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THE HEALTHCARE COST AND UTILIZATION PROJECT (HCUP)
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METHODS FOR PRODUCING
RAPID CYCLE ESTIMATES
DELIVERABLE #1325.04A

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INTRODUCTION

This report lays out our plans for creating same-year projections for inpatient and outpatient statistics using quarterly data from selected Partners. Currently, release of NIS data lags the calendar year from which that data was drawn by 17 months. The goal of this task is to greatly reduce the time lag for issuing National-, Regional-, and/or State-level information. We envision the primary outcome of this process will be information-centered rather than database-centered.

To achieve these goals, we plan to leverage the current HCUP Partner relationships to obtain quarterly data available from HCUP Partner shortly after a quarter's end. Prior to constructing projections, these data will be processed, and their quality and completeness assessed. We mention these tasks only to acknowledge their importance. This report focuses on plans and issues of using that processed data to create same-year projections. This work involves designing, testing, and implementing methods to generate those projections.

This report summarizes the proposed approach for creating and testing early projections using quarterly data. Earlier efforts in this direction using “early” annual data found insufficient data to produce accurate estimates. AHRQ and Thomson Reuters speculated that broadening the data pool through quarterly data might improve both the accuracy and timeliness of early projections. Towards those ends, this report proposes:

1. Methods for producing same-year projections
2. Approaches for testing the projections
3. Criteria for evaluating the tests.

The methods described in this report assume access to all available quarterly data. Implementation of these methods in 2010, however, may not be possible because all such data will not be available. The first processing of quarterly data will not occur until 2010, and then only for five states.

BACKGROUND

In 2008, as part of the broader Rapid Cycle Estimates Task, the HCUP team was tasked with evaluating the feasibility of collecting quarterly discharge data from HCUP Partners. For the quarterly data feasibility study, conducted in November 2008, the HCUP Team surveyed all 40 HCUP Partners to determine the availability, quality, and consistency of quarterly data. Thirty-six out of 40 Partners responded to the survey and approximately 80% of HCUP Partners (32 states) indicated that they are collectors of quarterly inpatient data. Twenty-six percent of the respondents reported that the quality of their quarterly data differs from that of their annual data, and 32 percent reported that their quarterly data are less complete than their annual data. Our biggest concerns relate to the Partners’ ability to obtain all of the records in a timely manner, given frequent hospital delays and subsequent resubmissions. The evaluation report1 summarized the findings and recommended strategies for pursuing quarterly data from HCUP Partners. A subsequent report2 estimated costs and examined infrastructure requirements for obtaining and processing quarterly data.

A separate task attempted to generate national estimates of selected statistics for the previous year based on annual inpatient discharge data from a subset of states that were expected to supply data

1Deliverable #825.21A “State Quarterly Data Evaluation Report”
2Deliverable # 825.21B “Quarterly Data Infrastructure and Recommendation Report”
“early” (before August or September). The focus of this effort was to develop estimates using existing data streams of annual inpatient data. We tested methods for predicting average charges, average lengths of stay, average mortality rates, and the total number of discharges for 28 diagnosis and procedure categories, as well as for four patient safety indicators\(^3\). These projections were found wanting. Rather than attempt to fit more complicated models to improve estimates using annual data, AHRQ and Thomson Reuters researchers concluded that resources would be better spent by shifting efforts to developing estimates using early quarterly data expected to be available from a broader array of states.

**RAPID CYCLE PROJECTIONS**

In the previous study, we attempted to develop projections for the previous year. In this study, we will attempt to develop projections for the current year. For example, in August of 2010 we will attempt to deliver estimates of average 2010 charges for patients hospitalized with asthma using previous year State Inpatient (SID) data in combination with 2009 quarterly data and 2010 first quarter data obtained from states with quarterly data available by July of 2010.

