A New Quality Adjustment Methodology for Nursing Home Price Indexes[i]

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*** The views expressed are those of the authors and do not reflect the policies of the U.S. Bureau of Labor Statistics or the views of other BLS staff members**

INTRODUCTION

The Producer Price Index (PPI) program introduced output price indexes for Skilled and Intermediate Care Facilities (SIC 8053) in 1994. Transaction prices representing industry revenues (outputs) were sampled on a probability proportionate to size basis. As Triplett and others have noted, output price indexes in theory should *measure the ratio of (maximum) revenues associated with remaining on the same production possibility curve in two or more periods*[ii]. The assumption of a static production possibility curve implies fixed inputs, meaning that so long as input requirements do not change, then measures of price change are relatively straightforward. This industry output perspective (as opposed to an input or consumption index) is represented conceptually by the Fixed-Input Output Price Index (FIOPI) model, which the PPI approximates with a fixed reference period (Laspeyres) formula. The Laspeyres approximation introduces the additional restriction of holding outputs fixed at the reference period, which normally corresponds with the sample collection period. Of course in the real world inputs do change enabling changes to output quality. How pricing agencies respond to disparities between the real and theoretical worlds is often of keen interest to index users. Conceptually simple but difficult in practice, valuing quality change when FIOPI assumptions are violated requires data on the marginal cost of new input requirements. When quality improves, the marginal cost of new input requirements is subtracted from the numerator of a price relative. This quality adjusted price relative enables price change to be disentangled from a shift in the production possibility curve. When outputs are difficult to define or when marginal cost data is unavailable to value quality change, price indexes may be biased. Because price indexes are often used as deflators, the direction and magnitude of bias due to inappropriate or no quality change valuation, is transmitted to industry output and productivity measures. In other words, if a nominal price index (not adjusted for quality change) has an upward bias of 5 percent then deflated measures of output will have an equal but opposite bias. Data has recently become available from the Department of Health and Human Services (HHS) that provides the PPI with an empirically-driven methodology for assessing and then valuing changes in the quality of output services produced by Skilled and Intermediate Care Facilities (hereafter referred to as Nursing Homes).

The HHS data is presented on its Nursing Home Compare (NHC) website at www.medicare.gov/nhcompare. The NHC dataset provides detailed information for every Medicare and Medicaid certified nursing home in the nation. (Over 95% of U.S. nursing homes participate in the Medicare and/ or Medicaid programs.[iii]) Each nursing home has information on nursing home characteristics (number of beds and type of ownership), quality measures (percentage of residents with pressure sores, pain, etc.), inspection results (which can include deficiencies in resident rights), and nursing staff levels (number of Registered Nurses [RNs], Licensed Practical Nurses/ Licensed Vocational Nurses [LPNs/ LVNs], or Certified Nursing Assistants [CNAs] per resident per day).

The PPI defines the primary outputs of Nursing Homes as all care and services provided to residents. Provision of these outputs are delivered through inputs largely represented by nursing staff, therefore changes in staff intensity per resident per day may indicate a change in output quality. The NHC data is released monthly, which allows the PPI to track how these inputs may change over time for specific Nursing Homes sampled by the PPI. To the extent that changes in staffing levels per resident correlate with changes in health quality measures (described later), it is possible to develop an estimation tool that enables an explicit value of quality adjustment (VQA). The VQA could then be used to transform nominal price relatives into constant quality price relatives. If quality change is positive, the marginal costs associated with new input requirements establish the VQA in a price relative that can take the form: $\frac{\mathbf{P_c - VQA}}{\mathbf{P_r}}$. If quality declines, the price relative takes the form: $\frac{\mathbf{P_c + VQA}}{\mathbf{P_r}}$; where $\mathbf{P_c}$ is the comparison period price and $\mathbf{P_r}$ is reference period price.

The PPI for Nursing Homes measures the monthly change in prices received by nursing homes in the United States. This is accomplished by measuring changes in net transaction prices between sampled facilities and various public and private payers. For health service industries, price refers to the total amount the provider is reimbursed by any combination of public or private payers. A number of net transaction prices are collected from a sampled facility using patient bills or claim forms, specifying the type and quantity of inputs needed to provide the service. Medicare bases its reimbursement levels on fixed Resource Utilization Groups (RUGs) which the PPI tracks on a per diem basis. Medicaid reimbursements vary by state and also are tracked on a per diem basis. When the payer type is a private insurance company and/ or an out-of-pocket payer, reimbursement is based upon per diem rates or interim bills which include room and board and nursing care along with additional charges/ ancillary charges (e.g. haircuts, telephone service, and blood glucose tests). These services and all other terms surrounding the transaction are held fixed for as long as the service is offered by the sampled facility under the specified conditions. When inputs and outputs are fixed, pricing agencies are able to maintain a "matched model" that yields unambiguous measures of price change. One of the most difficult measurement challenges occurs when the "matched model" breaks down thereby requiring an adjustment (VQA) that accounts for differences in period to period outputs.

