

Approaches to designing and conducting research on hospitalization in view of the reduced samples in the 2008 to 2010 National Hospital Discharge Surveys

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Abstract

This paper describes challenges presented by reducing the sample size of the National Hospital Discharge Survey (NHDS) by half for the years from 2008-2010. NHDS, a nationally representative sample survey, was conducted annually from 1965 to 2010 by the National Center for Health Statistics, Centers for Disease Control and Prevention, and is the only source of trend data on hospitalizations during this period. Until 2007, data were gathered from about 400 hospitals and 360,000 discharges. In 2008-2010, data were gathered from about 200 hospitals and 166,000 discharges. Data from the half sample years are particularly important since they encompass the period when health care reform legislation passed, which is the baseline period to which any subsequent changes will be compared. This paper describes our findings on the effects of the half sample on data reliability for certain categories, and the implications of these findings for researchers interested in studying certain illnesses and patient groups.

Key Words: National Hospital Discharge Survey, reliability, hospitalization, sample size reduction

1. Background

The National Center for Health Statistics (NCHS) is part of the Centers for Disease Control and Prevention (CDC). NCHS collects, analyzes and disseminates information to monitor health and health care use. A number of health care provider surveys are conducted by the Division of Health Care Statistics including the National Ambulatory Medical Care Survey of visits to physicians' offices and community health centers, the National Hospital Ambulatory Medical Care Survey of visits to emergency departments, outpatient departments, and ambulatory surgery centers, and the National Hospital Discharge Survey (NHDS) of discharges from inpatient hospitals. This paper is focused on NHDS and the decision to reduce its sample size for the years 2008-2010. The consequences this change had on the reliability of estimates from the survey and suggestions for researchers on using and interpreting the half sample NHDS data are included.

2. National Hospital Discharge Survey

2.1 Description and Design

NHDS was initiated in 1965 and ended in 2010. It was the longest, continuously-fielded annual survey of inpatient care in US hospitals. Its objective was to provide information on the utilization of the Nation's hospitals and the nature and treatment of illness among hospitalized patients. The original survey was conducted from 1965 to 1987, and utilized a 2-stage, stratified, cluster design. In 1988, the survey was redesigned and a modified 3-stage, stratified, cluster design was implemented. The hospital sample was updated periodically to account for changes in the hospital universe over time.

Hospitals that were in-scope for NHDS were short-stay hospitals (average length of stay < 30 days); general (medical or surgical) and children's general hospitals, regardless of average length of stay; hospitals with at least 6 beds staffed for inpatient use; and those located in the 50 states and the District of Columbia. Out-of-scope hospitals for NHDS were Federal, military, Veterans Administration hospitals, and hospital units of institutions, such as prisons.

Since 1988 NHDS has had a modified three-stage probability design. The 1st stage was made up of Primary Sampling Units (PSUs): hospitals or geographic areas (e.g. counties, groups of counties, or metropolitan statistical areas). The 2nd stage was made up of hospitals selected within area PSUs, using PPS (sampling with probability proportional to size, that is, patient volume), and the 3rd stage was made up of inpatient discharges selected within hospitals according to a systematic random sampling technique.

2.2 Standard errors and reliability standards

Because a sample rather than the entire universe was surveyed, each estimate has a sampling error which is a measure of the sampling variability that occurs by chance when only a sample rather than the universe is surveyed. To derive standard errors for NHDS estimates, statistical software must be used that accounts for the complex survey design (e.g. SUDAAN, STATA or SAS). The relative standard error (RSE) of an estimate is obtained by dividing the standard error by the estimate itself. When multiplied by 100, the RSE is expressed as a percent of the estimate. This paper will present RSE's in the form of a percentage in the tables that follow.

In NHDS reports, estimates are not presented if they are based on fewer than 30 sampled cases or have a relative standard error greater than 30 percent. If a researcher chooses to report an estimate that does not meet these reliability guidelines, it is recommended that this be noted in the presentation or publication of the results.

3. Decision to cut the NHDS sample size

Before 2008, data were collected annually from about 400-500 hospitals, yielding approximately 300,000 inpatient discharges each year. From 2008-2010, due to budgetary constraints and the need to simultaneously fund a redesign of the NHDS, the decision was made to halve the sample. An average of about 200 hospitals was expected to yield about 150,000 inpatient discharges annually.