We foresee same-year projections as supplemental information that augments and enhances HCUP data. Estimates from annual Nationwide Inpatient Sample (NIS) files will remain the “gold standard” for hospital-based health care statistics. In descending order of importance, our goals are to generate:

- national or regional projections for the entire current year,
- national or regional projections for Q1 of the current year, and
- State-specific projections for all of the current year.

**Methods**

Initially, we will give higher priority to estimates for average charges and numbers of discharges over estimates for ALOS and mortality. These outcomes are expected to be particularly relevant to the present health care funding debate.

**Outcome statistics and patient conditions**

We will generate projections of discharge counts and average total charges for patients with selected principal diagnoses and procedures. Table 1 lists the conditions, procedures, and patient safety indicators (PSIs) we will employ in our analyses. Most of the condition and procedure categories are defined by AHRQ’s Clinical Classification Software (CCS). Other categories are defined by specific ICD-9-CM diagnosis and procedure codes.

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\(^3\)Deliverable #825.11B “Rapid Cycle Estimates Test Methods Report”  
### Table 1. Patient Conditions and Procedures

<table>
<thead>
<tr>
<th></th>
<th>Single-CCS</th>
<th>Multi-CCS</th>
<th>ICD-9-CM codes</th>
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<td><strong>Diagnoses</strong></td>
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<tr>
<td>1. Asthma</td>
<td>128</td>
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<td>2. Cancer - Breast</td>
<td>174.x, 175.x, 233.0</td>
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<td>3. Cancer - Colon</td>
<td>153.x, 159.0, 230.3</td>
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<td>4. Cancer - Lung</td>
<td>162.2-162.9, 231.2</td>
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<td>5. Cancer - Prostate</td>
<td>185, 233.4</td>
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<td>6. Diabetes</td>
<td>49, 50</td>
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<td>7. Acute Myocardial Infarction</td>
<td>100</td>
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<td>8. Depression (MHSA Mood disorders)</td>
<td>657</td>
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<td>9. Decubitus Ulcers</td>
<td>12.3.1</td>
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<td>10. Stroke, ischemic</td>
<td>433.x1, 434.x1, 436</td>
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<td>11. Dementia</td>
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<td>12. Methicillin-resistant <em>Staphylococcus</em></td>
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<td>13. Pneumonia</td>
<td>122</td>
<td>CCS 122 or ICD-9 code 487.0</td>
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<td>14. Ventilator associated pneumonia</td>
<td>997.31 (implemented FY2008)</td>
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<td>15. Postoperative infection</td>
<td>998.51, 998.59</td>
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<td>16. <em>Clostridium difficile</em></td>
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<td>17. Peptic Ulcers</td>
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<td>18. Septicemia</td>
<td>See Table 3</td>
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<td>19. Cellulitis</td>
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<td>20. Renal Failure, Acute</td>
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<td><strong>Procedures</strong></td>
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<td>21. Hip Replacements</td>
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<td>22. Knee replacements</td>
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<td>23. Bariatric Procedures</td>
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<td>24. C-sections</td>
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<td>25. CABG</td>
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<td>26. PTCA</td>
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<td>27. Spinal fusion</td>
<td>81.00-81.09, 81.31-81.39, 81.64</td>
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<td><strong>Patient Safety Indicators</strong>*</td>
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<td>28. Selected infections due to medical care (Central line infections)</td>
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<td>29. Postoperative sepsis</td>
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<td>30. Accidental puncture or laceration</td>
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<td>31. Iatrogenic pneumothorax</td>
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<tr>
<td>32. Postoperative hemorrhage or</td>
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<tr>
<td>33. Postoperative respiratory failure.</td>
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</table>

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*PSI specifications are available at [http://www.qualityindicators.ahrq.gov/psi_download.htm](http://www.qualityindicators.ahrq.gov/psi_download.htm)
### Table 2. Codes for Methicillin-Resistant *Staphylococcus Aureus* (MRSA)

