HCFE Working Paper

HCFE WP# 2003-01

PREVENTABLE HOSPITALIZATION AS A MEASURE OF QUALITY OF CARE IN NURSING HOMES

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June, 2003

Health Care Financing & Economics

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Abstract

Objective: To evaluate the rate of potentially preventable hospitalization as a measure of quality of care in nursing homes relative to established alternatives including those based on facility-reported data and those based on data from external sources.

Data Sources/Study Setting: Secondary data were extracted from acute care hospitalization records and nursing home patient assessments for all residents in Veterans Health Administration nursing homes between October of 1997 and October of 2000.

Study Design: We use the preventable hospitalization rate to study a new population (nursing home residents) and develop a new risk-adjustment model. We compare the performance of the preventable hospitalization rate with six established measures of nursing home quality of care.

Data Collection/Extraction Methods: All data were extracted from centrally maintained VHA and Medicare databases.

Principal Findings: Among seven measures, we find the preventable hospitalization rate to be the second most stable through time and the third most strongly related to staffing.

Conclusions: The preventable hospitalization rate compares well with alternative measures of nursing home quality. Furthermore, because preventable hospitalization and mortality rates can be constructed from relatively objective data generated outside the nursing home, they provide valuable alternatives to measures based on facility-reported data.

INTRODUCTION

Because nursing home residents typically have limited abilities to advocate on their own behalf, policy makers have long supported efforts to develop quantitative measures of nursing home quality of care (IOM, 1986). These have taken on new urgency in recent years for two reasons. First, the skilled nursing facility prospective payment system mandated by the Balanced Budget Act of 1997 created an incentive to reduce the amount of care received by nursing home residents, thereby increasing the need for quality of care monitoring (GAO, 2002a; Angelelli et al., 2002). Second, in 2002, in hopes of improving quality through increased competition and public scrutiny and following the example set by several state Medicaid programs, the Bush administration announced plans to make nursing home quality measures available to the public over the Internet (Harris and Clauser, 2002). The announcement of this nursing home quality initiative certainly accelerated research efforts, but may have rushed the decision to rely on some measures rather than others (GAO, 2002b; Manard, 2002).

As was the case with state efforts, the federal initiative sifted through a variety of potential measures, eventually settling on a subset to be publicized. All of the measures selected are constructed from resident assessments generated by nursing home staff who use a standard instrument to report information on the health and functional status of residents (Berg et al., 2002). Unfortunately, these assessments may not be of uniform accuracy and completeness, potentially compromising the quality measures derived from them (GAO, 2002b).

This article adapts an alternative quality measure, the preventable hospitalization rate, from its established use evaluating outpatient care for use with nursing home

patients. We develop a risk adjustment model to account for differences in case mix among nursing homes, and compare the resulting quality measure with six established alternatives: risk-adjusted rates of mortality, pressure ulcer development, dehydration, urinary tract infection (UTI), functional status change, and change in behavior problems.

These six measures have all been extensively studied as nursing home outcomes in the literature (Berlowitz et al., 1997; Porell et al., 1998; Selim et al., 2002; Mukamel and Spector, 2000; Rosen et al., 2000; Zimmerman et al., 1995). By contrast, preventable hospitalization rates are newer measures that have primarily been applied to the evaluation of outpatient care in the community (Bindman et al., 1995; Culler and Parchman, 1998; AHRQ, 2001). Hospitalizations are deemed to have been potentially preventable if the principal diagnosis associated with the admission was for a condition that does not ordinarily result in hospitalization if managed properly on an outpatient basis. These conditions include bacterial pneumonia, dehydration, hypertension, UTI, perforated appendix, angina without procedure, asthma, chronic obstructive pulmonary disease, congestive heart failure, and diabetes. This reasoning applies equally well to nursing home residents, who as a group have high prevalence rates of these chronic conditions and ought to receive consistent monitoring and treatment in the nursing home setting, thus avoiding the need for acute inpatient hospitalization.

Using Veterans Health Administration (VA) data from October 1997 through October 2000, we find that, although none of the seven measures evaluated were strongly correlated with each other, the measures that were based on external data (preventable hospitalizations and mortality) when considered together were stable through time and associated with levels of nursing staff in regression models controlling for output volume

and case mix. By contrast, the five quality measures based on facility-reported data (functional status, pressure ulcers, urinary tract infections, dehydration, and behavior problems) as a group were less related to staffing and less stable through time. These results are consistent with high measurement error in resident assessments and indicate that measures based on external data should be considered as alternatives.

The remainder of this article is organized as follows. In the following section we describe the data files we assembled and our sample. Next, we discuss our statistical methods in two stages. First, we discuss the resident-level risk adjustment regressions used to create adjusted facility-level quality measures. Second, we discuss the facility-level analysis used to evaluate the performance of each measure. After the methods section we present results and conclude with some discussion of the implications of our work.

METHODS

Data Sources

To construct the outcome measures discussed above, resident-level data were extracted and merged from several VA administrative data sets. In general, health and functional status information from a baseline point in time were used to risk-adjust an outcome measured up to six months later (the follow-up point). Because all residents in VA nursing homes were assessed on a semi-annual schedule, once in April and again in October (as well as upon admission or transfer), data from these scheduled assessment points can be arrayed in a time series and treated as a sequence of representative samples, which can be analyzed for evidence of improvement or deterioration in quality of care over time. Although it would no doubt be better from a monitoring point of view to have

more frequent assessment points, the fact that all nursing home residents were assessed at regular intervals is enough to provide a reasonable assurance of representativeness. Because our study period was three years long (October 1997-October 2000), we had six sub-periods, each anchored by a semi-annual assessment date.

