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Small Patient Population and Low Frequency Event Effects on the Stability of SNF Quality Measures

A study conducted by staff from the Division of Health Care Policy and Research University of Colorado at Denver and Health Sciences Center (UCDHSC) for the Medicare Payment Advisory Commission

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1.0 INTRODUCTION

In 2004, Medicare beneficiaries experienced approximately 2.5 million admissions to post-acute skilled care in nearly 15,000 Medicare-certified skilled nursing facilities (SNFs) nationally, requiring Medicare expenditures of $16 billion (Centers for Medicare & Medicaid Services, 2004; Medicare Payment Advisory Commission, 2005b; Medicare Payment Advisory Commission, 2006b). In November 2002, the Centers for Medicare & Medicaid Services (CMS) implemented the Nursing Home Quality Initiative (NHQI) involving public reporting of quality measures on the Nursing Home Compare Web site (http://www.medicare.gov/nhcompare/home.asp) to increase nursing home accountability and release quality information to the general public (Harris & Clauser, 2002). Of the 15 publicly reported quality measures, only three pertain to post-acute care relevant to Medicare SNF patients: delirium, moderate to severe pain, and pressure ulcers. Furthermore, the three short-stay quality measures require the 14-day Minimum Data Set (MDS) assessment (as well as the 5-day MDS assessment in the case of pressure ulcers) be present in order to calculate the measure. Because only 45 to 52 percent of SNF patients remain in the facility long enough to have a 14-day assessment completed (the remainder are discharged to the community, rehospitalized, transferred, or deceased before the 14-day assessment occurs), the patient population on which the measures are calculated is systematically biased (DataPRO Team, 2002; Medicare Payment Advisory Commission, 2005c). For these reasons, the Medicare Payment Advisory Commission (MedPAC) has endorsed the addition of nursing home quality measures that are specific to short-stay patients in SNFs, including rehospitalization and community discharge rates (Medicare Payment Advisory Commission, 2005b; Medicare Payment Advisory Commission, 2006b).

For many patients admitted to SNFs, the primary treatment goal is the stabilization of medical or post-surgical problems following an acute hospitalization. Measures of rehospitalization therefore capture an important quality domain. For many other SNF patients, the major goal of SNF care is rehabilitation, either for traditional rehabilitation conditions such as stroke or fractures or for functional losses following extensive medical or surgical problems ("deconditioned" individuals). The primary goal of rehabilitative therapy is often discharge to community, and therefore community discharge is another important quality domain. In fact, 78 percent of SNF patients received rehabilitation services in 2003 (Medicare Payment Advisory Commission, 2005a) and 43 were percent expected to be discharged within 90 days[1]. This study focuses on measures of rehospitalization and community discharge as facility quality indicators.

Rehospitalization as a measure of SNF quality has face validity—patients would prefer to avoid it whenever possible—and has been used as a quality marker in other settings. A growing body of literature exists on hospitalizations for ambulatory care sensitive conditions in the ambulatory care setting (Fleming, 1995; Caminal, Starfield, Sanchez, Casanova, & Morales, 2004; Laditka, 2003; Solbert et al., 1990; Weissman, Gatsonis, & Epstein, 1992; Bindman et al., 1995; Intrator, Castle, & Mor, 1999), and hospitalization is

[1] Author's calculations from DataPRO SNF Stay File MDS item Q1a for admissions in 2003.

a publicly reported quality measure for home health care (Agency for Healthcare Research and Quality, 2002; Centers for Medicare & Medicaid Services, 2006; National Quality Forum, 2005). In the nursing home setting, studies have shown that hospitalization of nursing home residents are frequently avoidable (Gillick & Steel, 1983; Gabow et al., 1985; Saliba et al., 2000; Intrator, Zinn, & Mor, 2004). Studies have demonstrated associations between rehospitalization and nurse staffing ratios and between rehospitalization and the usage of advanced practice nurses (physician extenders), further supporting the validity of rehospitalization measures as indicators of facility quality (Kramer & Fish, 2001; Intrator et al., 1999).

Researchers commonly examine overall rates of rehospitalization without considering the reason for hospitalization. However, when assessing facility quality of care, we believe it is critical to focus on only those conditions for which hospitalization may be avoided with high quality nursing care. Through a combination of clinical considerations and analyses of rehospitalization rates, Kramer and colleagues at UCDHSC identified five conditions for which rehospitalization is potentially avoidable in nursing homes (Kramer, Eilertsen, Lin, & Hutt, 2000b; Hutt, Lin, & Kramer, 2000; Kramer, Eilertsen, Lin, Martau, & Hutt, 2000a; Kramer et al., 2001). These five conditions are congestive heart failure (CHF), respiratory infection, urinary tract infection (UTI), sepsis, and electrolyte imbalance. Not all hospitalizations for these conditions are preventable; however, rates of hospitalization for these conditions were significantly lower in facilities with higher nurse's aide and licensed staff levels as well as in facilities with higher staff retention, after adjusting for facility case mix (Kramer et al., 2001).

For each of these conditions, reducing hospitalization requires the use of preventive measures to avoid declining health, the early detection of signs and symptoms of worsening health, and prompt intervention by nursing staff and the physician when needed. For CHF, hospitalization might be reduced by proper medication administration, adherence to any fluid or dietary restrictions, and early recognition of increased shortness of breath or edema. Respiratory infections may be reduced by following proper precautions, appropriate positioning of residents with swallowing problems to avoid food aspiration that could lead to pneumonia, and administering pneumonia and influenza vaccinations. Hospitalization for electrolyte imbalance often results from dehydration or poor nutrition, which may be prevented with careful monitoring of patient fluid and nutrient intake. UTI can be reduced by weaning patients from urinary catheters (Wald, Epstein, & Kramer, 2005), following sterile procedures, and the early recognition of the signs and symptoms of UTI. Sepsis, a blood-borne bacterial infection, can be avoided if infections are identified and treated before becoming systemic. However, infections can present in unusual ways in older adults (e.g., confusion) and staff must be alert and respond promptly when any symptoms of infection are identified.

Community discharge has clear implications for both patient quality of life and cost of care, and is frequently used as a construct for evaluating rehabilitation (Kramer et al., 1997; Kramer et al., 2000c; Coleman et al., 2000; Hutt et al., 2001; Murry, Singer, Dawson, Thomas, & Cebul, 2003; Braun, 1991; Fitzgerald, Moore, & Dittus, 1988; Fitzgerald & Dittus, 1990; Jette, Warren, & Wirtalla, 2004). Community discharge,

while itself a gross marker of functional improvement, has been associated with significant functional recovery across a range of specific functional measures. In four studies, community discharge was also associated with processes of SNF care (Braun, 1991; Murry et al., 2003; Jette et al., 2004; Kramer et al., 2006). Community discharge is clearly an important indicator of quality of care.

The development of a SNF stay file linking claims and MDS assessment data made it possible to calculate rates of rehospitalization for potentially avoidable causes and rates of community discharge (DataPRO Team, 2002). However, important questions remain if these measures are to be used in public reporting. First, optimal methods for risk adjustment need to be developed so that facilities are not at a disadvantage by admitting sicker patients for whom it is more difficult to achieve the outcomes. Second, the minimum number of SNF admissions per facility must be determined so that facility measures are accurate and stable, and unbiased comparisons between facilities can be made. If the minimum number of stays is set too low, then measures can be misleading in small facilities, but if the minimum is set too high, then many facilities will be excluded from the measures. Third, the duration of the measurement period should be assessed to determine whether there are advantages of focusing on shorter stays such as 30 days, or whether the entire SNF stay (up to 100 days) is the more appropriate focus. The purpose of this study was to investigate these measurement issues for the rehospitalization and community discharge measures.

2.0 METHODS

2.1 Data source

The national DataPRO SNF Stay File (DataPRO) for calendar years 1999 through 2004 was used for all analyses. Data for calendar years 1999 through 2004 were selected as they represent SNF stays that occurred following the introduction of the SNF prospective payment system. The file contains claims data (Medicare Standard Analytic Files Part A) corresponding to the qualifying hospital stay, SNF stay, and rehospitalizations following the SNF stay in addition to selected MDS items for each SNF admission. Each DataPRO record contains facility level characteristics from the Online Survey Certification and Reporting (OSCAR) system. Resident level variables include demographics; ICD-9-CM diagnosis codes for the qualifying hospital stay, SNF admission, and any rehospitalizations; MDS physiologic, functional and cognitive performance measures; SNF and hospital stay charges and Medicare payment; length of SNF and hospital stays; admission and discharge location; and mortality. Facility characteristics include type of ownership, number of beds, and facility structure (e.g., hospital-based vs. freestanding). Facility MSA was obtained from CMS to determine urban versus rural setting as this data item is not contained in the DataPRO file. Documentation including variable specification for the DataPRO file is available (Malitz & DataPRO Project Investigators, 2002).