<table>
<thead>
<tr>
<th>MRSA requires 2 codes:</th>
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<tr>
<td>1. V09.0 (infection with microorganisms resistant to penicillins) plus a code for Staph aureus Infection.</td>
</tr>
<tr>
<td>2. <strong>Staph aureus infections:</strong></td>
</tr>
<tr>
<td>482.41 Pneumonia due to Staphylococcus aureus</td>
</tr>
<tr>
<td>038.11 Staphylococcus aureus septicemia</td>
</tr>
<tr>
<td>041.11 Staphylococcus aureus infection in conditions classified elsewhere and of unspecified site</td>
</tr>
</tbody>
</table>

### Table 3. Codes for Septicemia

<table>
<thead>
<tr>
<th>Any of the following codes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>038.0 Streptococcal septicemia</td>
</tr>
<tr>
<td>038.10 Unspecified staphylococcal septicemia</td>
</tr>
<tr>
<td>038.11 Staphylococcus aureus septicemia</td>
</tr>
<tr>
<td>038.19 Other staphylococcal septicemia</td>
</tr>
<tr>
<td>038.2 Pneumococcal septicemia</td>
</tr>
<tr>
<td>038.3 Septicemia due to anaerobes</td>
</tr>
<tr>
<td>038.40 Septicemia due to unspecified gram-negative organism</td>
</tr>
<tr>
<td>038.41 Septicemia due to hemophilus influenzae (H. influenzae)</td>
</tr>
<tr>
<td>038.42 Septicemia due to Escherichia coli (E. coli)</td>
</tr>
<tr>
<td>038.43 Septicemia due to pseudomonas</td>
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<tr>
<td>038.44 Septicemia due to serratia</td>
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<tr>
<td>038.49 Other septicemia due to gram-negative organism</td>
</tr>
<tr>
<td>038.8 Other specified septicemia</td>
</tr>
<tr>
<td>038.9 Unspecified septicemia</td>
</tr>
<tr>
<td>003.1 Salmonella septicemia</td>
</tr>
<tr>
<td>054.5 Herpetic septicemia</td>
</tr>
<tr>
<td>036.2 Meningococcemia</td>
</tr>
</tbody>
</table>
Estimation strategies

We will use historical SID data to simulate the expected arrival of quarterly data availability (shown in Table 4), generate projections from those data, and then assess the accuracy of those projections, as we explain in this section.

We will develop and test the accuracy of our methods using historical data. In particular, we will generate projections using only the data expected to be available in July of the current year. We will then compare those projections to the actual known national estimates provided by the entire NIS for that year.

Our objective is to generate early projections, not to create an early version of the NIS. So we will not sample hospitals as we do for the NIS. However, we will use the NIS hospital stratification scheme to help produce estimates, as explained below.

By dividing each of the annual SID files for the years 2003—2007 into separate quarterly files, we will simulate the arrival of quarterly State Inpatient Data (SID) files for the years 2003—2007. Using those data we can approximate the expected quarterly data available for projections.

For example, to estimate full-year 2006 discharge counts we will use:

1. Quarterly data from 2003 and 2004, which will be available for all four quarters for all NIS states,
2. Quarterly data from 2005, which is expected to be fully available from some NIS states and partially available from others, and
3. First-quarter data from 2006, which is expected to be available from a subset of NIS states.

The next section of this report presents methods for forecasting estimates.

Perhaps the simplest approximation for future NIS estimates is the most recently available NIS estimate. For example, we will use the 2004 NIS discharge estimates to forecast the 2006 NIS discharge estimates. Any proposed methods should do at least as well as this “carry the latest available year forward” forecast. Therefore, we will use these simple predictions as comparison benchmarks for model performance.

Below, we propose methods to produce estimates from a combination of the NIS, the SID, and early quarterly data. During the course of the study, we may modify these methods or use completely different methods depending on the success of these methods and on what we learn about the observed trends.

Statistical methods

We will develop estimates of quarterly trends based on full NIS estimates beginning with the 1998 data year. We will then use the simulated early quarterly data to extend the quarterly NIS estimates beyond the latest available year of the NIS. The forecasting models will estimate quarterly statistics for up to three years past the latest available NIS file.