Resident assessment data for this analysis were drawn from the VA Patient Assessment File (PAF), which contains patient assessments collected in April and October of each year.[1] All VA nursing home residents in those months were assessed using a standard form (the Patient Assessment Instrument). Complete data are readily available from April 1986 to October 2000, after which a transition began to a new form, the Minimum Data Set or MDS. In addition to the PAF, the Patient Admission and Transfer (PAT) file contains patient assessments in the same format, generated by patients who were assessed either at admission or transfer (from acute care into the nursing home) sometime between PAF assessment dates.

For risk adjustment purposes, we supplemented assessment data from the PAF and PAT with diagnosis codes extracted from Bed Section records contained in the Patient Treatment File (PTF) and Extended Care File (ECF). All diagnosis codes were selected from records dating between 365 days prior to 14 days after a baseline assessment date. Thus all diagnoses recorded during inpatient encounters up to one year prior to assessment were linked to the baseline assessment record.

To construct six-month mortality models it is necessary to know whether each resident survived the six-month period following his or her baseline assessment. To gather such information we looked for evidence of continuing utilization of VA services

after the end of the six-month period. Data sets checked for such evidence included PTF, ECF, outpatient clinic, pharmacy, and fee basis files. In addition, we combined dates of death recorded in the PTF and ECF files with dates of death recorded in the Beneficiary Identification and Records Locator Subsystem (BIRLS). Using these two methods, we were able to confirm survival status for 98.5% of the cases included in this study.

For the five outcomes that relied on facility-reported assessment data, each outcome measure was constructed by relating risk adjustment information from one patient assessment (the baseline assessment) to outcome information from a subsequent patient assessment (the follow-up assessment). Because representativeness is important, the universe of PAF assessments was selected to define the sample. Following Rosen et al. (2000), each PAF assessment (April or October) was considered to be a follow-up and was paired with the immediately preceding assessment for that patient, whether from the PAF or the PAT. Thus, the longest interval between baseline and follow-up was about 7 months (e.g., if the baseline were done early in April and the follow-up were done late in the following October). The shortest interval permitted was 14 days and pairs of assessments with shorter inter-assessment intervals were excluded from the analysis.

Because the goal of this analysis is to evaluate quality of care in nursing homes, it is critical that patients whose outcomes are considered were actually in the nursing home during the interval between assessments. For this reason, follow-up assessments were paired with the immediately preceding assessment even though this meant that the inter-

[1] Summary information about the collection, use, and maintenance of PAF data is recorded in the VHA Corporate Databases Monograph, available from the Veterans Affairs Information Resource Center (VIReC): http://www.virec.research.med.va.gov/library.

assessment interval was not standardized (e.g., to six months).[2] Using a standard inter-assessment interval would have resulted in some patients having one or more assessments between baseline and follow-up, implying that some fraction of the interval must have been spent outside the nursing home (e.g., in an acute care ward).

Our measure of staffing was derived from the VA's Cost Distribution Report (CDR).[3] We extracted the number of full time equivalent staff assigned through the nursing service to the nursing home care unit. These counts of personnel included registered nurses, licensed practical nurses, nurses' aides, and a few administrative support staff.

Sample

Approximately 7% of the assessments in the PAF file could not be matched to any preceding assessment, indicating that these patients were admitted on a date close enough to the semi-annual assessment date that a separate admission assessment was not done for them. Of the remaining assessments, approximately 10% were excluded because the inter-assessment interval was less than 14 days. The remaining sample of 57,858 follow-up assessments was distributed across the six time periods as shown in Table 1.

The preventable hospitalization and mortality samples differed because they did not rely on paired assessments. Instead, the universe of PAF assessments (April and October) was used for baseline information, and survival or preventable hospitalization status over the following six months was determined from records generated outside the

[2] We controlled for differences in inter-assessment intervals by including this interval in our risk adjustment models (see Appendix A).
[3] The quality of CDR data is discussed in Swindle et al. (1996), and Nugent et al. (2003) suggest adjustments that researchers should make to improve comparability with private sector payment categories.

nursing home. Consequently, it was not necessary to exclude those with inter-assessment intervals of less than 14 days, resulting in a larger initial sample of 64,529.

Quality Measures

We selected seven measures of quality, choosing some that have been developed specifically for VA nursing homes and some that we adapted from their application to community nursing homes or other uses. We group these measures into two broad categories, those that rely primarily on facility-reported data from patient assessments and those that rely primarily on data generated by patient interactions outside the nursing home (e.g., inpatient admissions, diagnosis codes, and dates of death).

Five quality measures were constructed primarily from patient assessments. These were: incidence of pressure ulcers, prevalence of dehydration, prevalence of urinary tract infection (UTI), change in score for activities of daily living (ADLs), and change in score for behavior problems. The two quality measures based on external data were rates of mortality and rates of potentially preventable hospitalization, both measured over the six months following a PAF assessment.

Analysis of risk-adjusted mortality requires as a first step the accurate determination of when and if each patient died during the study period. For patients who died in the hospital, dates of death were extracted from VA inpatient and extended care records. Additional dates of death are recorded in the BIRLS file for VA enrollees and in Medicare enrollment records for Medicare beneficiaries. The dates of death from these two sources occasionally conflict, so we have prioritized the Medicare dates in prior work (CHQOER, 2003) due to the fact that these dates corresponded more consistently with inpatient records. Rather than rely exclusively on date of death records, it is advisable to

confirm wherever possible that those not listed as deceased were still alive (Berlowitz et al., 1997, CHQOER, 2003). We did this by locating the most recent record of VA utilization and inferring that the patient was alive at least until that date.

