4. The definitions and availability of NIS database variables changed over time. For example, diagnosis codes, procedure codes, and diagnosis-related groups changed annually. In addition, beginning with the 2012 NIS, data elements on the NIS were restricted to those available from all participating states and certain data elements such as State were no longer included.

Analysts who want to use the NIS to estimate trends in patient and hospital outcomes may need to adjust for these changes. This report described these changes, provided information on the impact that these changes had on estimates of numbers of discharges and other key variables, and contains recommendations for handling these and other issues when doing trend analyses. In particular, analysts may want to take advantage of discharge weights developed to overcome discontinuities associated with changes to the 1998 and 2012 NIS sample designs (http://www.hcup-us.ahrq.gov/db/nation/nis/nistrends.jsp).

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