Rather than use patient-level data, which would involve inordinately large databases, we will use data summarized by quarter. For example, we will calculate average charges for each quarter. We will also calculate standard errors of average charges, which can be used to weight observations in some longitudinal regression models.

We will employ SAS® Forecast Studio, a time series forecasting application. SAS introduced this tool earlier in 2009 with version 9.2 SAS® (it was unavailable for earlier efforts to create early NIS estimates).

The same-year projections described in this report will involve a large number of forecasting models. Forecasting four separate measures for 33 different conditions will result in 132 different models for the NIS component alone. Additional state-specific forecasts will also be generated. The SAS® time series tool was designed for problems requiring some degree of automation such as this. Figure 1 represents one of the outputs from this tool, demonstrating the discharge count model and projections for Septicemia.
Figure 1. Septicemia Model

In reading this graph:

- Black dots represent the historical quarterly NIS estimates from 1998 through 2007.
- The blue line represents the modeled values.
- Hollow circles represent projected values from Q1 2008 through Q4 2010.
- The purple lines represent the upper and lower ranges of a 95 percent confidence interval for each projection.

The SAS® tool compares the results of approximately 20 different time series models based on user supplied criteria and selects the most accurate model. As described in a SAS White Paper5:

The goal is to provide a list of candidate models that will forecast the large majority of the time series well. In general, when an analyst has a large number of time series to forecast, the analyst should use automatic forecasting for the low-valued forecasts; the analyst can then spend a

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5Large-Scale Automatic Forecasting Using Inputs and Calendar Events: A demonstrated technique for efficiently producing forecasts for millions of time series. The SAS Institute
larger portion of his/her time dealing with high-valued forecasts or low-valued forecasts that are problematic.

The types of models considered range from relatively simple to very sophisticated and complex methods. These models decompose time series into:

- Level (mean) component,
- Trend factors, and
- Seasonality factors.

In addition, these models can identify inflection points where observed behavior changes, perhaps caused by changes in coding or treatments.

Figure 2 illustrates another example with the average total charge model for Asthma discharges by quarter. This chart demonstrates the model’s ability to derive seasonality factors. Although Figure 2 shows the trend in unadjusted dollars, we will be modeling inflation-adjusted dollars in this project.

**Figure 2. Asthma Model**

Using only NIS data, accurate projections for many of the 33 conditions appear feasible. In addition, these same techniques will be used to project state-level estimates.
Mean Absolute Percentage Error (MAPE)

We will use the mean absolute percentage error for evaluating the fit of each model by comparing the actual data to the predictions. This is a common measure of forecasting accuracy, which we will use to compare the performance of the various models. Smaller values of MAPE are better.

We will usually select the model with the lowest MAPE value. However, we will also consider second-best and third-best models if the "best" model generates seemingly unlikely forecasts.

Incorporating Quarterly Data into the Models

While NIS data will be used for projecting overall levels, trends, and seasonality for the various measures, it is historical and will lag the current year by at least six quarters. When the underlying factors are relatively constant, this should be sufficient for accurate and reliable projections. Trends, however, sometimes change. There are inflection points when state or Federal policies are altered, and when technology advances. We see quarterly state data as a data tool that will help us identify these inflection points.

More research and testing are needed to determine how to incorporate quarterly state data into the models for adjusting national projections. However, quarterly data will be immediately useful for modeling specific state-level outcomes. Once a suitable method is determined, the project team will assess the value of adding the quarterly data from early states.

One approach we will consider for incorporating early quarterly data is the identification of potential "bell weather" states that accurately anticipate the NIS trend beyond the latest NIS year.

Another approach we will test is a process wherein we will:

1. "inflate" estimates from the early states up to the national level for each quarter beyond the latest NIS year,
2. append these quarterly estimates to the historical NIS trend, and
3. re-fit the forecasting model based on the appended time series.

