Pay-for-performance in health care: Evidence from a nationwide randomized experiment in the home health sector

Jun Li

Pre-Analysis Plan

April 12, 2019

This pre-specified analysis plan describes the planned approach and main analyses of a nationwide stratified cluster-randomized trial of a Medicare value-based purchasing program for home health care. The Home Health Value-Based Purchasing program was designed by the Centers for Medicare & Medicaid Services and implemented in January 2016. Randomization was conducted at the state level within nine regions. In the first year, 1,626 home health agencies from 9 states were assigned to the treatment group and 6,981 agencies from 41 states were assigned to the control group. This study will examine the effect of the intervention on health care quality in the first performance year (i.e., from January through December 2016).

Introduction

The use of value-based purchasing arrangements to address high spending growth and low quality of health care has increased rapidly in United States (Doran, Maurer, and Ryan, 2017; Golden & Sloan, 2008; Rosenthal, 2006). Value-based purchasing arrangements use pecuniary rewards to incentivize quality and spending outcomes. Building on previous experience, the Centers for Medicare & Medicaid Services (CMS) implemented a family of programs with similar designs for hospitals, skilled nursing facilities, and home health care (Centers for Medicare & Medicaid Services, 2018). These three Value-Based Purchasing programs reward providers for both improvement and attainment in quality performance (Centers for Medicare & Medicaid Services, 2011; 2017; 2015). The Home Health Value-Based Purchasing Program (HHVBP) is the only one initially designed as an experiment and has not yet been implemented nationally.

Despite the theoretical appeal of linking financial rewards with quality performance, whether pay-for-performance programs can improve health care has not been settled (Rosenthal, 2006; Ryan, Tompkins, Markovitz, & Burstin, 2016; Scott, Liu, & Yong, 2018). It is also unclear whether the design of the Value-Based Purchasing programs has been appropriate (Scott, Liu, & Yong, 2018). Studies examining programs with improvement and attainment incentive schemes, such as the Hospital Value-Based Purchasing program, report mixed results (Figueroa, Zhen, Orav, & Jha, 2016; Ryan, Krinsky, Maurer, 2017; Ryan & Blustein, 2011; Scott, et al., 2018). However, extrapolating the findings from previous literature on value-based purchasing programs to the HHVBP is challenging because programs with similar incentive features to the HHVBP were not designed for rigorous evaluation. For example, Hospital Value-Based Purchasing was implemented nationally at one time, leaving few options for plausibly comparable control groups. As a result, prior studies do not include control groups or use control groups that differ in important ways from the exposed units.

In this study, I will examine the first performance year of the HHVBP, a cluster-randomized trial. For the HHVBP, CMS randomly assigned nine states and all of their eligible home health agencies into the treatment group (Centers for Medicare & Medicaid Services, 2015). The program was implemented on January 1, 2016 and is anticipated to end on December 31, 2020. In the first year, there were 1,626 agencies assigned to treatment and 6,981 agencies in the control group.

This study will contribute to the literature for several reasons. First, it will quantify the effects of a prominent pay-for-performance arrangement in health care. While the program targets the home health sector, the findings will be relevant for other similar programs, which do not include random assignment.

Second, the study will examine health care delivery for a vulnerable patient population. Ensuring the quality of care received by approximately 3.5 million home health patients each year has been a longstanding concern for health policy, particularly because home health quality varies substantially across agencies. For instance, hospital admission rates from some home health agencies are double those of other agencies with similar patient characteristics (Medicare Payment Advisory Commission, 2018).

Third, this study will directly examine the role of incentives on behavior. It will test whether agencies with greater incentives to improve under the program will do so. Better understanding of how agencies are responding to incentives will help with program refinements and improve understanding of how financial rewards affect quality of health care.

Medicare's Home Health Value-Based Purchasing Program and Experimental Design

The Home Health Value-Based Purchasing (HHVBP) program is a Medicare pay-for-performance program structured in a similar way as the Hospital Value-Based Purchasing Program and Skilled Nursing Facility Value-Based Purchasing Program. The program financially rewards (or penalizes) Medicare-certified home health agencies based on their performance on pre-specified measures and for reporting new quality information to CMS. The HHVBP program affects agencies in 9 randomly selected states from January 2016 through December 2020.

Incentives

The HHVBP program evaluates each home health agency on quality achievement, improvement, and reporting of new information. Among the measures targeted by the HHVBP program, 17 measures were assessed for achievement and improvement performance and three measures were assessed for reporting information to CMS (Table 1). Each measure is assigned a measure-specific score (Figure 1) then summed to obtain a Total Performance Score. Agencies are compared within each state. A higher Total Performance Score translates to a higher financial reward in terms of Medicare reimbursement adjustment using a linear formula. For performance in 2016, an agency may be rewarded a maximum of 3% increase or penalized with a maximum of 3% decrease in its total Medicare reimbursement, effective in 2018.