THE RELATIONSHIP BETWEEN NURSE STAFFING AND QUALITY OF NURSING HOME CARE

A positive correlation between nurse staffing levels and the quality of services provided by nursing homes must be demonstrated before any steps are taken to quality adjust the Nursing Homes index . While nurse staffing is only one of many complex factors that impact the quality of nursing home services, analyses by the Institute of Medicine (IOM) , the Centers for Medicare and Medicaid Services (CMS), and the General Accounting Office (GAO) point to nurse staffing as a key factor in determining the quality of nursing home care. Although the IOM[iv], CMS[v], and GAO[vi] analyses all establish a positive correlation between nurse staffing and the quality of nursing home care, only the two-phased CMS report, "Appropriateness of Minimum Nurse Staffing Ratios in Nursing Homes", provides empirical evidence supporting minimum nurse staffing ratios, below which critical quality of care problems occur and above which there is no incremental quality improvement.

On March 19, 2002, the CMS (an HHS agency) submitted Phase II of its report to Congress. The Phase II study replicated the Phase I analysis using more recent and better quality data, and a larger, more nationally representative sample of nursing homes.[vii] Taking into consideration the differing needs of short and long-stay populations, two samples of nursing home patients were used. Samples of short-stay Medicare Skilled Nursing Facility (SNF) patients and long-stay nursing home residents who remained in the sampled facility for at least 90 days were selected from 10 states: Maine, Massachusetts, New York, Ohio, Illinois, Texas, Iowa, Colorado, Washington, and California. Four staffing level measures were used in the study: CNA staff hours per resident day, LPN hours per resident day, RN hours per resident day, and total licensed staff (RN + LPN) hours per resident day.

"Nursing facility quality is multidimensional, encompassing clinical, functional, psychosocial, and other aspects of resident health and well-being."[viii] Multidimensional quality factors make it unlikely that a single measure would be capable of capturing every facet or change in the quality of services provided by a nursing home. In the CMS study, multiple quality indicators (QIs) were developed reflecting both the manner in which care is delivered and patient care outcomes for both the short and long-stay samples. Criteria used for selecting the QIs included the following:

1. The quality construct was likely to be affected by nurse staffing;
2. A sufficiently high incidence rate was found such that the measure was stable;
3. Identifiable risk factors were identified so risk adjustment procedures could be employed.
4. Secondary data was accurate based on available information.

QIs for the short-stay sample included hospital transfer measures due to the following reasons: congestive heart failure, electrolyte imbalance, respiratory infection, sepsis, and urinary tract infection.

QIs for the long-stay sample included the following: measures of functional improvement, whether residents resisted assistance from staff, the incidence of pressure ulcers, weight loss, and skin trauma.

As is required by criterion 1, nursing facility staff plays a pivotal role in determining a facility's performance for each QI. The following table provides information concerning impact of nursing staff on one QI, hospital transfers due to respiratory infections.

Table 1:

All Nursing Staff	Registered Nurses (RNs) and Licensed Practical Nurses (LPNs)	Certified Nursing Assistants (CNAs)
-recognize symptoms of pneumonia and other upper airway infections	-ensure proper administration of medicines and vaccinations	-prevent aspiration by properly positioning and feeding patients
-report signs of respiratory infections to a physician	-supervise CNAs	-take proper infection precautions to reduce spread of contagious infections

Recognizing that the relationship between staffing levels and quality of care was not linear, logistic regression models were used to demonstrate incremental quality improvements associated with increased staffing up to "thresholds" beyond which there were no marginal benefits of additional staffing and below which quality of care was compromised. At the time the study was conducted, 92 percent of facilities in the short-stay sample and 97 percent of facilities in the long-stay sample failed to meet these minimum staffing thresholds for at least one provider type. The thresholds are provided in Tables 4 and 5.