The goal in implementing the half sample was to adopt a very simple, efficient method of selecting a subsample of hospitals using the 2006 updated NHDS sample (excluding any out-of-scope hospitals) as the “frame.” An attempt was made to preserve the region and hospital sampling strata of the full sample. More information about this sampling is available (1).

4. Effects of Cutting the NHDS Sample

Table 1. Participation levels in the full (2007) and half sample (2008, 2009,2010) National Hospital Discharge Surveys

	Full sample 2007	Half sample 2008	Half sample 2009	Half sample 2010
# of in-scope hospitals	477	238	238	236
# of hospitals providing data	422	207	205	203
# of discharges sampled	365,648	165,630	162,151	151,551
Unweighted response rate	88%	87%	86%	86%
Weighted response rate	82%	79%	79%	79%

SOURCE: CDC/NCHS, National Hospital Discharge Survey

Table 1 presents NHDS data on the number of hospitals, unweighted discharges, and response rates, for the last full sample year (2007) and for the 2008-2010 half sample years. The half sample yielded close to, or in some cases even more than, the number of hospitals and discharges expected.

4.1 Reliability of demographic and clinical estimates based on the half sample NHDS data

The ability to report general information from the half sample years wasn't seriously affected. But, as was expected, the standard errors were larger. The data in Tables 2 and 3 show that many relative standard errors were double what they had been before the sample was reduced. Standard errors of larger estimates remained relatively low, and the reliability of these data were not of concern. Statistical testing found that there were few statistically significant differences before and after the half sample in the estimates we generally report in our publications or online.

Table 2. Numbers of hospitalizations and relative standard errors (RSEs) by sex and by age in 2007 (full sample) and 2008 (half sample)

	2007	2008	2007 RSEs	2008 RSEs
	Estimate in millions		%	%
Total	34.4	35.7	4.01	10.54
Male	13.8	14.4	4.50	10.77
Female	20.5	21.3	3.82	10.46
Under 15	21.8	19.8	18.08	24.28
15-44	10.6	10.5	3.95	10.61
45-64	8.8	9.3	4.06	10.49
65 and over	12.9	13.9	4.46	10.53

SOURCE: CDC/NCHS, National Hospital Discharge Survey

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Table 2 shows the numbers of hospitalizations and the relative standard errors by sex and by age for the last year of the full sample (2007) and the first year of the half sample (2008).

Table 3. Selected medical diagnoses and procedures from the full and half samples of the National Hospital Discharge Survey

	2007 (full sample)			2010 (half sample)		
	Sample Size	Weighted Estimate	Relative Standard Error (RSE)(%)	Sample Size	Weighted Estimate	Relative Standard Error (RSE)(%)
Pneumonia	9,696	1,056,000	5.3	4,074	1,128,000	12.4
Stroke	8,400	829,000	5.1	3,879	1,015,000	13.8
Diabetes	5,683	626,449	5.1	2,551	629,742	11.6
Hysterectomy	4,902	517,000	6.4	1,664	497,000	13.0
Hip Replacement	2,181	230,000	8.7	1,526	332,000	15.8

SOURCE: CDC/NCHS, National Hospital Discharge Survey

Table 3 shows examples of NHDS sample sizes and estimates of specific diagnoses and procedures for the last full sample year and the last half sample year. For these and a large number of other diagnoses and procedures which are reported annually the RSE's remained reliable.

5. Potential for drawing incorrect conclusions from NHDS data after the half sample if standard errors are not used

Although many overall estimates remained reliable during the half sample years, a number of concerns about reporting the data and drawing conclusions from smaller estimates from the half sample years remain. The concerns are different for non-technical audiences (like the media) and technical audiences (like researchers).

5.1 The Media

NHDS data is commonly reported by the media. Published articles almost always include only point estimates, with little or no mention of standard errors. Fortunately, conditions of interest to the press and the public are often common and RSEs remain relatively low. Point estimates from the half sample years and the full sample years may be included in reports of trends in hospital utilization with no mention of the difference in precision. Erroneous conclusions may be drawn about whether numbers have changed over time.

We continue to stress to the media that we produce estimates which have some degree of statistical uncertainty associated with them, since our results are based on a sample and not the universe. We now explain that estimates for the years 2008 to 2010 are based on a much smaller sample, and thus they are less precise than prior year estimates. Whenever possible, we test the data reporters plan to report in their articles, so that they can report whether apparent changes are statistically significant.