The "inflated" early quarterly estimates will essentially treat the early data available each quarter as a new sampling frame for the NIS. We will stratify the early quarter hospitals using the NIS stratification scheme and weight the estimates in each stratum to the national level. We will have potentially different early states for each quarter. Therefore, these inflated estimates will be created quarter-by-quarter. These new quarterly estimates will be appended to the end of the historical NIS time series. These new quarterly estimates will be treated by the forecasting model as if they are actual NIS estimates. However, the model will take into account the entire series, not just the new quarterly estimates. Therefore, the new quarterly estimates will influence forecasts, but the new estimates will not substitute for the forecasts.

Outpatient Data

Our initial efforts will focus on inpatient measures, although the task at hand is much broader. HCUP Inpatient data, including the NIS spans nearly 20 years. There is obviously a rich and robust source of information and a long period of time series data. For outpatient data, however, the data is more limited. While some ambulatory surgery (AS) and emergency department (ED) data reaches back more than 15 years, many state data files have more limited availability. In addition, there are no nationwide samples of AS data and only one year for Nationwide ED data. For that reason, our approach for outpatient data is narrower and limited to state-level AS and ED projections for the states selected. National projections are unlikely until there are at least two, and possibly three or more years of Nationwide ED data.
Available Data

AHRQ has tasked the HCUP team with creating same-year projections by August of 2010. At that time, data resources available will include Nationwide Inpatient Sample (NIS), State Inpatient Data (SID), as well as quarterly data from up to five states.

Nationwide Inpatient Sample

NIS files are created annually for the calendar year two years prior. The NIS are generally available before the end of the second quarter. For example, the 2007 calendar year NIS were released in June of 2009. We expect the 2008 NIS to be available two months prior to delivery of the 2010 Rapid Cycle estimates.

State Inpatient Data

Availability of annual state data spans approximately 10 months (although longer interludes are not uncommon). The first state data are supplied to HCUP beginning in May following the calendar year’s end. We will use any and all available 2009 SID files. In practical terms, this means that only state data received by HCUP before July 1, 2009 can be used. The 2008 HCUP data acquisition experience saw eight states supply their 2008 data before July 1, 2009.

Quarterly State Inpatient Data

Same-year projections can also use quarterly data acquired and processed for the Rapid Cycle estimates task (Task C.25). For 2010, we will have quarterly data from up to only five states.

The initial states have not been selected, although we will target states that report availability of quarterly data within four or five months after the quarter’s end. These are states that tend to also supply annual data before July 1st, so we expect a great deal of overlap between the quarterly data states and the states with 2009 SID data.

Based on the “State Quarterly Data Evaluation Report” quarterly data is available from most states. Hypothetically, by July of 2010, some quarterly data will be available from 34 states. By quarter,

- Q1 2009: 34 States
- Q2 2009: 33 States
- Q3 2009: 31 States
- Q4 2009: 25 States
- Q1 2010: 8 States

Table 4 summarizes data availability by state and quarter.

Because of the limited range of quarterly data, it is unlikely that same-year projections in 2010 will utilize quarterly data. Where annual data for 2008 and quarterly 2009 data are available, state-level projections are possible. But to the extent that quarterly data are required to adjust projections, implementing same-year projections may need to wait until sufficient quarterly data is available.

Processing of quarterly data will be more limited than processing of annual data. For quarterly data, the focus will be those variables required for generating same-year projections along with data elements necessary for assessing the quality and completeness of the quarterly data.
## Table 4. Availability of Quarterly Data in July of 2010

<table>
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<tr>
<th></th>
<th>2009 Q1</th>
<th>2009 Q2</th>
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## TIMELINE

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<td>Test and evaluate methods for rapid cycle quarterly data methods report on quarterly inpatient data</td>
<td>November 30, 2009</td>
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<tr>
<td>Full and final detailed report on same year projections (rapid cycle quarterly data with IP, ED and AS data)</td>
<td>December 31, 2009</td>
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