The next outcome of interest is the rate of potentially preventable hospitalization. Potentially preventable hospitalizations were defined according to the AHRQ definitions (AHRQ, 2001) for 13 distinct types of hospitalizations (AHRQ also defined 3 types that reflect pediatric diagnoses, but these were not appropriate for our study population). These types are identified by ICD-9-CM principal diagnosis codes and by procedure codes. In the case of Medicare-financed hospitalizations, each admission was evaluated to determine whether it matched criteria characterizing preventable hospitalizations. Each admission thus identified was flagged to reflect which type it was (e.g., asthma, diabetes, COPD) and the date of admission was recorded. Because VA nursing home residents can move from the nursing home care unit to an acute care unit and back without recording a new admission, we used a sub-admission unit called a bedsection stay as the equivalent of an admission.[4] Thus, bedsection stays that meet the preventable hospitalization criteria, based on diagnosis and procedure codes, were flagged and the corresponding dates were recorded.[5]

Following Berlowitz et al. (1997, 1996), pressure ulcer incidence (development of new pressure ulcers) was defined to be stage 1 or better at baseline and stage 2 or worse

[4] A new bedsection stay record is created whenever a patient is "admitted" to a VA acute care unit (either from the community, from another institution, or from some other unit of the VA medical center (like the nursing home). Because this method of record keeping differs from what is done in non-VA hospitals, preventable hospitalization rates might not be directly comparable between VA and non-VA patients. Because our sample consists exclusively of VA patients, this does not present a problem for our analysis.
[5] Because our study population consisted of VA nursing home residents, most acute care hospitalizations occurred in VA hospitals (94%). We tested whether the inclusion of Medicare-financed hospitalizations made a substantial difference for this population and found that it did not (the overall average rate increased

at follow-up. Dehydration and urinary tract infection prevalence were defined as presence of the condition at follow-up, regardless of baseline dehydration or UTI status, respectively. This approach is consistent with the "sentinel event" interpretation[6] suggested by Zimmerman et al. (1995), with the modification that we risk-adjust these measures as suggested by more recent literature (e.g. Mukamel, 1997).

Functional status and behavior problems were both measured on scales ranging from 3 to 15. The functional status scale was constructed, following Rosen et al. (2000), as the modified sum of activity of daily living (ADL) ratings for eating, transferring, and toileting.[7] The behavior problem scale was constructed similarly as the sum of ratings for physically aggressive, disruptive, and verbally disruptive behavior (Porell et al., 1998). Functional status and behavior changes were both calculated by subtracting baseline scores from follow-up scores.

For the sake of consistency and ease of exposition, we constructed each outcome variable so that larger positive numbers signify less favorable outcomes. Thus, for example, a change in a patient's functional status score of +3 indicates more dependence in activities of daily living from baseline to follow-up. Similarly, dichotomous variables were coded with zero representing the absence of the condition and one representing its presence (e.g., dehydrated, new pressure ulcers, urinary tract infection, died within six months).

Resident-level Risk Adjustment

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from 9.1% to 9.7%). Nevertheless, to be comprehensive, we included Medicare-financed hospitalizations in our rates of preventable hospitalization.

[6] The term "sentinel event" refers to a rare and troubling situation that arguably should never occur. Therefore, its occurrence signals potentially serious quality problems, even without risk adjustment.

[7] Note that this definition (Rosen's) differs from some others in that only three ADLs are used. We followed this standard because it was developed specifically for VA data.

To be consistent with the bulk of the risk adjustment literature, we applied resident-level regression techniques to adjust each outcome measure for differences in resident risk at baseline. This type of risk adjustment is critical when attempting to compare quality between facilities that may have very different resident populations. A facility that specializes in the care of residents suffering from Alzheimers' disease, for example, would be expected to have higher rates of behavior problems than a facility that specializes in post-acute care. If the two facilities were compared without accounting for differences in their baseline risk, the possibly erroneous conclusion would be drawn that the Alzheimers' facility provides lower quality care.

Because the analysis in this section compares the entire VA nursing home population to itself over time, the importance of risk adjustment ought to be reduced. However, if the average case mix of VA nursing homes is changing through time (becoming more post-acute, for example), then risk adjustment may make a noticeable difference and, nevertheless, is a reasonable precaution.

Risk Adjustment Variables

Where possible, this study applies risk adjustment models that were developed for use with PAF data, including the functional status change model developed by Rosen et al. (2000) and the pressure ulcer and mortality models developed by Berlowitz et al. (1996, 1997). Because PAF-based models were not available in the literature for dehydration, urinary tract infection, or behavior problems, we combined elements from the other models into a hybrid model, which we estimated separately for each of these

three outcomes.[8] In selecting variables for the hybrid model, we chose to err on the side of inclusiveness, incorporating variables that were shown in the literature to be useful for risk adjusting pressure ulcers, mortality, or functional status change unless they were clearly redundant (see Appendix A for a complete list).

Depending on which outcome was being risk adjusted, data from the same semi-annual (PAF) assessment was used either as baseline information (externally reported outcomes) or as follow-up information (facility-reported outcomes). For the five facility-reported outcomes, the dependent variables were outcomes measured from PAF assessments (treated as follow-ups) and the independent variables were drawn from the immediately preceding assessment (PAF or PAT treated as baseline). These included baseline values of the outcome as well as potentially associated health and functional status variables supplemented by diagnoses from inpatient and outpatient records. In the mortality models, the dependent variable was six-month mortality drawn from several sources external to the nursing home and the independent variables were baseline health and functional status from PAF assessments and diagnoses, both individually and combined into the Charlson index—a measure of co-morbidity (Charlson et al., 1987; Deyo, Cherkin, and Ciol, 1992). In the preventable hospitalization models, the dependent variable was whether the resident had one or more preventable hospitalizations over the six months following baseline (PAF) assessment and the independent variables were the same as in the hybrid models, with the addition of lagged preventable hospitalization.