We often provide suggested wording to reporters to use when describing our data and its limitations so that they will include some mention of the precision of the estimates. Partly due to the increase in data from polling, including political polling, it has become more common to read about the margin of error of estimates and whether changes are considered “real” or “important” by experts. Articles increasingly say whether a difference or change in the data is considered to be significant.

5.2 Other Researchers

There are different issues with the use of our data by other researchers, including epidemiologists, health services researchers, economists, physicians, and other health professionals. These researchers often report findings from our data in health and medical journals, and at scientific and professional association meetings. They may have some statistical training themselves, or be working with co-authors who have some proficiency in statistics.

In the past some articles presenting data from NHDS did not use standard errors. Some researchers do not recognize the importance of taking errors into account when testing and interpreting data. When data from the half sample years, which have larger standard errors, are analyzed, it becomes even more important to avoid presenting incorrect or misleading conclusions.

The NHDS public use data files, due to confidentiality considerations, do not contain design information needed to produce standard errors. Specific standard errors are only available on our website for a limited number of categories in our posted tables. Instructions on how to calculate generalized standard errors using formulas are included in our data documentation. But researchers must request confidential data files from the NCHS Research Data Center to actually generate specific standard errors.

6. Designing, conducting and presenting research on hospitalization in view of the reduced sample sizes

When choosing research topics, data users should check to see if overall estimates in their areas of interest have relatively large standard errors. They can find these estimates in the posted tables on our website

http://www.cdc.gov/nchs/nhds/nhds_products.htm

or calculate them using formulas in the data use documentation. If these errors are high, the ability to drill down further, and still have reliable estimates will be limited. This limitation will affect their ability to conduct even general descriptive analyses of NHDS data. Researchers may have to limit drilling down, combine like categories, OR even not pursue a topic at all.

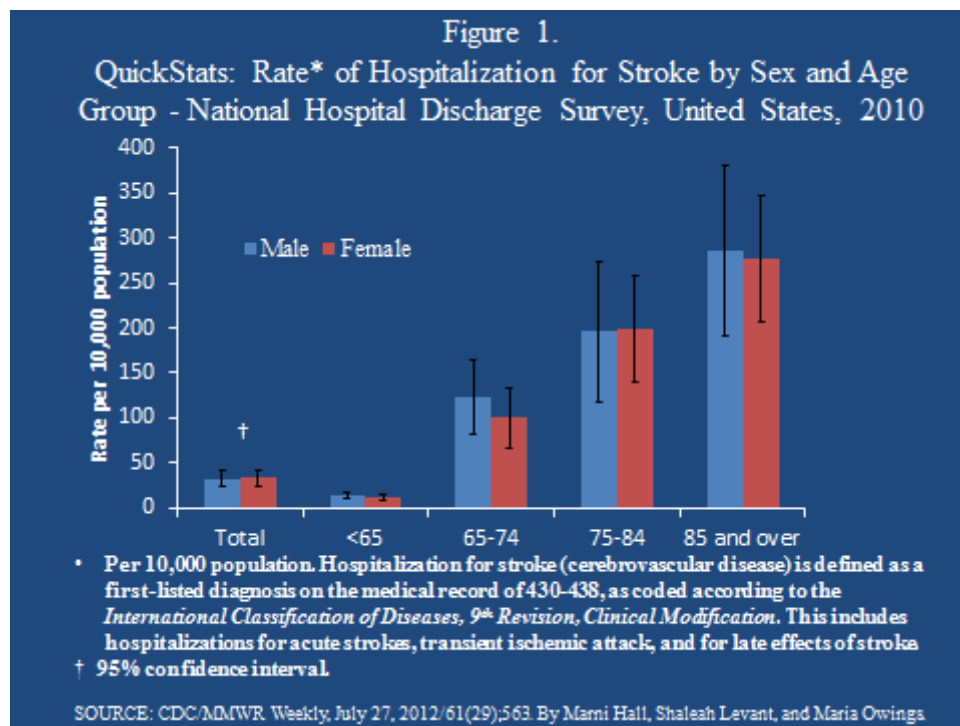
Many frequent users of NCHS provider surveys are accustomed to combining data over multiple years in order to augment sample sizes and obtain more reliable estimates. This will not work in the case of NHDS half sample years because estimates for each year are based on essentially the same independent sampling units, so combining years would not increase sample size. If a single-year estimate has low reliability, then the multiple year estimate would not show any improvement.