To reduce the likelihood of bias against homes with sicker populations facility mean risk scores were generated based on the varying acuity levels, or case mixes, of different nursing home populations. The logistic regression models examined associations between incremental increases in staffing and whether the sampled facility was in the worst 10 percent of facilities with respect to each QI while controlling for the unique resident characteristics that were predictive of each quality measure. These resident characteristics, presented as covariates in the Phase II report, include age, visual impairment, and history of hypertension, among others. First, risk scores were generated for residents at sampled facilities to reflect the probability of a negative outcome based on the covariates. The resident level risk scores were then aggregated to reflect the mean risk score for each facility. Although fewer lower risk facilities were classified in the worst 10 percent category, quality improvements occurred until about the same staffing

thresholds. Regardless of case mix, staffing levels needed to prevent inclusion in the worst 10 percent category were relatively similar.

The tables below provide the means and standard deviations for each staffing measure for both the short and long-stay samples. They also show that the worst 10 percent of facilities for each QI had quality measure rates much larger than the median values. The worst decile for each QI can thus be considered an indicator of poor quality.

Table 2:

Staffing and Quality Measure Descriptive Statistics for the Short-Stay Facility Sample (n=3,632)

	Mean	S.D.	1%	25%	50%	75%	90%	99%
Staffing Type (Hours per Resident Day)								
Aide	2.07	.521	0.96	1.76	2.02	2.32	2.67	3.73
LPN	0.65	.293	0.04	0.46	0.63	0.80	0.96	1.51
RN	0.47	.422	0.01	0.23	0.38	0.59	0.83	2.41
RN plus LPN	1.11	.526	0.40	0.83	1.02	1.26	1.53	3.58
Hospital Transfer Quality Measures								
Congestive Heart Failure	.057	.037	0.00	0.03	0.05	0.08	0.11	0.17
Electrolyte Imbalance	.064	.044	0.00	0.03	0.06	0.09	0.12	0.2
Respiratory Imbalance	.049	.037	0.00	0.02	0.04	0.07	0.10	0.16
Sepsis	.020	.024	0.00	0.00	0.01	0.03	0.05	0.11
Urinary Tract Infection	.044	.037	0.00	0.02	0.04	0.06	0.09	0.16

Source: Table 2.1 Phase II Final Report, December 2001

Note: this table does not include covariate statistics - please refer to the full report for those details

Table 3:

Staffing and Quality Measure Descriptive Statistics for the Long-Stay Facility Sample (n=5,294)

	Mean	S.D.	1%	25%	50%	75%	90%	99%
Staffing Type (Hours per Resident Day)								
Aide	2.02	0.58	0.85	1.71	1.99	2.30	2.66	3.66
LPN	0.63	0.29	0.02	0.45	0.61	0.79	0.95	1.37
RN	0.40	0.32	0.00	0.19	0.34	0.55	0.77	1.33
RN plus LPN	1.03	0.41	0.28	0.78	0.97	1.20	1.44	2.34
Quality Measures								
Functional Improvement	.075	.045	0.00	0.04	0.07	0.10	0.14	0.21
Incident Pressure Ulcer	.031	.025	0.00	0.01	0.03	0.04	0.06	0.11
Resisting Care Improvement	.301	.186	0.00	0.16	0.29	0.43	0.57	0.71
Skin Trauma	.100	.095	0.00	0.02	0.08	0.15	0.24	0.40
Weight Loss	.055	0.54	0.00	0.00	0.05	0.08	0.12	0.25

Source: Table 2.2 Phase II Final Report, December 2001

Note: this table does not include covariate statistics - please refer to the full report for those details

Based on the results of the logistic regression models, the following staffing thresholds were identified:

Table 4:

Staff Type	Staffing Hours per Resident Day	Adjusted Odds Ratio (95% CI)
Aide		
Congestive Heart Failure	2.40	1.47 (1.02 - 2.11)
Electrolyte Imbalance	2.30	1.45 (1.02 - 2.04)
Sepsis	2.40	2.43 (1.51 - 3.92)
Urinary Tract Infection	2.40	1.53 (1.01 - 2.30)
Weighted Average	2.37	
Licensed (RN+LPN)		
Electrolyte Imbalance	1.15	1.40 (1.04 - 1.89)
Respiratory Infection	1.05	1.31 (1.01 – 1.71)
Sepsis	1.30	1.49 (1.02 – 2.18)
Urinary Tract Infection	1.15	1.60 (1.17 – 2.18)
Weighted Average	1.14	
RN		
Electrolyte Imbalance	0.55	1.41 (1.01 – 1.99)
Sepsis	0.55	1.44 (1.02 – 2.02)
Urinary Tract Infection	0.55	1.46 (1.03 – 2.06)
Weighted Average	0.55	