Thus, starting from the same semiannual (PAF) assessment, the facility-reported outcomes were constructed by looking backwards for baseline information, and the

[8] Note that we did not attempt to construct the best possible risk adjustment model for each outcome. Our more limited goal was to apply a model that would eliminate well-known sources of case mix variation and

externally reported outcomes were constructed by looking forwards for six months for deaths or hospitalizations. Appendix A provides definitions for all the independent variables and Appendix B reports coefficients used for each model. Table 3 reports unadjusted and risk-adjusted means and standard deviations for each outcome.

Diagnosis codes used in the functional status change and hybrid models were extracted from PTF and ECF Bed Section records dating from 365 days prior to the date of baseline assessment until 14 days afterwards. These diagnosis codes were grouped into broad categories and specific disease variables following Rosen et al. (2000).

Facility-level Analysis

Once risk adjustment models were constructed, we evaluated each quality measure on the basis of two facility-level criteria, comparing the performance of the preventable hospitalization rate to the other six established measures. The criteria were stability through time as measured by two-period correlation coefficients and the strength of the relationship between the quality measure and the level of nursing staff. Measures that exhibit stability through time and a strong relationship to nursing staff are considered desirable. In these analyses the quality measures were facility-period means of residuals from the risk adjustment models.

We began by calculating two-period correlation coefficients to measure how stable each quality measure was through time. Stability has been considered to be a desirable characteristic in quality measures because researchers believe that many of the factors that contribute to high or low quality of care are durable through time (Berg et al., 2002). Stability is also critical from a management point of view. If measures of quality

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facilitate comparison among quality measures.

are not stable through time, current management or enforcement interventions cannot be targeted based on data from the prior period, rendering them practically useless.

Next, we estimated the elasticity of each quality measure with respect to the level of nursing staff per resident at each nursing home. A strong empirical relationship between quality measures and staffing is considered desirable because theoretical models of nursing home behavior predict a trade-off between inputs such as nursing staff and outputs like quality (Cohen and Spector, 1996; Gertler and Waldman, 1992). This theoretical relationship is consistent with the concern expressed by policymakers that quality of care might suffer if budget pressures induce reductions in nursing staff. Policymakers at the state and federal levels have responded to this concern by attempting to develop minimum staffing standards for nursing homes (Hutt, Lin, and Kramer, 2001). We estimated these elasticities by regressing the natural logarithm of each quality measure on the natural logarithm of nursing staff, controlling for variations in case mix and the number of residents in each facility.[9]

RESULTS

Resident-level Results

The most striking result from the preventable hospitalization risk adjustment model is that having a lagged preventable hospitalization very strongly increases the odds of having another one (Table 2). This could be due in part to the fact that most residents stay in the same nursing home from period to period, so whatever facility characteristics contributed to the first preventable hospitalization would also contribute to the second one. On the other hand, this result could also arise because of resident characteristics that

would otherwise have gone unmeasured. In either case, however, it is appropriate to include the lagged outcome in the risk adjustment model because our goal is to measure the quality of care in the study period, controlling as much as possible for pre-existing differences between residents. At the beginning of each period under study, lagged preventable hospitalizations are pre-determined—they cannot be influenced by quality of care in the nursing home that occurs during the study period.

Beyond lagged preventable hospitalization, endocrine disease, heart disease, and pulmonary disease diagnoses were all strongly positively related to the outcome, and neurological disease was strongly negatively related. Considering that the definitions of preventable hospitalizations depend on admission for uncontrolled diabetes, CHF, COPD, asthma, and angina, among other conditions, this profile of diagnoses is not surprising. Receipt of oxygen or radiation therapy as well as dependence in eating or bed mobility, the presence of pressure ulcers, and the Charlson index score were also positively related to the outcome, suggesting that frailty and the presence of co-morbidities make preventable hospitalizations more likely. Finally, terminal status and an indicator for baseline assessment in April (as opposed to October) were negatively associated with the outcome. The coefficient estimated for the April indicator conveys that adverse events are less likely between April and October than between October and April, perhaps because of the relative severity of winter weather (this relationship is also observed in the mortality model, see Appendix B). Terminal patients ought to be less likely than others to experience preventable hospitalizations because they are more likely to be in hospice or deceased for all or part of the six-month follow-up period. The overall explanatory

[9] A regression specification that relates the log of one variable to the log of another produces coefficient estimates that can be interpreted as elasticities (percentage change in dependent variable given percentage

power of this risk adjustment model was comparable to others, generating a c-statistic of 0.70.[10] Additional details including regression coefficients and explanatory power statistics for the other risk adjustment models can be found in Appendix B.

Facility-level Results

Our facility-level sample consisted of up to 124 VA nursing homes over six time periods for a total of 639 observations,[11] with seven mean risk-adjusted outcome measures for each observation. In general, these quality measures were not highly correlated with each other (Table 3). The highest correlations were between the change in behavior score and the change in ADL score (0.37), pressure ulcer incidence and mortality (0.28), dehydration and incidence of UTI (0.24), and pressure ulcer incidence and change in ADL score (0.22). All other correlations were 0.18 or less. These low correlations could be due to the fact that a substantial portion of the variation in these quality measures coming from essentially random measurement error. They are also consistent, however, with the hypothesis that each quality measure reflects a separate, independent dimension of quality of care. For example, the causes of high risk-adjusted behavior problems (e.g., lack of staff sensitivity to resident preferences) may be completely different from the causes of high risk-adjusted urinary tract infection (e.g., lack of staff training in appropriate use of catheters). To help evaluate these hypotheses, we analyzed for each measure its stability through time and its relationship to staffing.