Researchers may decide to use modeling procedures with NHDS data, but unreliable numbers may affect how and if certain variables are included in the model. Low sample size may affect the Beta weight.

6.1 Hospitalizations for stroke – illustration of the use of confidence intervals

When presenting data from the half sample years, it is advisable to include confidence intervals with trend data since they effectively illustrate that standard errors for the half sample years are higher than other years. Also, presenting results of statistical testing in graphs, or in the text that accompanies them, will prevent readers from drawing their own conclusions based on perceived differences.

Figure 1 is similar to a graph that was published as a Quick Stat for the Morbidity and Mortality Weekly Review (MMWR) published by the Centers for Disease Control and Prevention (2). It is a good illustration of just how large the error bars are for 2010, the last of the half sample years. As with a number of publications, the MMWR requires that error bars be included in graphs to show the 95% confidence interval around estimates from sample surveys. This graph illustrates quite clearly that males and females within each of the age groups do not have significantly different rates. Although on visual inspection it appears that each successive age group of males and females has a higher rate than the preceding group, these changes were not significant in every case because of the large standard errors.

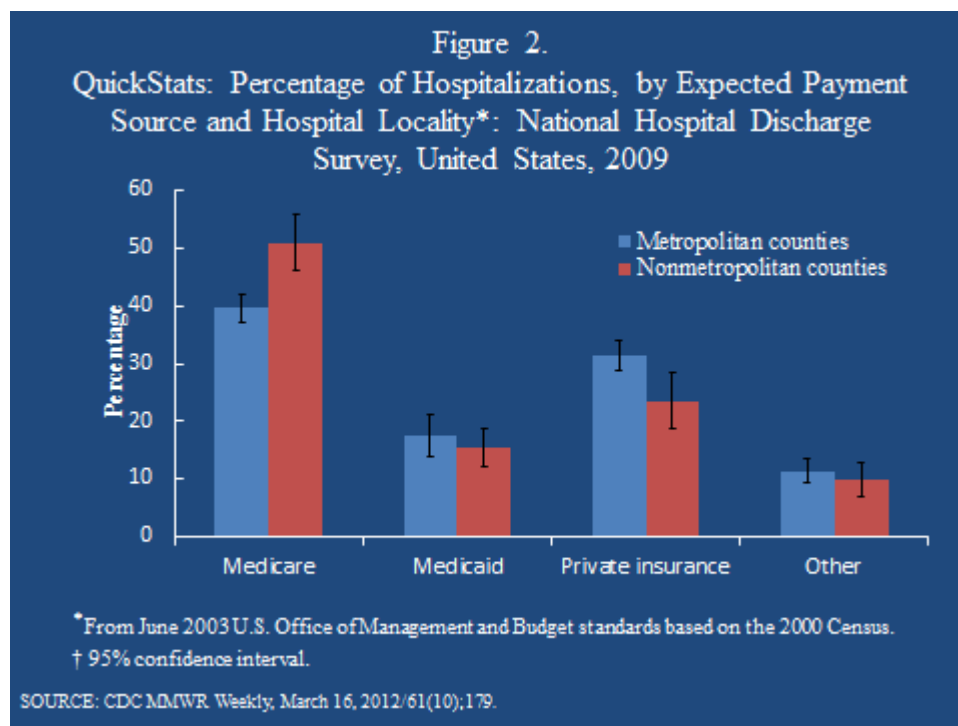


6.2 Hospitalizations by expected payment source and locality – illustration of use of percents when estimates would have been unreliable

In some cases, it may be advisable for researchers to report percents, or other statistics based on ratios, like average lengths of stay, since the standard errors of

these ratios are generally lower than estimates or rates. Figure 2 is another graph similar to one published as a QuickStat (3), which was based on 2009 data and compared inpatients in metropolitan and nonmetropolitan hospitals by expected source of payment. Overlapping error bars for the metropolitan and nonmetropolitan percent estimates indicate that the percentage of inpatients with Medicaid and other payment sources did not differ significantly between the two groups of inpatients. On the other hand, error bars for the percentage of metropolitan and nonmetropolitan hospital inpatients with Medicare and private insurance do not overlap. Inpatients in nonmetropolitan as opposed to metropolitan hospitals were more likely to have Medicare and less likely have a private insurer as the expected payment source for their hospitalization.