2.2 Sample

A total of 13,146,278 stays for calendar years 1999 through 2004 were extracted from the DataPRO file. Approximately 10 percent (1,301,444) of stays were excluded from subsequent analyses for reasons related to payer (e.g., no Medicare payment), facility type (e.g., swing beds), or data quality (e.g., SNF stays without a qualifying hospital claim). The resulting analysis file contained 11,844,834 valid stays averaging approximately two million stays and approximately 14,700 facilities per calendar year. Analysis file exclusions and detailed analysis file information for the calendar year 2004 file are enumerated in Appendix Table A. Resident characteristics for SNF stays beginning in calendar year 2004 are presented in Appendix Table B.

2.3 Outcome measures

Measures of community discharge and potentially avoidable hospitalization for five conditions – electrolyte imbalance, respiratory infection, congestive heart failure, sepsis, and urinary tract infection – were calculated within 30 and within 100 days of SNF admission. In addition, measures of rehospitalization for *any* of the five conditions within 30 and within 100 days were calculated. All measures excluded residents who died during the outcome measure period (i.e., for the 30 day outcome measures, any resident who died within 30 days of his/her SNF admission was excluded from the measure).

2.3.1 Community discharge definition: Community discharge was defined as the number of residents discharged directly to the community from the SNF. However, if a resident was rehospitalized within one day of the community discharge the stay was reclassified as a rehospitalization and the resident was not classified as discharged to the community.

2.3.2 Rehospitalization definitions: The rehospitalization outcomes were defined as rehospitalizations at either an acute-care or critical access hospital, excluding any hospitalizations with an intervening Medicare claim between the SNF stay and rehospitalization. The measure included rehospitalizations that occurred within one day of the end of the SNF stay (regardless of discharge location). Condition-specific rehospitalization measures were defined as follows:

- **electrolyte imbalance**
- **respiratory infection** included pneumonia that may be either bacterial or viral, and upper airway infections like bronchitis
- **congestive heart failure**
- **sepsis** - included infection of the bloodstream from any bacteria
- **urinary tract infection** included infections of the bladder, kidney, prostate, urethra, or any other part of the urinary tract.

A composite measure of rehospitalization for *any* of the above five conditions was also created.

2.4 Analysis

2.4.1 Risk adjustment: Some SNFs admit more people who have higher illness burdens, who are frailer, and who have less functional reserve. Residents with these characteristics are less likely to be discharged to the community and more likely to be rehospitalized. Evaluating SNF performance must take into account the mix of characteristics of the individuals receiving SNF care. To evaluate outcomes for residents from different SNFs, each outcome measure was risk adjusted using logistic regression.

Selection of covariates: The first step in the development of risk models for each of the outcome measures entailed conceptually and clinically selecting candidate variables that might influence the outcome under consideration. Candidate variables that were deemed subjective (e.g., MDS item Q1c - discharge expected within 30 days), related to incentives (e.g., payment), or that had questionable data quality (e.g., MDS Section I – diagnoses) were excluded. Additionally, composite measures (e.g., Barthel Index) were selected instead of individual data items (e.g., transferring) to increase parsimony of the resulting models. Covariates derived from MDS items used the five-day MDS assessment to capture baseline status. Covariates for facility characteristics such as hospital-based SNFs were also included.

Weighted comorbidity indices were created based on the approaches of Charlson et al., 1987; Deyo et al., 1992; and Romano et al., 1993 using the qualifying hospital stay diagnoses. Using a 3 percent sample of 2004 data, regression models of hospitalization for each dependent measure were developed using 17 diagnostic categories. The beta coefficients derived from the regression models were used as weights for the entire 2004 sample, and the comorbidity indices were calculated by summing the beta coefficients with $p<.05$.

Development and validation of risk adjustment models: Bivariate measures of association (Pearson correlation) and stepwise logistic regression were conducted to address the relationship between candidate risk factors and outcome measures under consideration. To estimate and then validate each logistic regression model, the entire pool of SNF stays for 2004 was randomly split into two groups, a developmental sample comprised of 10 percent of the stays and an independent validation sample comprised of the remaining 90 percent of SNF stays. Using the developmental sample, a logistic regression model was estimated for each outcome, and the coefficients and odds ratios for each risk factor were examined. Risk factors with questionable or insignificant coefficients were eliminated. Stepwise addition of covariates continued until the model c statistic (concordance rate) improved less than .01 or when the c statistic decreased by more than .01 when a variable was removed.

Upon completion of the developmental models, the stability of the model was tested using the validation sample. The developmental model was fit to the validation sample and the coefficients and concordance rates between the two models were compared. The coefficients and concordance rates between the two models were nearly identical,

indicating a good model fit. Model covariates, odds ratios, and fit statistics for all fourteen models can be found in Appendix Tables C1 and C2.

2.4.2 Calculating facility level adjusted rates: For each outcome, resident-level risk-adjusted scores reflecting the resident's probability of experiencing the outcome were calculated based on the risk adjustment models. Facility-level scores for each outcome were then calculated by averaging the resident-level scores for all residents within the facility. *Risk-adjusted* facility-level scores were calculated using the methodology for calculating quality measures for Nursing Home Compare (Abt Associates Inc, 2004). The risk-adjusted score is adjusted for the specific risk for that measure in the nursing facility, and can be thought of as an estimate of what the facility's score would be if the facility had residents with average risk. The facility-level risk-adjusted score is calculated using the facility observed outcome rate, the facility expected outcome rate (the facility-level score calculated by averaging the resident scores), and the national average resident observed outcome rate.

2.4.3 Examination of composite measures: To examine the potential value of using a composite measure for potentially avoidable rehospitalization for *any* of five conditions versus condition-specific rehospitalization measures, analyses of measure properties (including associations between the condition-specific measures) were conducted. Methods for examining measure properties and associations between the condition-specific rehospitalization measures included Spearmans rank order correlations, principal components analysis, continuity of covariates retained for the logistic regression models, and stability of the individual measures over time using Pearsons correlation coefficient. Principal components analysis is a factor analysis method used to discover if the observed variables (e.g., the condition-specific rehospitalization measures) can be explained largely or entirely in terms of a much smaller number of variables called factors.

2.4.4 Analysis of minimum sample size: In order to determine the percent of facilities with insufficient resident stays for the community discharge and rehospitalization outcome measures, the impact of facility volume on outcome measure variability was examined using three methods. (A more detailed description of the three methods is presented in Appendix Table D.)

Population simulation outcome measure variance: Using 2004 data, residents were pooled across the entire population of low-volume facilities ($N \leq 50$) and then randomly selected *without* replacement to create 500 new samples for each outcome measure at each facility volume of interest (e.g., 10, 15, 20, …, 50). The average standard deviation of the simulated facility adjusted rates across the 500 samples was computed for each measure.

Bootstrap of outcome measure variance within facility: Using 2004 data, for each low-volume facility (facility stays ≤ 50) residents were randomly selected *with* replacement from within the facility to create 500 new facility samples of equal size (e.g., a facility with 25 stays would have 500 samples of 25 stays). The average standard deviation of the facility outcome rates across all 500 samples within a facility was

calculated. For each facility volume (e.g., 10 stays) the mean of the facility average standard deviation was computed.

Theoretical outcome measure variance: A theoretical distribution of the variance for a hypothetical outcome measure was created using assumptions of a normal distribution (mean=0.5, standard deviation=1) truncated at 0 and 1 and with a national rate of .20.

Using each of these three approaches, the relationship between measure variance and facility sample size were graphed and the point at which variance ceased to decrease appreciably was determined. In addition to examining the decrease in measure variance, the determination of a minimum stay threshold also was based on the distribution of facility sample size. This information was used to identify the number of facilities that might be lost at any given facility stay threshold (e.g., number and percent of facilities lost with a minimum stay threshold of 20 versus 25). This process was repeated for all measures independently.

2.4.5 Impact of longer reporting period on facility sample size: An examination of the percent of facilities lost due to inadequate sample size was used to determine the effect of increasing the reporting period on the number of facilities with valid data. To examine the impact of longer reporting periods (e.g., 18 months, 24 months) on the ability of facilities to reach the minimum sample size of 25, a combined calendar year 2003-2004 file was used to calculate facility-level adjusted scores for a range of reporting periods.

2.4.6 Analysis of trends in community discharge and rehospitalization rates from 2000 through 2004: Repeated measures ANOVA was used to compare adjusted facility rates of community discharge and rehospitalization for any of five conditions at 30 and 100 days for 2000 through 2004. Contrasts were conducted between consecutive years (e.g., 2000-2001, 2001-2002), and between 2004 and each year (e.g., 2000-2004, 2001-2004). Within facility stability over time was examined using Pearsons correlation coefficients.

3.0 RESULTS

3.1 SNF facility characteristics

Characteristics of skilled nursing facilities based on calendar year 2004 data are presented in Table 1. In 2004, 67 percent of facilities, representing 78.5 percent of SNF stays, were located in designated urban areas. Less than nine percent of facilities were hospital-based, (over 90 percent were freestanding), yet these facilities accounted for more than 15 percent of SNF stays. Low volume facilities with less than 25 stays during calendar year 2004 represented 7.9 percent of SNFs but less than 1 percent of SNF stays. Large volume facilities with more than 200 stays represent 23.5 percent of SNFs, but accounted for more than 54 percent of SNF stays in 2004.