To study stability we calculated correlations between each quality measure and its own value, lagged one period. The results, shown in Table 4, indicate that the quality

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change in independent variable).

[10] This is also comparable to results reported in the literature for other risk adjustment models. For example, c-statistics for Rosen's ADL decline model and Berlowitz' pressure ulcer model were 0.70 and 0.76, respectively.

measures that were based on external data (mortality and preventable hospitalization) were relatively stable through time (correlations of 0.29 and 0.43, respectively). By contrast, only two of the five quality measures based on facility-reported assessments (behavior change and dehydration) were comparably stable (0.24 and 0.47, respectively). The correlation coefficients for the other three measures were 0.11 or lower. To our knowledge, no absolute standard of desired stability has been applied in the literature, so we did simulations with 100 imaginary facilities to illustrate the implications of these results.[12] A correlation of 0.5 implies that the top 10 facilities in one period would have an average rank of approximately 27 in the next period (a completely random rank would be 50.5). A correlation of 0.3 implies an average rank of about 37, and a correlation of 0.1 implies an average rank of about 47. Thus, quality measures with correlation coefficients in the neighborhood of 0.1 provide little information about the next period's rankings and would not be useful for targeting inspections or management resources.

To study the relationship to staffing we estimated the elasticity of each quality measure with respect to nursing staffing by regressing the natural logarithm of the outcome on the natural logarithm of nursing staff, the number of residents, and a case mix measure for each facility in each period.[13] Risk-adjusted mortality exhibited the only significant relationship (elasticity=-0.93, p=0.03), indicating for example that a 10% decrease in staffing would be associated with a 9% increase in risk-adjusted mortality.

The next largest point estimates were for pressure ulcer incidence (elasticity=-0.81, p=0.19), preventable hospitalization (elasticity=-0.25, p=0.58), and UTI prevalence

[11] The number of observations does not equal 6x124 because of mergers and closures of facilities.
[12] We assumed quality was distributed normally in the first period and as a mixture of the first period's result and an additional normal disturbance in the second period.

(elasticity=-0.22, p=0.58), with all others greater than –0.15 (Table 5). Because these results were not statistically significant, conclusions should not be drawn from them, but it is worth noting that the point estimate for preventable hospitalization was less than (more negative than) all but one of the remaining measures, consistent with the conjecture that externally reported measures would perform better. Future research with larger sample sizes will be needed to confirm or reject this hypothesis.

DISCUSSION

On the two criteria selected to evaluate quality measures, stability through time and relationship to the level of nursing staff, the rate of preventable hospitalization ranked second of seven in stability and third in relation to staffing. Although none of the evaluated quality measures performed particularly well, these results, together with the strong intuitive appeal of preventable hospitalizations as a measure of quality, suggest that the rate of preventable hospitalization should be considered for standard use in nursing home administration and quality research.

Beyond this basic finding, the data indicate a broader pattern of strength in the measures based on external data, relative to those that rely on facility-reported resident assessments. This result is not entirely surprising. Because facility staff completes resident assessments, one might expect that facilities providing poor quality care would also suffer from greater measurement error in their resident assessments. It should be noted as well that the externally reported measures might reflect more objective phenomena, an important factor contributing to accurate reporting.

[13] We used the facility mean predicted probability of mortality as a measure of case mix in these models. We also tried mean predicted probabilities of other outcomes and combinations of outcomes without affecting the results qualitatively.

At a minimum, further research is needed to determine whether this pattern will be found with newer resident assessment instruments such as the Minimum Data Set Version 2.0 (MDS), currently in use in Medicare- and Medicaid-certified facilities and recently adopted by the VA. If the relative strength of externally based measures is borne out with MDS data, then the current exclusive reliance on facility-reported quality indicators in the federal Nursing Home Quality Initiative (Harris and Clauser, 2002) should be reconsidered. Furthermore, this research supports attempts to track and improve the accuracy of resident assessments. The Centers for Medicare & Medicaid Services (CMS) has adopted software standards to improve accuracy and has undertaken research projects intended to identify elements of the assessment that are particularly vulnerable to measurement error (Manard, 2002).

Several limitations should be kept in mind when considering the results of this study. First, although the list of preventable hospitalizations used in this research has intuitive appeal, it was developed for use in outpatient populations, so it may not be optimal for nursing home populations. Also, as noted above, we did not attempt to develop the best possible risk adjustment model for each outcome, so it is possible that better risk adjustment could lead to better performance for some measures. Finally, this research was conducted on a sample of VA nursing home residents, a population known to differ from residents of community nursing homes in some important ways (e.g., most VA residents are men and most community nursing home residents are women). Consequently, similar analysis should be performed on a sample of community nursing home residents before any conclusions are applied to non-VA nursing home policy.

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Table 1. Composition of Sample from PAF Assessments.