It is interesting to note the small error bars around these percents, though the figure includes half sample data from 2009. RSEs for percents, and for other ratio estimates (like average length of stay), are smaller because both the numerator and the denominator are from the NHDS. When they are positively correlated, this covariance component is removed from the variance estimate. For this reason, using ratio statistics can help researchers in their analyses, provided the correlation between numerator and denominator is positive. In cases like this, some of the aggregate estimates for rural inpatients with various sources of payment were unreliable for the half sample years and so they would not have been presented.



6.3 Pneumonia hospitalizations – comparing RSE's for estimates and percents

Table 4 presents the estimated number and percent of pneumonia inpatients by age. The RSEs for both the numbers and percents are included to illustrate that the estimates based on ratios – in this case based on the percents – have much lower RSEs. This table also

includes information about the sample sizes on which the estimates are based. Estimates for pneumonia hospitalizations, even when broken down by age, are still based upon a sufficiently large sample, and have RSEs low enough, to be reliable. This is an indication that more drilling down of the data is possible, without running into problems of data reliability. If the estimates did become unreliable, comparing percents with their lower RSEs could still be possible.

Table 4. Pneumonia inpatients in the National Hospital Discharge Survey half sample, 2010

	Sample Size	Weighted Estimate	RSE* of Weighted Estimate %	Percent Distribution	RSE* of Percent %
AGE	4,074	1,128,000	12.4	100%	N/A
< 15 years	457	156,000	23.0	13.9%	11.4
15-44 years	329	94,000	15.6	8.3%	10.1
45-64 years	971	257,000	12.2	22.8%	7.0
65-74 years	648	180,000	13.5	16.0%	8.2
75-84 years	890	240,000	12.6	21.2%	7.1
85+ years	779	201,000	14.0	17.8%	8.1

* RSE is relative standard error.

SOURCE: CDC/NCHS, National Hospital Discharge Survey

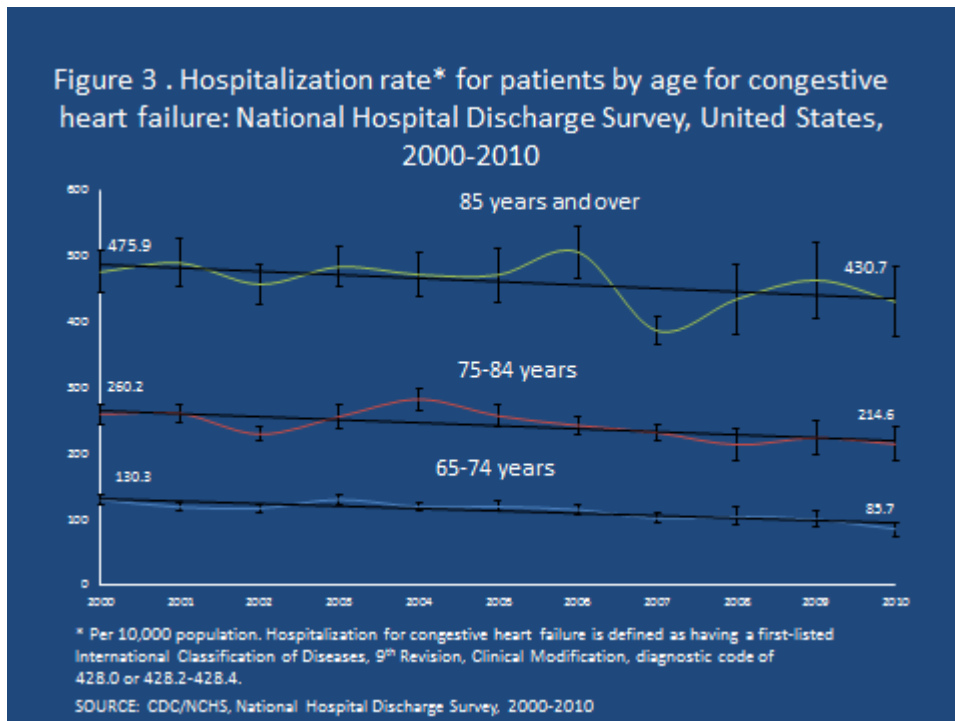
6.4 Congestive heart failure hospitalization rates for 11 years – illustrates issues analyzing trend data with full and half sample years.

This is a graph (Figure 3) showing CHF hospitalization rates from 2000 to 2010 for 3 older age groups. The final 3 years of the survey, based on the half sample, resulted in much larger error bars. But even with these large errors, the rate of hospitalization for CHF still increased with advancing age.