3.2 Resident-level outcome rates for 2004

Thirty-day (30-day) and 100-day outcome measures for community discharge, rehospitalization for five conditions (congestive heart failure, electrolyte imbalance, respiratory infection, sepsis, and urinary tract infection), and rehospitalization for *any* of the five conditions were calculated for all 2004 SNF residents who did not die during the outcome measure period (e.g., 30-day measures exclude those residents who died anytime within 30 days of SNF admission). Resident-level rates for each outcome measure for 2004 are presented in Table 2. As expected, resident level rates increased as the outcome measure period increased (100-day rates are higher than 30-day rates). Thirty-eight percent of SNF stays ended in a community discharge in 2004, and 22 percent ended in a rehospitalization.

Rehospitalizations for any of the five conditions represented 78 percent of all SNF rehospitalizations at 30 and 100 days. Although these conditions accounted for the majority of SNF rehospitalizations, the facility rates (presented in Appendix Table E) for each of the condition-specific rehospitalization measures were quite low (2.0 percent for sepsis at 30 days to 8.1 percent for CHF at 100 days). Furthermore, across the condition-specific measures, the percent of facilities with a rate of zero (the event never occurred during 2004 within the facility) for any given rehospitalization measure ranges from 7.3 percent for CHF at 100 days to 29.9 percent for sepsis at 30 days (see Appendix Table E).

Due to the low incidence rates for the condition-specific rehospitalization measures, we examined the feasibility of a composite measure defined as rehospitalization for any of the five conditions. First, an examination of correlations among the condition-specific rehospitalization measures indicated moderate to strong associations (see Appendix Table F). Second, principal components analysis of the five condition-specific rehospitalization measures resulted in a single factor with all five condition-specific measures retained with factor loadings greater than .45. This finding suggests that the five condition-specific measures could be adequately represented through a composite measure. Third, as shown in Appendix Table C, the covariates retained in the risk adjustment models for the condition-specific outcome measures are nearly identical. Finally, the composite measure demonstrates greater stability overtime than the condition-specific measures (see Table 7 and Appendix Table G). Based on these findings, we recommend that the composite measure of rehospitalization for *any* of the five conditions be retained as the single rehospitalization outcome measure. All subsequent analyses will be conducted on the community discharge measure and composite rehospitalization measure.

3.3 Stability of outcome measures based on facility volume

In order to determine the percent of facilities with insufficient resident stays for the community discharge and rehospitalization outcome measures, a necessary first step was to determine a minimum for number of stays per facility (facility volume) necessary to validly compute the outcome measures. We examined the impact of facility volume on

outcome measure variability using three methods; p*opulation simulation outcome measure variance*, *bootstrap of outcome measure variance within facility*, and *theoretical outcome measure variance*. A detailed description of the three simulation methods is presented in the Methods section and in Appendix Table D.

Results from the three variance simulation methods were graphed separately and the three graphs were examined to determine where the slope of the curve began to level off; indicating the number of stays needed for stability in the variance of the measure. Graphs representing the results of the three simulation methods are presented in Figures 1, 2, and 3. Across all three simulation methods, the steepest area of the slope occurs with stays less than 20. The slope continues to level off between 20 and 30 stays. Table 3 presents the cumulative percent of facilities that would be lost at various stay thresholds. Taking into consideration the percent of facilities that would be excluded from the measure at five stay increments it was determined that a minimum of 25 stays would result in acceptable measure stability while retaining more than 90 percent of SNF facilities. Although approximately 10 percent of facilities will be excluded with a minimum of 25 stays, these facilities account for less than 1 percent of SNF stays.

Facilities with less than 25 stays are less likely to be owned by a chain, more likely to be hospital-based, and are more likely to be classified as rural compared to those facilities with 25 or more stays.

3.4 Facilities lost by reporting period

The effect of modifying the reporting period length on number of stays was examined. Rates presented in Table 4 represent the percent of facilities lost at 6, 12, 15, 18, 21, and 24 months. (The 12-month rates reported in this table differ slightly from those presented previously in Table 3 because these rates include loss due to deaths which was an exclusion already made in previous analyses.) A marked difference exists in the number of facilities retained between the 6- and 12-month reporting periods. However, very little is gained with regard to facility retention between 12 and 24 months (2 to 4 percent of facilities). The disadvantage of a longer reporting period, namely the inability to improve on the quality of care that occurred up to two years ago (for a 24-month reporting period), outweighs the advantage of a 2 to 4 percent increase in the retention of facilities. Therefore, we recommend a 12-month reporting period.

3.5 Unadjusted and adjusted facility rates of proposed SNF outcome measures

Having established the recommended measures (community discharge and rehospitalization for any of five specific conditions), the reporting period (12 months), and the facility stay minimum (25 stays) for computing outcome measures, the remainder of the analyses examined the rates for 2004, and the mean differences and stability of the rates over time. Descriptive statistics for unadjusted and adjusted rates for each of the outcome measures at 30 and 100 days are shown in Table 5. The adjusted rate for community discharge within 30 days is 23.9 percent and within 100 days is 32.8 percent. Rehospitalization for any five conditions within 30 days is 13.4 percent and within

100 days is 17.1 percent. The unadjusted rates are less normally distributed than the adjusted rates, where the mean and median were extremely close. For community discharge the adjustment broadened the distribution but for rehospitalization, which had a small percentage of outlier facilities, the adjustment narrowed the distribution.

3.6 Change in facility rates from 2000 to 2004

Table 6 presents the average facility adjusted rates for each year, the difference between years, and the relative difference between years. A comparison of adjusted rates of community discharge and rehospitalization for any of five conditions at 30 and 100 days from 2000 through 2004 was conducted using repeated measures ANOVA. Findings for each of the models demonstrated a significant overall effect of time. Community discharge rates decreased steadily from 2000 through 2004. The relative decrease for community discharge within 30 days from 2000 to 2004 was –13.46 percent whereas the relative decrease for the 100-day measure was –2.84 percent. These findings suggest that over time fewer residents were discharged to the community within 30 days, however the change in rates of community discharge by the end of the SNF stay, although statistically significant, was slight.

Rehospitalization measures within 30 and 100 days increased markedly from 2000 through 2004. There was a relative increase of 50.5 percent in rehospitalization rates for any of five conditions within 30 days and a relative increase of 45 percent within 100 days.

Most contrasts between consecutive years (e.g., 2000 and 2001, 2001 and 2002, etc.) and between 2004 and all other years (e.g., 2004 and 2000, 2004 and 2001, etc.) were statistically significant at $p<.005$. Two exceptions were community discharge in 30 days between years 2003 and 2004, and community discharge in 100 days between years 2002 and 2003.

3.7 Stability of proposed SNF outcome measures from 2000 to 2004

In order to examine stability within facility over time, correlations between the 2000, 2001, 2002, 2003, and 2004 measures were examined (see Table 7). Strong to moderate associations were found for each of the outcome measures at each time point. Correlations were stronger between measures at consecutive years and for the measures calculated within 100 days versus 30 days.

4.0 DISCUSSION

A useful and valid measure of nursing home quality for post acute residents should represent care provided to the majority of residents and reflect care across a range of conditions and throughout the entire SNF stay. Additionally, publicly reported measures should be adequately adjusted for differences in resident case mix between facilities so that facilities are not at a disadvantage by caring for sicker residents for whom it is more difficult to achieve desirable outcomes. Currently, the three publicly reported measures

for post-acute care require 14-day MDS assessments, resulting in a loss of 45 percent of residents that do not remain in a SNF long enough to have 14-day MDS assessments completed (Medicare Payment Advisory Commission, 2006b). This measurement limitation has resulted in a set of quality measures that significantly under-represent the SNF population. Furthermore, only one of the three post-acute care measures (percent of short-stay residents with pressure sores) is adjusted for resident risk[2] (Abt Associates Inc, 2004). In light of these concerns, the current project examines alternative measures of SNF quality for post-acute SNF residents.

4.1 Summary of findings

The project activities leading up to this report resulted in: 1) risk-adjusted measures of community discharge and rehospitalization for any of five conditions; 2) an evaluation of the minimum number of stays a facility must have to validly and reliably compute these measures as well as an evaluation of the impact on the number facilities lost due to the minimum stay threshold; 3) an examination of the duration of the measurement period to determine whether there are advantages of focusing on shorter stays such as 30 days or the entire SNF stay (up to 100 days); and 4) a preliminary examination of trends in community discharge and rehospitalization rates from 2000 through 2004 using the new measures developed during the project.

4.2 Risk-adjusted measures of community discharge and rehospitalization

As discussed previously, community discharge and potentially avoidable rehospitalization for *any* of five conditions are outcome measures that demonstrate both face and construct validity and are meaningful outcomes for residents, care providers, and payers. Rehospitalizations are costly, represent substantial declines in the resident's health, and impact resident quality of life. Rehospitalizations for the conditions examined in this project (CHF, electrolyte imbalance, respiratory infections, UTI, and sepsis) while not always avoidable represent markers of SNF quality because they can be reduced with better quality of care and improved staffing. Community discharge is the goal of many SNF residents and marks the ultimate success of multidisciplinary rehabilitation.