Table 5:

Quality Measure	Staffing Hours per Resident Day	Adjusted Odds Ratio (95% CI)
Aide		
Functional Improvement	2.40	1.34 (1.03 – 1.73)
Incident Pressure Ulcer	2.80	1.60 (1.08 – 2.36)
Resisting Care Improvement	2.80	1.54 (1.01 – 2.36)
Skin Trauma	2.80	1.59 (1.04 – 2.42)
Weight Loss	3.10	2.25 (1.04 – 4.83)
Weighted Average	2.78	
Licensed (RN+LPN)		
Functional Improvement	1.55	1.79 (1.08 – 2.73)
Resisting Care Improvement	1.35	1.53 (1.14 – 2.05)
Skin Trauma	1.15	1.31 (1.06 – 1.63)
Weight Loss	0.95	1.23 (1.02 – 1.49)
Weighted Average	1.30	

Quality Measure	Staffing Hours per Resident Day	Adjusted Odds Ratio (95% CI)
RN		
Functional Improvement	0.80	1.54 (1.04 – 2.27)
Incident Pressure Ulcer	0.60	1.33 (1.06 – 1.69)
Revisiting Care Improvement	0.75	1.68 (1.18 – 2.39)
Weighted Average	0.75	

Quality indicators used in the Phase II analysis are not analogous to those used on the NHC website. A national validation study conducted by ABT Associates with help from HRCA Research and Training Institute and the Center for Gerontology and Health Care Research at Brown University, was published July 15, 2002. The study examined the reliability and accuracy of 45 QIs. After reviewing the validation report, the CMS selected 10 QIs to be used on the NHC website.

The following QIs are found on the NHC website for short stay patients: the percentage of short stay residents with delirium (with and without an additional level of risk adjustment), the percentage of short stay residents with pain, and the percentage of short stay residents who walk as well or better.

The following QIs are found on the NHC website for long term residents: the percentage of residents with loss of ability in basic daily tasks, the percentage of residents with pressure sores (with and without an additional level of risk adjustment, the percentage of residents with pain, the percentage of residents in physical restraints, and the percentage of residents With infections.

QUALITY ADJUSTMENT METHODOLOGY

The PPI will use staffing data from the Nursing Home Compare website to quality adjust the Nursing Homes index. All staffing data come from the CMS' Online Survey, Certification, and Reporting (OSCAR) database. OSCAR data is collected by state survey agencies during evaluations conducted once every 15 months or sooner if a complaint is filed. When asked if nursing homes are given advance warning of evaluations, a CMS source familiar with the NHC dataset said that the evaluations were "unannounced, but not unanticipated." The data is not formally audited to ensure accuracy; however the same CMS source said "decision rules" are used to delete data that is grossly erroneous. A source at ABT Associates explained that nursing homes report data related to staffing levels by completing two forms, the CMS-671 and the CMS-672. These forms are collected by the survey team during on-site evaluations. Instructions on the forms require all staffing level calculations to be based upon the last completed pay period and resident counts to be based upon the day that the survey team arrives.

The staffing levels are updated as part of the NHC dataset on the medicare.gov website. These updates are very revealing in terms of each provider's nursing payroll and the date of the staffing changes. Every month the newest figures from the OSCAR database are released. These updates are downloadable for future research and contain the newest staffing and resident levels from all nursing homes that had an evaluation since the last update.

By using this website data, the PPI is able to determine when staffing levels changed, in what direction and by how much. All staffing levels are presented in the following way:

- nurse hours per resident per day

In terms of staffing wages, this is equivalent to the following:

- $ per hour per resident per day

In order to develop a QA methodology that can be implemented in the PPI, the value of the quality changes must be expressed in dollars (as it is in the above expression).

This data is used to determine the dollar value of the change in input costs associated with each time period. When any of the nurse hours change according to the NHC dataset, the corresponding dollar value for the difference in staffing between time periods will be calculated and will be used as a proxy of how an establishment's nursing payroll and, consequently, their inputs have changed. If the nursing home adds nursing staff or resident levels decline while holding the price constant, the quality will increase and the index should fall.