Figure 3 includes a trend line which shows that, even though estimates in the last three years had larger errors, the data still look consistent with the trends in effect before the half sample. If anything, the dip in the rate for the oldest age group shown in 2007 is what stands out in this figure. This was the last year of the full sample and is due to the relatively small sample sizes for this age group as well as sampling variability.

In trend analyses it is advisable to look at the data over a number of years to see what the trend has been up to and then after the half sample. Even if findings are not found to be statistically significant, researchers should advise readers that this could be due to larger standard errors in the half sample years. It is also possible to see discontinuities

beginning in 2008 with the half sample, which could be an artifact of the reduction in sample size.



7. Summary of discussion of half sample use

The National Hospital Discharge Survey remains a useful source of nationally representative hospitalization data for individual years and for tracking trends over time, even after reducing the sample size by half. Larger estimates, which generate the most interest, continue to be reliable and still have low relative standard errors. But estimates describing patients hospitalized for less common conditions and procedures, particularly for subgroups of patients, may not be reliable for the half sample years. When conducting in-depth analyses for less common conditions and procedures, it is advisable to request access to confidential data files from the NCHS Research Data Center so that specific standard errors can be generated, to allow for statistical testing of results. The research project's time line and budget will be affected by this added step.

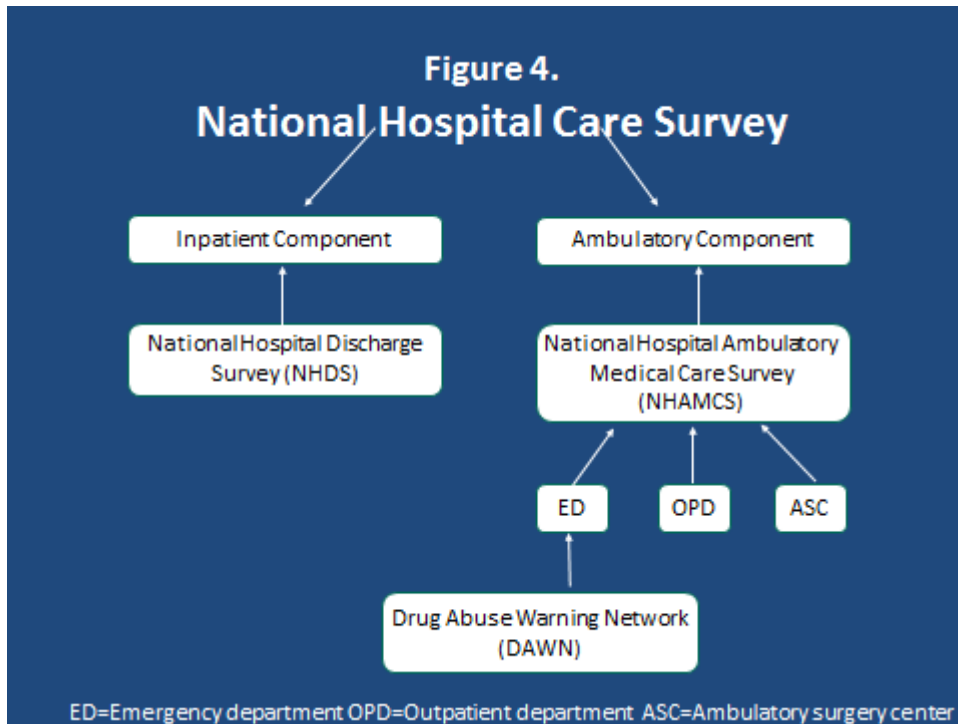
For additional information about the NHDS half sample, see the data file documentation for the half sample years (4-6).

8. Collection of national data on hospitalizations since NHDS ended.

NHDS ended in 2010, but this did not end inpatient hospital data collection by NCHS. Data for 2011 is being gathered as part of a new survey called the National Hospital Care Survey (NHCS). As depicted in Figure 4 below, inpatient data collection is now part of this larger hospital survey which will, beginning in 2013, also collect data from outpatient departments, emergency departments and ambulatory surgery locations in the

hospital and in freestanding centers. The Drug Abuse Warning Network (DAWN) will also be merged into this survey. More information about the NHCS can be found at

<http://www.cdc.gov/nchs/nhcs.htm>.



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