The measures of community discharge and rehospitalization for any of five conditions examined in this study can be computed on nearly all SNF patients. These outcome measures do require a 5-day MDS assessment to adjust for resident risk. Based on 2004 data, 9.3 to 10.3 percent of stays were lost for the outcome measures (depending on the specific measures) examined in this study due to deaths and missing 5-day MDS assessments, far less than the 45 percent of residents stays lost due to missing 14-day MDS assessments.

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[2] The measure of *percent of short-stay residents with delirium* is adjusted for no prior residential history when possible.

Although the five condition-specific rehospitalization measures have been evaluated as discrete measures in previous studies (Kramer et al., 2000b; Hutt et al., 2000; Kramer et al., 2000a; Kramer et al., 2001), one goal of this study was to examine the value of a composite measure of rehospitalization. An examination of the condition-specific measure properties and associations between measures indicated that a measure of rehospitalization for *any* of the five conditions would be preferable to the condition-specific measures. First, several of the condition-specific measures occur rather infrequently and therefore are often not evident in small- to medium-volume facilities. Second, the five condition-specific measures are highly related suggesting that these measures reflect care as a broad construct rather than care for specific residents or specific conditions. Third, the measure of rehospitalization for any of the five conditions demonstrates greater stability over time and the measure approximates a more normal distribution than the condition-specific measures. For these reasons, we recommend that a composite measure of rehospitalization for *any* of five conditions be used instead of condition-specific rehospitalization measures.

4.3 Minimum stay size recommendation

Results from three methods examining measure variability as a function of facility size suggest that with a minimum of 25 stays, community discharge and rehospitalization for *any* of five conditions result in acceptable measure stability while retaining more than 90 percent of SNF facilities and more than 99 percent of SNF stays. Facilities with less than 25 stays are less likely to be owned by a chain, more likely to be hospital-based, and are more likely to be classified as rural compared to those facilities with 25 or more stays. Although the measures evaluated in this project can be calculated for most facilities and represent the vast majority of SNF stays, an examination of potential quality measures for very small facilities warrants consideration.

After determining the minimum number of stays required to calculate measures, we examined the impact of various reporting period lengths on the number of facilities excluded. For example, would measures be available for significantly greater numbers of facilities if the reporting period were increased from 12 to 18 months? There is relatively little gain in the percent of facilities retained when the reporting period is increased beyond 12 months. Furthermore, a longer reporting period has the disadvantage of reflecting care that occurred so far in the past that the ability of SNFs to examine the care provided to their residents and address areas of concern is inhibited. Additionally, consumers may find it difficult to interpret measures that reflect care that occurred up to two years in the past. It should be noted that between 6 and 12 months a substantial number of facilities are retained and therefore we recommend that a 12-month reporting period be used for calculating community discharge and rehospitalization measures.

Our examination of reporting period lengths indicates that when the proposed measures are calculated based on a 6-month reporting period approximately 25 percent of facilities are lost using a minimum of 25 stays. The number of facilities lost due to missing 14-day MDS assessments and the 6 month reporting period specified for the current post-acute

measures is far greater than the 10 percent that would be lost for the proposed measures. Therefore, the proposed measures of community discharge and rehospitalization would be reported on significantly more facilities than the current post-acute measures.

4.4 Measure duration

Although the MDS post-acute measures correspond to the initial 14 days of the SNF stay, and previous studies have restricted the post-acute care hospitalization or community discharge measures to the first 30 days of the SNF stay (Kramer et al., 2001; DataPRO Team, 2002), findings from the current investigation suggest that measures examining care within 100 days of SNF admission (the covered benefit) may be more desirable. First, the covariates used to risk adjust the 30- and 100-day measures are nearly identical suggesting that these two populations are quite similar. Second, the 100-day measures have several empirical and conceptual advantages over the 30-day measures. They demonstrate greater stability over time, are more normally distributed, and have fewer facilities with an observed rate of zero (the event never occurred). Conceptually, 100-day measures represent care provided throughout the SNF stay and do not create incentives to discharge residents at 30 days and/or delay hospitalizations until after 30 days. For these reasons, we recommend that community discharge and rehospitalization at 100 days be used as quality measures of post acute care.

4.5 Trends in the rates of community discharge and rehospitalization

Having established measures of community discharge and potentially avoidable rehospitalization, we examined the trends in facility risk-adjusted rates over time. Results from this analysis demonstrated a marked increase in potentially avoidable rehospitalization rates within 100 days of SNF admission from 11.8 percent in 2000 to 17.0 percent in 2004, a relative increase of 45 percent. Multiple explanations may exist for this alarming trend, which has implications related to the quality of care, quality of life, and cost of care for Medicare SNF patients.

One issue that may influence the increase in rehospitalization rates is the ongoing decline in acute hospital lengths of stay (Mardis & Brownson, 2003; Medicare Payment Advisory Commission, 2006a), causing SNFs to admit patients who are not sufficiently stable for them to treat. A second potential factor is that nursing home staffing is associated with rehospitalization for potentially avoidable causes (Kramer et al., 2000b; Hutt et al., 2000; Kramer et al., 2000a; Kramer et al., 2001). These increased rehospitalization rates may be associated with growing staffing shortages and increases in staff turnover. These studies found that the skill level of staff (e.g., RN, LPN, CNA), not total staffing levels, and staff turnover/retention were related to avoidable rehospitalization rates. Other issues relate to incentives. Physicians, who ultimately make the decision about whether to hospitalize a resident, have incentives to hospitalize residents because providing acute care in the nursing home setting often requires extra visits at relatively low reimbursement. It has been argued that the SNF PPS does not adequately cover the costs of treating higher acuity patients in nursing homes, in relation to respiratory therapy and medications, for example. Furthermore, SNF PPS also encourages SNFs to discharge patients to the hospital when they become acutely ill. The decline in hospital-based SNFs

may also contribute to the increasing rehospitalization rate. Hospital-based SNFs on average have lower rehospitalization rates than freestanding SNFs, possibly due to more skilled staffing, greater physician availability, and proximity to the acute services, or possibly due to unmeasured differences in resident characteristics. The reasons underlying the increasing trend in potential avoidable rehospitalizations require further exploration.

Rehospitalization for potentially avoidable causes is not a quality measure for public reporting nor is it monitored in the current nursing home survey and certification process. Use of the current post-acute care quality measures in fact creates an incentive to hospitalize patients who are in pain, have delirium, or have severe pressure sores before 14 days in order to have better quality measure scores. Two demonstration initiatives underway use rehospitalization as a quality measure including the nursing home quality-based purchasing demonstration that will be conducted over the next several years and the five-state demonstration of the revised nursing home survey termed the Quality Indicator Study. Even with these demonstrations underway, however, there is no reason not to move expeditiously with a rehospitalization quality measure for public reporting.

We also found a significant decrease in 100-day community discharge rates from 33.8 percent in 2000 to 32.8 percent in 2004, a 2.8 percent relative decrease, with a larger decrease in community discharge rates within 30 days from 27.6 percent to 23.9 percent, a relative decrease of 13.5 percent. This suggests that residents are remaining in the SNF for longer periods of time before being discharged to the community and fewer are being discharged by the end of the SNF benefit. The same reasons discussed above for hospitalizations may contribute to this trend in community discharge. That is, shorter hospital stays for those who can go home. Under SNF PPS, the rehabilitation groups have tended to be the most profitable, particularly in the moderate intensity categories. Thus, there is little incentive for SNFs to discharge rehabilitation patients back to the community at the earliest point.

No marker of community discharge is included in the publicly reported quality measures or emphasized in the current survey process, despite a significant portion of SNF care devoted to rehabilitation. Community discharge has been validated repeatedly as a marker of rehabilitation quality, and based on this evidence, is included in the revised Quality Indicator Survey as a quality of care measure for post-acute residents. However, community discharge is not included in the quality-based purchasing demonstration and is not being considered for public reporting.

As the measures of the community discharge and rehospitalization examined in this project can be calculated for the majority of SNF residents and reported for the majority facilities, reflect care across a range of conditions and throughout the entire SNF stay, and have been adequately adjusted for differences in resident case mix between facilities, it is recommended that these measures be added to CMS's set of publicly reported quality measures.