Example:
Data below is from the NHC dataset. Each nursing home has a unique provider number (Provnum) and a current count of residents, registered nurse hours per resident per day (RNHR), licensed practical nurse/ licensed vocational nurse hours per resident per day (LPNLVNHR), certified nursing assistant hours per resident per day (CNAHR) and the total amount of nursing per resident per day (TOTALHR).

Provnum: 395380	12/02	1/03
Number of residents:	144	154
RNHR:	1.33	1.17
LPNLVNHR:	0.18	0.29
CNAHR:	3.06	2.71
TOTALHR:	4.57	4.17

Step 1: Determine the change in staffing intensity (measured in hours per resident per day)

	12/02	1/03	Change in staffing intensity
RNHR	1.33	1.17	-0.16
LPNLVNHR	0.18	0.29	0.11
CNAHR	3.06	2.71	-0.35

Step 2: Multiply and sum the change in staffing intensity by the mean wage as published by the National Occupation Employment and Wage Estimates. (This data is collected and published by the BLS.)

Change in RNHR times wage:	-.016 * $23.19= -$3.7104
Change in LPNLVNHR times wage:	0.11 * $15.14= $1.6654
Change in CNAHR times wage:	-0.35 * $9.54= -$3.3390
Summation of marginal cost of new input requirements	-5.3840

If the newly reported staffing levels (in this case 1/03) are lower than the staffing levels reported during the last inspection (in this case 12/02), then the nursing

home inputs have declined and the quality of care has deteriorated. This would lead to an increase in the index level for that particular nursing home. This example yields a VQA of -5.3840. This figure would be applied to the price relative, as the following illustrates. Recall from page 2 if quality declines, the price relative takes the form:

Price relative: $\frac{P_c + VQA}{P_r}$

P_c =100.0000 (the current month's per day reimbursement to the nursing home)

P_r =100.0000 (the previous month's per day reimbursement to the nursing home)

VQA = -5.3840

Price relative: $\frac{100.0000 + (5.384)}{100.0000} = 1.05384$

As mentioned earlier, the NHC dataset is updated on a monthly basis and includes the date of the last inspection. Every month the staffing level information will be downloaded and any changes in staffing levels for establishments that reprice for the PPI will be quality adjusted using the steps outlined above. The date of the inspection will be used as the effective date for the adjustment.

CONCLUSION

This nursing home case study illustrates the value in the general strategy of searching for external sources that contain both quality indicators and corresponding input cost valuations that can be used to quality adjust PPI data. Because of the availability of external source data (the empirical study by the CMS in this case) citing the correlations between changes in inputs and quality change, the PPI did not need to expend additional resources to reach the same conclusions. The PPI has employed a similar strategy using external source data in the private passenger automobile insurance industry.

[i] Data is currently published under SIC 8053, Skilled and Intermediate Care Facilities. The PPI will begin publishing data by NAICS in early 2004.

[ii] Triplett, J., 1983, "Concepts of Quality in Input and Output Price Measures: A Resolution of the User-Value Resource-Cost Debate", in Studies in Income and Wealth, Volume 47, University of Chicago Press for the National Bureau of Economic Research, pp. 296-311.

[iii] The FIOPI allows movement along a fixed production possibility curve, a Laspeyres approximation does not.

[iv] According to a 1996 IOM review, Nursing Staff in Hospitals and Nursing Homes: Is It Adequate?, "The preponderance of evidence, from a number of studies using different types of quality measures, shows a positive relationship between nursing staff levels and quality of nursing home care…."

[v] Phase II of the "Appropriateness of Minimum Nurse Staffing Ratios in Nursing Homes" report explicitly states, "…findings demonstrated clear associations between nurse staffing levels and quality measures for short-stay Medicare patients as well as quality measures for long-stay nursing home residents."

[vi] The GAO report, "Nursing Homes: Quality of Care More Related to Staffing than Spending", states that in the states examined (Mississippi, Ohio, and Washington), "…nursing hours per resident day, especially nurses' aide hours, were related to quality of care deficiencies, with homes providing more nursing hours being less likely to have identified quality problems then homes providing fewer nursing hours."

[vii] Feuerberg, Marvin, Phase II of the "Appropriateness of Minimum Nurse Staffing Ratios in Nursing Homes- Overview of the Phase II Report", page 1-4.

[viii] Abt Associates Inc., Brown University, and HRCA Research and Training Institute. "Validation of Long-Term and Post-Acute Care Quality Indicators", CMS Contract No: 500-95-0062/T.O. #4; July, 2002: page 2.