Time Period	Total N	Matched pairs	Interval>=14 days	%>=14 days
1 (10/97-4/98)	12,520	11,524	10,530	91%
2 (4/98-10/98)	12,400	11,775	10,623	90%
3 (10/98-4/99)	11,929	11,088	10,130	91%
4 (4/99-10/99)	11,607	10,747	9,414	88%
5 (10/99-4/00)	10,502	9,737	8,732	90%
6 (4/00-10/00)	10,553	9,658	8,429	87%
Total	69,511	64,529	57,858	90%

Table 2. Preventable Hospitalization Risk Adjustment Model

Variable	Odds Ratio	Robust Standard Error	z	P > |z|
Lagged Preventable Hospitalization	2.422	0.084	25.36	0.00
Age	1.063	0.015	4.24	0.00
Male	1.198	0.101	2.14	0.03
Charlson Index	1.028	0.006	4.66	0.00
Cancer	0.939	0.052	-1.13	0.26
Endocrine Disease	1.288	0.041	7.94	0.00
Heart Disease	1.268	0.041	7.27	0.00
Neurological Disease	0.858	0.027	-4.87	0.00
Psychiatric Disease	0.945	0.030	-1.79	0.07
Pulmonary Disease	1.385	0.048	9.43	0.00
Sensory Disease	1.037	0.060	0.62	0.54
Other Disease	1.333	0.049	7.81	0.00
Terminal	0.400	0.032	-11.33	0.00
Oxygen	1.526	0.065	9.98	0.00
Radiation	1.283	0.160	2.00	0.05
Stage 2 pressure ulcer	1.144	0.076	2.03	0.04
Stage 3 pressure ulcer	1.283	0.089	3.60	0.00
Stage 4 pressure ulcer	1.158	0.106	1.60	0.11
Bed mobility ADL	1.108	0.013	8.60	0.00
Eating ADL	1.029	0.014	2.13	0.03
MS	1.214	0.121	1.94	0.05
April	0.834	0.023	-6.52	0.00

Number of observations = 64529
Pseudo R squared = 0.07
C statistic = 0.70

Table 3. Descriptive Statistics And Correlation Coefficients For Quality Measures

	Dehydration	Preventable hospitalization	Mortality	ADL change	Ulcer incidence	Behavior change	UTI prevalence
Unadjusted							
Mean	0.033	0.091	0.165	0.021	0.041	-0.046	0.059
Std. Dev.	0.178	0.287	0.371	2.145	0.199	1.900	0.235
N (Patient-level)	57,858	64,529	63,590	57,858	57,858	57,858	57,858
Risk-adjusted							
Mean†	-0.001	-0.003	0.005	-0.055	-0.002	-0.004	0.001
Std. Dev.	0.058	0.049	0.064	0.642	0.054	0.526	0.066
N (Facility-level)	639	639	639	638	639	639	639
Correlation Coefficients‡ For Risk-Adjusted Measures							
Prev. Hosp.	-0.02						
Mortality	-0.15*	-0.03					
ADL	0.06	-0.06	-0.03				
Ulcer	-0.01	-0.05	0.28*	0.22*			
Behavior	0.16*	-0.09*	0.07	0.37*	0.18*		
UTI	0.24*	0.04	-0.13*	0.10*	0.12*	0.08*	

† Means of risk-adjusted measures are all zero by construction in the patient-level sample.
‡ Correlations are of facility-period means of residuals from risk adjustment models.
* Significant at the 5% level.

Table 4. Stability Through Time: Two-period Correlation Coefficients.

Preventable Hospitalization	Externally reported	0.43*
Mortality		0.29*
ADL change	Facility-reported	-0.07
Ulcer incidence		0.08
Behavior change		0.24*
UTI prevalence		0.11*
Dehydration prevalence		0.47*

Correlations of facility-period means of residuals from risk adjustment models with own lagged value.
* Significant at the 5% level.
N = 503, except for correlations involving ADL, for which N=502.

Table 5. Elasticity Of Quality Measures With Respect To Nursing Staff/Resident.

Quality Measure	Elasticity	P value
Preventable Hospitalization	-0.25	0.58
Mortality	-0.93	0.03
ADL change	0.17	0.29
Ulcer incidence	-0.81	0.19
Behavior change	0.08	0.60
UTI prevalence	-0.22	0.58
Dehydration prevalence	-0.12	0.80

Elasticities of facility-period means of residuals from risk adjustment models with respect to nursing service staff, controlling for number of patients and average case mix.
N = 616

Appendix A. Definitions of Independent Variables Used For Risk Adjustment.

Variable	Models*	Definition/Comments
Bed mobility ADL	P, H, M	Level of dependence [1-5]
Transferring ADL	P, H, M	Level of dependence [1-5]
Toileting ADL	P, H	Level of dependence [1-5], coded following Rosen et al. (2000)
Stage 1 ulcer	P, H	Indicator of stage 1 ulcer at baseline
Stasis ulcer	P, H	Indicator from PAF form
Urinary tract infection	P, H	Indicator from PAF form
Terminal	P, H, M	Indicator from PAF form
Wound care	P, H	Receipt of wound care
Therapy sum	P, H	Count of specialized therapies received
2-6 months	P, H	2-6 months since admission
Months	P, H	Number of months between baseline and follow-up
Age	F, H, M	Age in years divided by 10
Decubitus ulcer	F, H	Indicator for any ulcer stage 2 or higher
Hemiplegia or quadriplegia	F, H	Constructed with indicators from PAF form
Hemiplegia	M	Indicator from PAF form
Quadriplegia	M	Indicator from PAF form
MS	F, H, M	Indicator from PAF form
CHF	F	Diagnosis codes in narrow category defined by Rosen et al. (2000)
Arthritis	F	Diagnosis codes in narrow category
Parkinson's	F	Diagnosis codes in narrow category
Seizures	F	Diagnosis codes in narrow category
Substance abuse	F	Diagnosis codes in narrow category
Cancer_D	F	Diagnosis codes in narrow category
Cancer_C	H	Diagnosis codes in broad category
Pulmonary	F, H	Diagnosis codes in broad category
ADL 3-7	F	ADL score = [3-7]
ADL 8-9	F	ADL score = [8-9]
ADL 10-11	F	ADL score = [10-11]
Dehydrated	H, M	Indicator from PAF form
ADL score	H	ADL score [3-15]
Heart	H	Diagnosis codes in broad category defined by Rosen et al. (2000)
Other	H	Diagnosis codes in broad category
Endocrine	H	Diagnosis codes in broad category
Muscular	H	Diagnosis codes in broad category
Neurological	H	Diagnosis codes in broad category
Sensory	H	Diagnosis codes in broad category
Psychiatric	H	Diagnosis codes in broad category
Sum of categories	H	Sum of broad diagnostic categories
Oxygen	M	Indicator from PAF form