TABLE 1: Facility characteristics of 2004 SNF admissions

Facility Characteristic	Percent of Facilities (n=14,914)	Percent of Stays (n=2,228,507)
Urban	67.0	78.5
Hospital-based	8.9	15.1
For-profit	67.3	65.0
Nursing facility chain	54.9	55.9
Total beds:		
1-50	13.2	12.5
51-100	36.1	22.3
101-150	31.7	34.3
151 or more	19.0	30.9
Number of stays per facility:		
1-10	2.7	0.1
11-24	5.2	0.6
25-50	13.5	3.5
51-100	25.0	12.4
101-200	30.1	28.9
201 or more	23.5	54.5

TABLE 2: Resident outcomes of 2004 SNF admissions

Outcome[1]	30-Day Outcomes (N=2,128,978)	100-Day Outcomes (N=2,107,333)
Discharged to community	28.8	38.2
Rehospitalized for:		
Any reason	17.7	22.4
Any of five conditions below:	13.9	17.5
CHF	7.9	8.7
Electrolyte imbalance	6.8	8.6
Respiratory infection	4.6	5.8
Sepsis	2.4	3.0
UTI	4.7	6.2

[1] Community discharge within 30 (100) days is derived from the discharge status code from the SNF claim and from the discharge status code from MDS assessments. Rehospitalization within 30 (100) days is determined by the presence of an acute or critical care access hospital claim within 30 (100) days of the SNF admission date, with no intervening HHA, hospice, or SNF claim. Stays for residents who are discharged to community within 30 (100) days and then rehospitalized within 3 days of the discharge are not considered discharged to community in 30 (100) days, but are instead considered a rehospitalization within 30 (100) days. Rehospitalization for a given diagnosis is derived from the primary and secondary diagnoses listed on the first hospital claim for that hospitalization. Residents who died prior to the end point of the outcome period (e.g., 30 days) were excluded from the measure.

FIGURE 1: Graph of population simulation: Community discharge (CD) and rehospitalization for any five conditions (RH5)

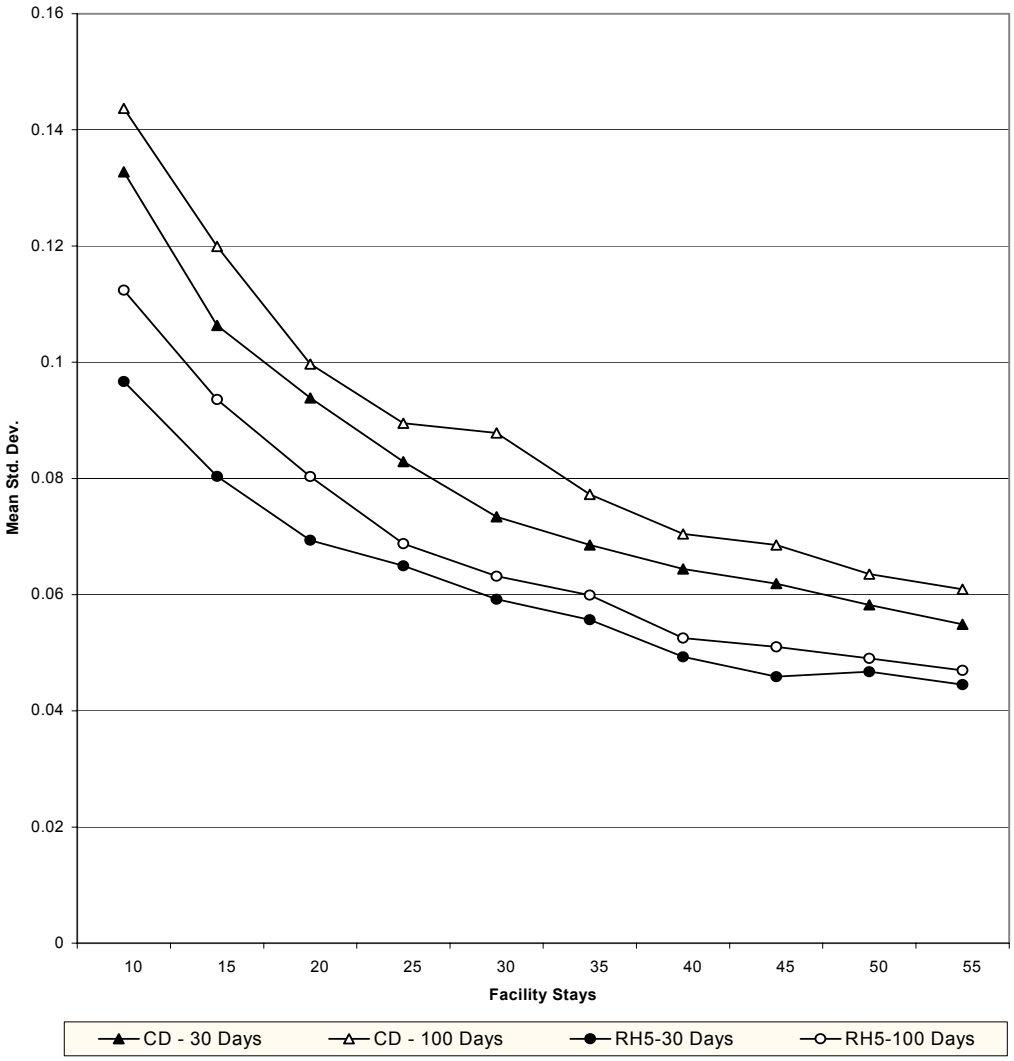

FIGURE 2: Graph of facility bootstrap: Community discharge (CD) and rehospitalization for any five conditions (RH5)

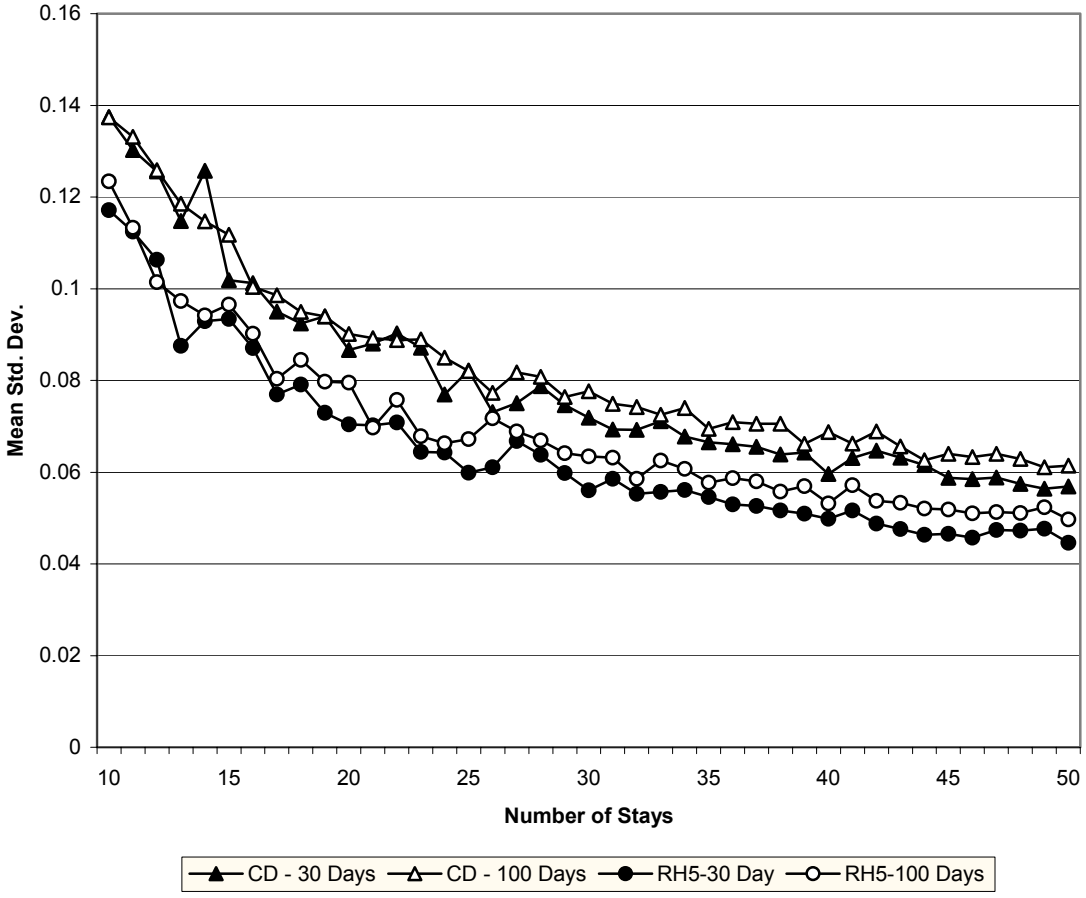

FIGURE 3: Graph of theoretically-derived variance for a hypothetical outcome from the normal distribution with a national rate of 0.20

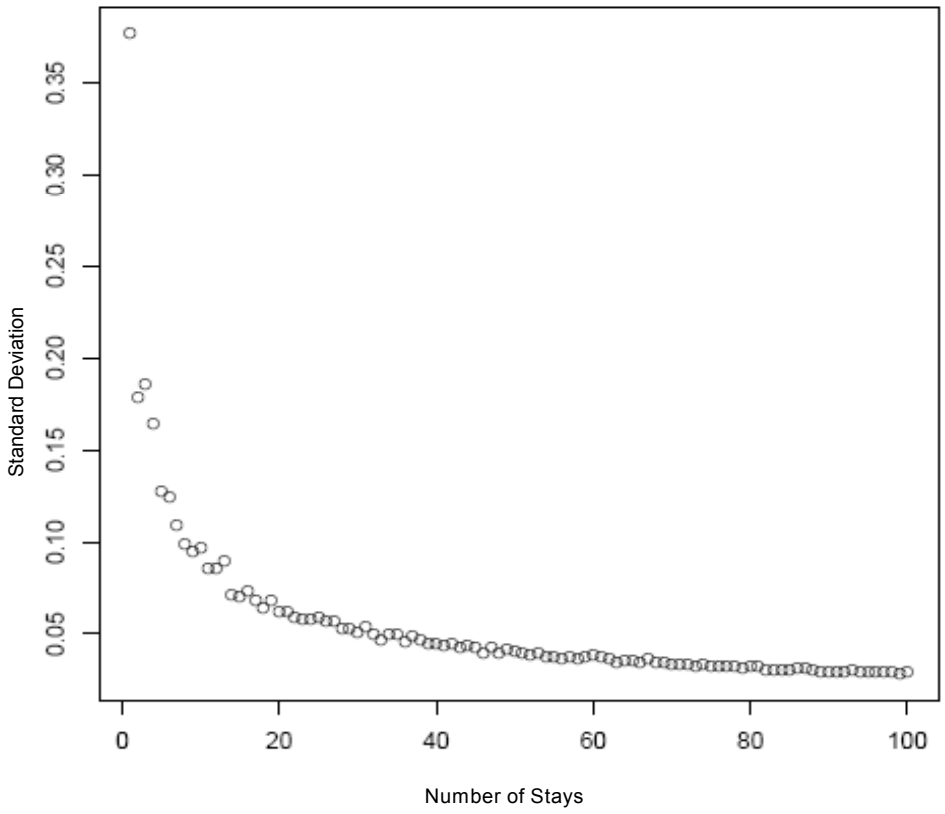

TABLE 3: Cumulative percent of facilities by number of stays with calculable value: Community discharge and rehospitalization for any five specific conditions

	Community Discharge		Rehospitalization for Any Five Specific Conditions	
Facility Stays	30 Days	100 Days	30 Days	100 Days
5	1.44	1.45	1.47	1.49
10	3.19	3.24	3.24	3.28
15	5.09	5.15	5.16	5.22
20	7.28	7.38	7.34	7.44
25	9.72	9.89	9.84	9.98
30	12.46	12.65	12.49	12.70
35	15.46	15.67	15.47	15.68
40	18.31	18.65	18.36	18.67
45	21.34	21.68	21.39	21.70
50	24.47	24.89	24.46	24.91

TABLE 4: Facilities lost by reporting period length for potential outcome measure

	6 Months	12 Months	15 Months	18 Months	21 Months	24 Months
30-Day Measures						
Community discharge	25.0%	10.3%	8.4%	7.2%	6.7%	6.1%
Rehospitalized for any of five conditions	25.0%	10.4%	8.5%	7.3%	6.7%	6.1%
100-Day Measures						
Community discharge	25.5%	10.5%	8.5%	7.3%	6.7%	6.2%
Rehospitalized for any of five conditions	25.5%	10.6%	8.6%	7.4%	6.7%	6.2%

TABLE 5: Unadjusted and adjusted facility rates of proposed SNF outcome measures

Outcome Variable	Mean (SD)	Min	25%	50%	75%	Max
Community Discharge						
30 days unadjusted	21.9% (17.4)	0	9.3	17.6	29.3	92.3
30 days adjusted	23.9% (13.3)	0	14.2	22.8	32.3	95.4
100 days unadjusted	30.9% (19.5)	0	15.8	27.8	42.9	96.9
100 days adjusted	32.8% (15.6)	0	22.2	32.7	45.7	98.6
Rehospitalized for Any of Five Conditions						
30 days unadjusted	13.4% (6.2)	0	9.0	12.9	17.3	57.1
30 days adjusted	13.4% (5.0)	0	10.0	13.1	16.4	44.7
100 days unadjusted	17.5% (8.0)	0	11.7	17.0	22.7	68.8
100 days adjusted	17.1% (6.1)	0	13.0	16.9	20.9	58.4

TABLE 6: Change in adjusted facility rates of proposed outcome measures for 2000 - 2004 SNF admissions[1]

	2000	2001	2002	2003	2004	Total[2]
Community Discharge						
30 days	27.57%	25.91%	24.96%	23.88%	23.86%	
		-1.66	-0.95	-1.08	-0.02	-3.71
		-6.02	-3.65	-4.34	-0.07	-13.46
100 days	33.75%	32.49%	32.38%	32.20%	32.79%	
		-1.27	-0.10	-0.18	0.58	-.96
		-3.75	-0.32	-0.57	1.82	-2.84
Rehospitalized for Any of Five Conditions						
30 days	9.54%	11.02%	11.93%	13.08%	13.36%	
		1.47	0.92	1.15	0.28	4.82
		15.43	8.33	9.60	2.13	50.52
100 days	11.76%	13.69%	14.98%	16.56%	17.05%	
		1.93	1.29	1.57	0.50	5.29
		16.41	9.44	10.50	3.02	44.98

[1] Table entries show facility-adjusted rate on the top row, change from previous year in the middle row, and relative change from previous year in the bottom row

[2] Repeated measures ANOVA for all outcomes measures demonstrated a statistically significant effect ($p<.0001$) of time in all four models. In addition, most contrasts between consecutive years (e.g., 2000 and 2001, 2001 and 2002, etc.) and between 2004 and all other years (e.g., 2004 and 2000, 2004 and 2001, etc.) were statistically significant at $p<.005$. Two exceptions were community discharge within 30 days between years 2003 and 2004, and community discharge within 100 days between years 2002 and 2003.

TABLE 7: Stability of proposed SNF outcome measures over time (30 days [top] and 100 days [bottom])[1]

	2000	2001	2002	2003	2004
Community Discharge					
2000	-				
2001	.790	-			
	.801				
2002	.717	.798	-		
	.732	.819			
2003	.667	.726	.803	-	
	.680	.748	.826		
2004	.617	.672	.727	.811	-
	.630	.689	.747	.831	
Rehospitalization for Any of Five Conditions					
2000	-				
2001	.367	-			
	.472				
2002	.323	.377	-		
	.421	.476			
2003	.297	.330	.381	-	
	.382	.417	.489		
2004	.273	.292	.344	.388	-
	.353	.381	.431	.486	

[1] All correlations are non-zero with p-values <0.0001

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APPENDIX

TABLE A: Analysis file information for 2004

Characteristic	Count
Beginning number of stays	2,457,348
Stays excluded[1]	228,841
Final number of stays	2,228,507
Final number of residents	1,548,714
Final number of facilities	14,914

[1] The file was first restricted to SNF admissions that occurred in calendar year 2004. The following records were then excluded from all analyses: 136,137 swing bed stays; 426 non-PPS stays; 6,907 managed care SNF (6,904) or qualifying hospitalization (3) stays; 40,694 stays with no Medicare payment for SNF (35,062), qualifying hospitalization (167), or rehospitalization (5,465) stay; 1,771 stays with 0 Medicare-covered SNF days; 37,572 stays without a qualifying hospitalization claim; and 5,334 stays with various inconsistent dates. An additional requirement specified that the SNF be Medicare-certified, but no records met that exclusion criteria.

TABLE B: Resident characteristics of 2004 SNF admissions (n = 2,227,507 stays)

Resident Characteristics	Percent of Stays
Age at admission:	
Younger than 65	7.0
65-69	7.1
70-79	28.8
80-89	42.6
90 or older	14.5
Female	65.3
Caucasian	86.6
Married	28.4
Do not resuscitate orders	35.4
Do not hospitalize orders	1.8
Died in SNF within 30 days of SNF admission date	4.5
Died in SNF within 100 days of SNF admission date	5.4
Number of stays per resident:	
1 stay	70.5
2 stays	19.9
3 stays	6.4
4 or more stays	3.2

Qualifying Hospitalization (QH) Characteristics	Percent of Stays
Admitted to QH from SNF/NF	4.4
Bone fracture	14.1
Cardiac arrhythmia	28.5
COPD	24.3
Dementia	22.0
Fluid/Electrolyte disorder	32.1
Genito-urinary disease	37.8
Hypertension, uncomplicated	43.2
Musculoskeletal disease	31.4
Nervous system disease	24.6
Respiratory disease (Excluding COPD)	27.0
Skin disease	13.5
Valvular disease	9.5
Weight loss	6.3
Average comorbidity score (-3.46 to 0.18) for "Community Discharge in 30 days"[1]	-0.47 score
Average comorbidity score (0 to 2.51) for "Rehospitalization for Any of Five Conditions in 30 Days"[1]	0.40 score
Average comorbidity score (-3.26 to 0.22) for "Community Discharge in 100 days"[1]	-0.48 score
Average comorbidity score (0 to 2.31) for "Rehospitalization for Any of Five Conditions in 100 Days"[1]	0.41 score
Average length of stay	8.9 days

TABLE B: Resident characteristics of 2004 SNF admissions (n = 2,227,507 stays) (cont'd)