Variable	Models*	Definition/Comments
Radiation	M	Indicator from PAF form
Dialysis	M	Indicator from PAF form
Transfusions	M	Indicator from PAF form
Male	M	Indicator from PAF form
Stage 2 pressure ulcer	M	Indicator of stage 2 ulcer at baseline
Stage 3 pressure ulcer	M	Indicator of stage 3 ulcer at baseline
Stage 4 pressure ulcer	M	Indicator of stage 4 ulcer at baseline
Eating ADL	M	Level of dependence [1-5]
Tracheostomy/suctioning	M	Indicator from PAF form
April	M	April assessment indicator
Behavior score	Behavior	Baseline behavior score [3-15]
Lagged preventable hospitalization	Preventable hospitalization, M	Indicator for one or more preventable hospitalizations occurred in six months prior to baseline assessment
Charlson Index	H, M	Sum of the constructed score ranging from 1 to 6 following Charlson (1987) and Deyo (1992)

* Model Codes: P- pressure ulcer incidence, M- mortality, F- functional status change, H- hybrid (used for urinary tract infection, dehydration, and behavior).

Note: The sample was defined based on six semi-annual (PAF) assessment dates (“anchor dates”). For the five facility-reported outcomes, the dependent variables were created from the “anchor date” assessment and the independent variables were created from the immediately preceding assessment (PAF or PAT). For the two externally reported outcomes, the dependent variables were created from external sources and the independent variables were created from the “anchor date” assessment.

Appendix B. Details of Risk Adjustment Models

Table B1. Functional Status Change
Regression with robust standard errors

Variable	Coefficient	Robust Standard Error	t	P > |t|
Age	0.108	0.008	13.14	0.00
ADL 3-7	1.327	0.025	52.82	0.00
ADL 8-9	0.337	0.028	11.89	0.00
ADL 10-11	0.165	0.026	6.44	0.00
Months	0.081	0.004	20.02	0.00
Decubitus ulcer	0.016	0.030	0.56	0.58
Terminal	0.271	0.047	5.73	0.00
Hemiplegia or quadriplegia	0.182	0.022	8.44	0.00
MS	0.519	0.043	12.11	0.00
CHF	-0.117	0.028	-4.21	0.00
Arthritis	0.067	0.060	1.11	0.27
Alzheimer's	0.430	0.024	18.26	0.00
Parkinson's	0.312	0.033	9.46	0.00
Seizures	0.207	0.026	7.90	0.00
Substance abuse	-0.301	0.034	-8.92	0.00
Cancer_D	0.124	0.031	3.94	0.00
Pulmonary	-0.136	0.021	-6.38	0.00
Constant	-1.967	0.067	-29.17	0.00

Number of observations = 57858
Number of clusters (scrssn) = 27943
R squared = 0.08

Table B2. Six-month mortality

Logistic Regression with robust standard errors adjusted for clustering on scrssn

Variable	Odds Ratio	Robust Standard Error	z	P > |z|
Terminal	4.365	0.199	32.28	0.00
Oxygen	2.262	0.080	23.19	0.00
Radiation	2.152	0.201	8.19	0.00
Dialysis	1.589	0.154	4.77	0.00
Transfusions	1.740	0.219	4.39	0.00
Male	1.383	0.098	4.59	0.00
Stage 2 pressure ulcer	1.419	0.078	6.38	0.00
Stage 3 pressure ulcer	1.476	0.092	6.28	0.00
Stage 4 pressure ulcer	1.528	0.117	5.53	0.00
Dehydrated	1.374	0.079	5.51	0.00
Age	1.322	0.017	21.55	0.00
Transferring ADL	1.179	0.020	9.73	0.00
Bed mobility ADL	1.062	0.015	4.36	0.00
Eating ADL	1.215	0.015	16.22	0.00
Hemiplegia	0.657	0.024	-11.58	0.00
Quadriplegia	0.560	0.047	-6.86	0.00
Tracheostomy/suctioning	0.728	0.064	-3.63	0.00
MS	0.518	0.057	-5.93	0.00
April	0.791	0.019	-10.00	0.00
Lagged Preventable Hospitalization	1.179	0.036	5.36	0.00
Charlson Index	1.154	0.006	29.87	0.00

Number of observations = 63590
Pseudo R squared = 0.17
C statistic = 0.77

Note: April indicator was significantly lower, indicating that death was more likely to be recorded between October and April than between April and October.

Table B3. Pressure ulcer incidence

Logistic Regression with robust standard errors adjusted for clustering on scrssn

Variable	Odds Ratio	Robust Standard Error	z	P > |z|
Bed mobility ADL	1.218	0.033	7.29	0.00
Transferring ADL	1.172	0.041	4.50	0.00
Toileting ADL	1.002	0.023	0.08	0.94
Stage 1 ulcer	2.850	0.157	19.00	0.00
Stasis ulcer	2.094	0.189	8.21	0.00
Urinary tract infection	1.059	0.078	0.78	0.44
Terminal	1.454	0.121	4.51	0.00
Wound care	1.376	0.076	5.79	0.00
Therapy sum	0.947	0.026	-2.00	0.05
2-6 months	1.164	0.055	3.23	0.00
Months	0.952	0.009	-5.06	0.00

Number of observations = 57858
Pseudo R squared = 0.05
C statistic = 0.68

Table B4. UTI prevalence

Logistic Regression with robust standard errors adjusted for clustering on scrssn