SNF Stay Characteristics	Percent of Stays
Catheter	25.1
Feeding tube	7.1
Parenteral/IV feeding	12.8
Pressure ulcer	25.0
Cognitive Performance Scale score (0-6):	1.8 (avg. score)
Intact (0)	36.4
Borderline impairment	13.1
Mild impairment	14.8
Moderate impairment	20.5
Moderately severe impairment	6.1
Severe impairment	3.4
Very severe impairment (6)	5.6
5-Day Barthel score (0 poor - 90 good) (n=2,119,173)	36.9
14-Day Barthel score (0 poor - 90 good) (n=1,328,687)	38.6
30-Day Barthel score (0 poor - 90 good) (n=689,793)	37.6
60-Day Barthel score (0 poor - 90 good) (n=215,123)	35.4
90-Day Barthel score (0 poor - 90 good) (n=83,090)	33.3
5-Day RUG hierarchies (n=2,133,009):	
Rehabilitation	78.5
Extensive services	14.1
Special care	3.6
Clinically complex	2.4
Cognitively impaired	0.4
Behavior problems only	0.1
Reduced physical function	0.9

Payment	Mean at Stay End
Average length of stay[2]	26.7 days
Medicare payment	$ 7,228
Total charges	$11,636

[1] Comorbidity scores were created for each outcome in which the outcome was the dependent variable and the independent variables were seventeen disease conditions based on ICD-9 and procedure codes specified by Romano (Dartmouth/Manitoba). The primary, eight secondary diagnoses, and six procedure codes from the qualifying hospital last claims record for the current stay and one previous stay, if present, up to 365 days prior to the current stay, were used to determine the incidence of the seventeen disease conditions for each stay. Each disease condition had a value of one if present and zero if not. Using logistic regression, the coefficients for each of the seventeen disease conditions were calculated and summed to generate the comorbidity score. Only those coefficients with a p value less than or equal to .05 were included in the summation. The logistic regressions were run on a 3% random sample of stays for calendar year 2004 where all stays that ended in death were removed.

[2] Medicare covered days.

TABLE C1: Resident regressions for 30-day models using 90% validation sample

Covariate	Community Discharge Adjusted Odds Ratio (95% CI)	Any of Five Conditions Rehospitalization Adjusted Odds Ratio (95% CI)	CHF Rehospitalization Adjusted Odds Ratio (95% CI)	Electrolyte Imbalance Hospitalization Adjusted Odds Ratio (95% CI)	Respiratory Rehospitalization Adjusted Odds Ratio (95% CI)	Sepsis Hospitalization Adjusted Odds Ratio (95% CI)	UTI Hospitalization Adjusted Odds Ratio (95% CI)
Age (18 to 114)						0.99 (0.99 - 0.99)	
Female (1,0)		0.87 (0.86 - 0.88)		0.85 (0.84 - 0.87)	0.65 (0.64 - 0.66)	0.76 (0.74 - 0.78)	1.17 (1.15 - 1.18)
Do Not Resuscitate (1,0)	0.63 (0.63 - 0.64)	0.67 (0.67 - 0.68)	0.71 (0.71 - 0.72)	0.68 (0.67 - 0.69)	0.74 (0.73 - 0.75)	0.57 (0.56 - 0.58)	0.67 (0.66 - 0.68)
Do Not Rehospitalize (1,0)		0.45 (0.43 - 0.47)	0.49 (0.46 - 0.52)	0.47 (0.44 - 0.50)	0.44 (0.41 - 0.48)	0.47 (0.42 - 0.53)	0.45 (0.42 - 0.48)
Barthel Score (0-90)	1.03 (1.03 - 1.03)	0.98 (0.98 - 0.98)	0.99 (0.99 - 0.99)	0.98 (0.98 - 0.98)	0.98 (0.98 - 0.98)	0.97 (0.97 - 0.97)	0.98 (0.98 - 0.98)
Cognitive Performance Score (0-6)	0.80 (0.79 - 0.80)						
Catheter (1,0)		1.30 (1.29 - 1.31)	1.21 (1.20 - 1.23)	1.28 (1.26 - 1.30)	1.21 (1.19 - 1.23)	1.58 (1.55 - 1.61)	1.99 (1.96 - 2.02)
Feeding Tube (1,0)		1.41 (1.39 - 1.43)		1.32 (1.30 - 1.35)	1.91 (1.87 - 1.95)	1.75 (1.70 - 1.79)	1.25 (1.23 - 1.28)
Parenteral_IV_Feeding (1,0)		1.17 (1.15 - 1.18)			1.20 (1.17 - 1.22)		
Pressure Ulcer (1,0)	0.78 (0.77 - 0.79)	1.28 (1.26 - 1.29)	1.25 (1.24 - 1.27)	1.23 (1.21 - 1.24)	1.32 (1.30 - 1.34)	1.64 (1.61 - 1.68)	1.29 (1.27 - 1.31)
Rehabilitation (1,0)	2.12 (2.09 - 2.14)						
Dartmouth/M Score (-3.5 to 3.3)	1.50 (1.49 - 1.52)	2.44 (2.41 - 2.46)	2.63 (2.61 - 2.65)	2.60 (2.54 - 2.67)	1.60 (1.55 - 1.64)	1.95 (1.89 - 2.00)	1.52 (1.48 - 1.57)
Bone Fracture (1,0)		0.80 (0.80 - 0.81)				0.68 (0.66 - 0.71)	
Cardiac Arrhythmias (1,0)		1.22 (1.21 - 1.23)	1.44 (1.43 - 1.46)		1.19 (1.17 - 1.21)		
COPD (1,0)					1.26 (1.23 - 1.28)		
Dementia (1,0)		0.83 (0.82 - 0.84)					0.82 (0.80 - 0.83)
Fluid/Electrolyte Disorders (1,0)		1.22 (1.21 - 1.23)		1.57 (1.55 - 1.59)	1.17 (1.15 - 1.19)		1.18 (1.16 - 1.20)
Genito-Urinary Disease (1,0)							1.49 (1.46 - 1.51)
Hypertension, Uncomplicated (1,0)						0.77 (0.75 - 0.79)	
Musculoskeletal Disease (1,0)	1.29 (1.28 - 1.30)						
Nervous System Disease (1,0)						0.75 (0.73 - 0.76)	
Respiratory Disease (1,0)		1.24 (1.23 - 1.25)	1.22 (1.21 - 1.24)		2.16 (2.13 - 2.19)		
Valvular Disease (1,0)			1.32 (1.30 - 1.34)				
Weight Loss (1,0)				1.25 (1.23 - 1.28)			
Hospital-based Facility (1,0)	3.81 (3.78 - 3.85)	0.52 (0.51 - 0.53)	0.59 (0.57 - 0.60)	0.50 (0.49 - 0.51)	0.57 (0.55 - 0.58)	0.60 (0.58 - 0.63)	0.42 (0.40 - 0.43)
C-Statistic	0.807	0.709	0.783	0.695	0.750	0.767	0.736

TABLE C2: Resident regressions for 100-day models using 90% validation sample

Covariate	Community Discharge Adjusted Odds Ratio (95% CI)	Any of Five Conditions Rehospitalization Adjusted Odds Ratio (95% CI)	CHF Rehospitalization Adjusted Odds Ratio (95% CI)	Electrolyte Imbalance Hospitalization Adjusted Odds Ratio (95% CI)	Respiratory Rehospitalization Adjusted Odds Ratio (95% CI)	Sepsis Hospitalization Adjusted Odds Ratio (95% CI)	UTI Hospitalization Adjusted Odds Ratio (95% CI)
Age (18 to 114)						0.99 (0.99 - 0.99)	
Female (1,0)		0.86 (0.86 - 0.87)		0.87 (0.86 - 0.88)	0.66 (0.65 - 0.67)	0.75 (0.74 - 0.76)	
Do Not Resuscitate (1,0)	1.02 (1.02 - 1.02)	0.73 (0.72 - 0.74)	0.79 (0.78 - 0.80)	0.73 (0.72 - 0.74)	0.81 (0.80 - 0.82)	0.63 (0.61 - 0.64)	0.73 (0.72 - 0.74)
Do Not Rehospitalize (1,0)		0.50 (0.48 - 0.52)	0.55 (0.52 - 0.58)	0.52 (0.50 - 0.55)	0.50 (0.47 - 0.54)	0.54 (0.50 - 0.60)	0.52 (0.49 - 0.55)
Barthel Score (0-90)	0.65 (0.65 - 0.66)	0.98 (0.98 - 0.98)	0.99 (0.99 - 0.99)	0.98 (0.98 - 0.98)	0.98 (0.98 - 0.98)	0.97 (0.97 - 0.97)	0.98 (0.98 - 0.98)
Bowel Incontinence (1,0)	0.92 (0.91 - 0.92)						
Cognitive Performance Score (0-6)	0.84 (0.84 - 0.85)						
Catheter (1,0)		1.33 (1.32 - 1.34)		1.29 (1.27 - 1.31)	1.21 (1.20 - 1.23)	1.59 (1.56 - 1.62)	2.04 (2.02 - 2.07)
Feeding Tube (1,0)		1.54 (1.51 - 1.56)		1.40 (1.37 - 1.42)	2.05 (2.01 - 2.09)	1.85 (1.81 - 1.90)	1.35 (1.32 - 1.37)
Pressure Ulcer (1,0)	0.78 (0.78 - 0.78)	1.34 (1.33 - 1.36)	1.32 (1.30 - 1.34)	1.29 (1.28 - 1.31)	1.35 (1.33 - 1.37)	1.60 (1.57 - 1.63)	1.36 (1.34 - 1.38)
Rehabilitation (1,0)	2.58 (2.56 - 2.61)						
Dartmouth/M Score (-3.3 to 3.1)	1.60 (1.59 - 1.62)	2.46 (2.43 - 2.48)	2.60 (2.58 - 2.61)	2.32 (2.26 - 2.37)	1.57 (1.53 - 1.60)	2.03 (1.98 - 2.08)	1.44 (1.41 - 1.48)
Bone Fracture (1,0)						0.75 (0.73 - 0.78)	
Cardiac Arrhythmias (1,0)		1.22 (1.21 - 1.23)	1.46 (1.45 - 1.48)		1.17 (1.16 - 1.19)		
COPD (1,0)					1.31 (1.28 - 1.33)		
Dementia (1,0)		0.82 (0.81 - 0.83)	0.82 (0.80 - 0.83)				
Fluid/Electrolyte Disorders (1,0)		1.22 (1.21 - 1.23)		1.56 (1.54 - 1.58)	1.16 (1.14 - 1.17)	1.20 (1.18 - 1.22)	1.17 (1.15 - 1.18)
Genito-Urinary Disease (1,0)							1.51 (1.49 - 1.53)
Musculoskeletal Disease (1,0)	1.27 (1.26 - 1.28)						
Nervous System Disease (1,0)			0.84 (0.82 - 0.85)			0.77 (0.75 - 0.79)	
Respiratory Disease (1,0)		1.24 (1.23 - 1.25)	1.20 (1.19 - 1.22)		2.07 (2.04 - 2.10)		
Skin Disease (1,0)						1.30 (1.28 - 1.33)	
Weight Loss (1,0)		1.22 (1.21 - 1.24)		1.29 (1.26 - 1.31)			
Hospital-based Facility (1,0)	2.56 (2.54 - 2.59)	0.43 (0.43 - 0.44)	0.50 (0.49 - 0.51)	0.43 (0.42 - 0.44)	0.49 (0.48 - 0.50)	0.53 (0.51 - 0.55)	0.35 (0.34 - 0.36)
C-Statistic	0.784	0.719	0.786	0.702	0.750	0.773	0.744

TABLE D: Comparison of statistical approaches to determine minimum sample size

Approach	Procedure	Advantages and Disadvantages
Theoretical Derivation	• Compute the variance[1] for a hypothetical outcome measure with a national rate of .20 using assumptions of a normal distribution (mean=0.5, standard deviation=1) truncated at 0 and 1. • Plot the variance by facility size (e.g. n=1, 2, …, 100). • Determine where the slope of the curve levels off (i.e., facility sample size where the variance begins to stabilize).	Advantages: Does not require significant computation time or real data. Disadvantages: Distributions of probabilities are not based on real data and therefore the type and shape of the distribution may not represent those found in the actual population.
Bootstrap	• For each "small" (N≤ 50) facility, randomly select patients *with* replacement from within the facility to create 500 new facility samples of equal size (e.g., a facility with 25 stays would have 500 samples of 25 stays; a facility with 35 stays would have 500 samples of 35 stays). • For each measure, calculate the adjusted rate for each of the 500 within facility samples and then compute the variance of the adjusted rate for each facility. Each facility will have a bootstrap variance for each measure. • Plot the variance of the adjusted rate by facility sample size and determine where the slope of the curve levels off.	Disadvantages: Several studies have demonstrated that the bootstrap method overestimates sample variance for small sample sizes and therefore thresholds for facility sample size may be set higher than necessary. Comment: No distributional assumptions necessary other than that a finite variance exists.
Simulation of Population Variance	• Pool patients across the entire population of small facilities (N≤ 50). • Randomly select patients *without* replacement from the pooled sample to create 500 new samples for each measure at each facility sample size of interest (e.g., 10, 15, 20, …, 50). • Calculate the adjusted rate for each simulated facility and then compute the variance of the adjusted rates within each facility size. Each facility size will have an adjusted rate variance for each measure. • Plot the variance of the adjusted rate by facility sample size and determine where the slope of the curve levels off.	Advantages: Provides a good approximation of the true variance of the adjusted rate with true random sampling for small n. Comment: Assumes the dataset contains the population of SNFs not a sample.

[1] Variance for a Bernoulli distribution is (1-p)/(p) where p is the probability of outcome.

TABLE E: Adjusted facility rates of potential outcome measures for 2004 SNF admissions

Facility Rate[1]	Mean	Percent of Facilities with Rate=0
Discharged to community in 30 days	23.1	6.2
Rehospitalized in 30 days for:		
Any of five conditions below	13.0	4.2
CHF	6.4	9.2
Electrolyte imbalance	6.3	9.2
Respiratory infection	4.3	13.3
Sepsis	2.0	29.9
UTI	4.3	14.1
Discharged to community in 100 days	31.7	4.6
Rehospitalized in 100 days for:		
Any of five conditions below	16.6	3.2
CHF	8.1	7.3
Electrolyte imbalance	8.0	7.4
Respiratory infection	5.5	10.4
Sepsis	2.6	25.6
UTI	5.7	11.2

[1] Excludes stays and facilities for which a measure could not be calculated due to missing values or stays ending in death (small facilities with less than 25 stays are not excluded). For 30 day measures, on average 207,547 (9.3%) stays and 169 (1.1%) facilities were excluded (varies slightly by each outcome). For 100 day measures, on average 228,147 (10.2%) stays and 169 (1.1%) facilities were excluded (varies slightly by each outcome).

TABLE F: Spearman's rank order correlations[1] of adjusted facility rates[2] of potential outcome measures at 30 days (top) and 100 days (bottom) for 2004 SNF admissions

	Community Discharge	Any of Five Conditions	CHF	Electrolyte Imbalance	Respiratory Infection	Sepsis	UTI
Community Discharge	-						
Any of Five Conditions	-0.168 -0.245	-					
CHF	-0.107 -0.163	0.731 0.744	-				
Electrolyte Imbalance	-0.119 -0.172	0.738 0.758	0.454 0.487	-			
Respiratory Infection	-0.091 -0.135	0.617 0.630	0.442 0.460	0.421 0.445	-		
Sepsis	-0.045 -0.071	0.416 0.433	0.270 0.276	0.351 0.370	0.291 0.312	-	
UTI	-0.138 -0.179	0.660 0.693	0.412 0.453	0.515 0.552	0.348 0.382	0.365 0.388	-

[1] All correlations are non-zero with p-values <0.0001.

[2] Excludes stays and facilities for which a quality measure could not be calculated due to missing values or stays ending in death and small facilities with less than 25 stays. For 30 day measures, on average 226,329 (10.2%) stays and 1,550 (10.4%) facilities were excluded (varies slightly by each outcome). For 100 day measures, on average 247,206 (10.2%) stays and 169 (1.1%) facilities were excluded (varies slightly by each outcome).

TABLE G: Correlations[1] of individual adjusted rehospitalization rates[2] over time (30 days [top] and 100 days [bottom])

	2000	2001	2002	2003	2004
CHF					
2000	-				
2001	.228 .298	-			
2002	.197 .266	.206 .276	-		
2003	.185 .232	.186 .260	.226 .300	-	
2004	.169 .216	.172 .225	.207 .263	.253 .330	-
Electrolyte Imbalance					
2000	-				
2001	.280 .367	-			
2002	.252 .329	.309 .385	-		
2003	.242 .303	.263 .329	.305 .384	-	
2004	.233 .295	.238 .299	.276 .351	.297 .380	-
Respiratory Disease					
2000	-				
2001	.202 .282	-			
2002	.202 .258	.215 .281	-		
2003	.163 .221	.190 .259	.217 .296	-	
2004	.161 .213	.181 .228	.192 .252	.219 .277	-
Sepsis					
2000	-				
2001	.211 .250	-			
2002	.183 .228	.212 .260	-		
2003	.180 .220	.227 .260	.235 .294	-	
2004	.153 .189	.202 .230	.218 .275	.263 .308	-

TABLE G: Correlations[1] of individual adjusted rehospitalization rates[2] over time (30 days [top] and 100 days [bottom]) (cont'd)

	2000	2001	2002	2003	2004
UTI					
2000	-				
2001	.268 .347	-			
2002	.250 .326	.288 .368	-		
2003	.225 .301	.259 .328	.291 .372	-	
2004	.197 .256	.218 .285	.261 .323	.292 .376	-

[1] All correlations are non-zero with p-values <0.0001.

[2] Excludes stays and facilities for which a measure could not be calculated due to missing values or stays ending in death and small facilities with less than 25 stays. For 30 day measures, on average 226,329 (10.2%) stays and 1,550 (10.4%) facilities were excluded (varies slightly by each outcome). For 100 day measures, on average 247,206 (10.2%) stays and 169 (1.1%) facilities were excluded (varies slightly by each outcome).