Variable	Odds Ratio	Robust Standard Error	z	P > |z|
Dehydrated	1.678	0.136	6.41	0.00
Age	1.108	0.023	4.85	0.00
Bed mobility ADL	1.069	0.026	2.77	0.01
Transferring ADL	1.095	0.046	2.17	0.03
Toileting ADL	0.994	0.033	-0.19	0.85
Stage 1 ulcer	1.166	0.075	2.40	0.02
Stasis ulcer	0.995	0.110	-0.04	0.97
Urinary tract infection	8.222	0.424	40.86	0.00
Terminal	0.881	0.082	-1.37	0.17
ADL score	1.067	0.021	3.26	0.00
Decubitus ulcer	1.212	0.074	3.17	0.00
Hemiplegia or quadriplegia	1.190	0.058	3.56	0.00
MS	2.311	0.305	6.34	0.00
Heart	1.018	0.104	0.18	0.86
Other	1.196	0.131	1.63	0.10
Endocrine	1.136	0.122	1.18	0.24
Muscular	1.108	0.135	0.84	0.40
Pulmonary	1.128	0.115	1.19	0.24
Neurological	1.027	0.106	0.26	0.79
Psychiatric	1.138	0.118	1.24	0.21
Cancer_C	1.224	0.145	1.71	0.09
Sum of categories	0.940	0.087	-0.66	0.51
Wound care	1.044	0.060	0.75	0.45
Therapy sum	1.008	0.026	0.29	0.77
2-6 month	0.927	0.041	-1.72	0.09
Months	0.991	0.010	-0.90	0.37
Charlson Index	1.005	0.009	0.51	0.61

Number of observations = 57858
Pseudo R squared = 0.14
C statistic = 0.76

Note: Sensory was dropped due to collinearity.

Table B5. Dehydration prevalence

Logistic Regression with robust standard errors adjusted for clustering on scrssn

Variable	Odds Ratio	Robust Standard Error	z	P > |z|
Dehydrated	30.242	2.401	42.93	0.00
Age	1.203	0.038	5.91	0.00
Bed mobility ADL	0.979	0.033	-0.63	0.53
Transferring ADL	1.027	0.060	0.46	0.65
Toileting ADL	0.816	0.039	-4.29	0.00
Stage 1 ulcer	1.218	0.104	2.31	0.02
Stasis ulcer	0.923	0.172	-0.43	0.67
Urinary tract infection	1.353	0.123	3.32	0.00
Terminal	0.969	0.114	-0.26	0.79
ADL score	1.177	0.032	6.07	0.00
Decubitus ulcer	0.846	0.080	-1.77	0.08
Hemiplegia or quadriplegia	0.958	0.076	-0.53	0.60
MS	1.254	0.280	1.01	0.31
Heart	0.858	0.116	-1.13	0.26
Other	1.005	0.150	0.03	0.97
Endocrine	0.980	0.137	-0.14	0.89
Muscular	0.986	0.171	-0.08	0.93
Pulmonary	1.030	0.152	0.20	0.84
Neurological	1.097	0.158	0.64	0.52
Psychiatric	1.205	0.165	1.36	0.17
Cancer_C	1.137	0.175	0.84	0.40
Sum of categories	0.944	0.117	-0.47	0.64
Wound care	1.051	0.088	0.60	0.55
Therapy sum	0.923	0.035	-2.15	0.03
2-6 month	0.876	0.055	-2.13	0.03
Months	0.993	0.014	-0.52	0.60
Charlson Index	1.064	0.012	5.69	0.00

Number of observations = 57858
Pseudo R squared = 0.24
C statistic = 0.80

Note: Sensory was dropped due to collinearity.

Table B6. Change in behavior scale

Regression with robust standard errors

Variable	Odds Ratio	Robust Standard Error	z	P > |z|
Dehydrated	0.288	0.054	5.31	0.00
Age	-0.009	0.007	-1.27	0.20
Bed mobility ADL	-0.046	0.007	-6.14	0.00
Transferring ADL	-0.074	0.015	-5.08	0.00
Toileting ADL	0.047	0.012	3.89	0.00
Stage 1 ulcer	0.003	0.028	0.12	0.90
Stasis ulcer	0.037	0.036	1.01	0.31
Urinary tract infection	0.053	0.033	1.62	0.10
Terminal	-0.099	0.031	-3.15	0.00
ADL score	0.031	0.007	4.29	0.00
Decubitus ulcer	-0.078	0.025	-3.16	0.00
Hemiplegia or quadriplegia	-0.128	0.020	-6.40	0.00
MS	-0.362	0.045	-8.01	0.00
Behavior score	-0.410	0.007	-60.90	0.00
Heart	-0.026	0.033	-0.79	0.43
Other	-0.032	0.036	-0.91	0.36
Endocrine	-0.016	0.035	-0.45	0.65
Muscular	-0.026	0.040	-0.66	0.51
Pulmonary	-0.028	0.034	-0.84	0.40
Neurological	0.164	0.034	4.82	0.00
Psychiatric	0.180	0.034	5.22	0.00
Cancer_C	-0.091	0.038	-2.37	0.02
Sum of categories	-0.016	0.030	-0.53	0.59
Wound care	-0.043	0.021	-2.10	0.04
Therapy sum	-0.029	0.009	-3.35	0.00
2-6 month	0.047	0.017	2.79	0.01
Months	0.021	0.003	6.52	0.00
Charlson Index	-0.006	0.003	-2.04	0.04
Constant	1.724	0.061	28.12	0.00

Number of observations = 57858
Number of clusters (scrssn) = 27943
R squared = 0.20