The program's financial reward structure also means that the incentives for agencies to improve are heterogeneous. Financial rewards are determined by how much an agency improved against its own baseline for each measure in addition to how well an agency performed relative to its peers for each measure (within state competitors). Therefore, an agency's expected reward for a given unit of improvement varies by how well it performed in 2015 and how well its competitors do in 2016. The variation in expected rewards from improvement means that the incentives for improvement are likely heterogeneous across agencies and measures.

Randomization

In November 2015, CMS randomly selected 9 states from 9 regions to participate in the HHVBP. The program started on January 2016 and lasts through December 2020 for Massachusetts, Maryland, North Carolina, Florida, Washington, Arizona, Iowa, Nebraska, and Tennessee (Table 2).

To select the participants, CMS first divided states into 9 regions based on a variety of characteristics, including geographic proximity, home health utilization rates, ownership model of agencies, proportion of home health users that are Medicare-Medicaid dually eligible beneficiaries, and average episodes of care per agency (Centers for Medicare & Medicaid

Services, 2015). Next, CMS used a random number generator to select one state within each of the 9 regions to be treated.

Agencies that meet the program's inclusion criteria within the 9 treatment states face mandatory participation. There are two inclusion criteria. First, only agencies that were Medicare certified in the baseline year (2015) and in the performance year (2016) are included. Second, agencies must have at least 5 measures that meet minimum denominator case requirements (e.g., 20 episodes for quality measures and 40 HHCAHPS surveys) in both the baseline and performance periods. Agencies that do not meet these inclusion criteria do not compete for incentive payments.

While randomization guarantees independence between treatment and covariates in expectation, randomization within a single trial, selecting from a modest sample of 50 states, may not resolve selection bias (Deaton & Cartwright, 2018). To assess the comparability of treatment and control agencies after randomization, I examined for balance in 2015 pre-treatment quality performance and agency characteristics (Table 3). I examine a large set of 46 characteristics, but I am particularly interested in characteristics likely to be correlated with future outcomes (Bruhn & McKenzie, 2009). Based on correlations in existing data[1], I focus on lagged quality performance measures (baseline outcomes). I am also interested in characteristics that are likely linked to the behavioral response of agencies, including size of the agency, ownership, rural status, and profit margins (proxied as the proportion of patients served are typically associated with lower profit margins for home health agencies).

For each characteristic or row of Table 3, I regressed the characteristic on whether agencies are part of the VBP treatment group, while clustering standard errors at the state level. The results in Table 2 suggest that the treatment and control agencies likely differ from one another.

Sample

There were 12,283 agencies with data in Home Health Compare in 2015, of which 671 no longer had data in Home Health Compare in 2016 (Figure 2). An additional 75 agencies were excluded from the analyses because they were located in parts of the US with 0% chance of being assigned to treatment (i.e., Washington, D.C., Puerto Rico, Guam, Northern Mariana Islands, Virgin Islands). Out of 11,537 agencies remaining, 8,611 agencies had at least 5 measures with a minimum of 20 cases for OASIS/claims quality measures and 40 completed patient experience surveys in both years. This yields 1,630 agencies in the treatment states and 6,981 agencies in the control states.

Proposed Analyses

Time frame of analysis

[1] Using 2014 and 2015 data, I examined correlations between the quality dimensions targeted by the program with all other characteristics in Table 2. Lagged quality performance measures are the most highly correlated characteristics (average $\rho = 0.59$) with future outcomes while all other characteristics are weakly correlated.

This analysis plan is for the first performance year of the program, from January 2016 through December 2016. I focus on data from 2015 (baseline year) through 2016 (performance year).

Data

My primary data source comes from Medicare's Home Health Compare website (Centers for Medicare & Medicaid Services, 2019). Home Health Compare provides quality performance information for the universe of Medicare-certified home health agencies in the US. I use Home Health Compare to obtain 16 of the 20 measures targeted by the HHVBP.

There are four remaining measures in HHVBP that are not available on Home Health Compare and excluded from my analysis. Three are report-based measures and one is performance-based measure *Discharge to Community*. I exclude these measures from the analysis because agencies not subject to the HHVBP do not report those measures to CMS and performance is currently unavailable to the public.

In addition to Home Health Compare data, I also use the 2015 Provider of Service file and Home Health Outcome and Assessment Information Set to obtain additional agency-level characteristics.

Estimation

This study seeks to examine the effect of the HHVBP program on the quality of care provided by home health care agencies. The analysis will begin by testing whether the program's introduction has an aggregate effect on measures of quality, using Equation (1) and (2). The study next tests whether agencies with varying expected gains from improvement respond differentially under the program, using Equation (3) and (4).

Aggregate effects of HHVBP

Equation (1) examines the aggregate effects of the program on quality performance. It assumes that treatment and control agencies are random samples and comparable except for treatment assignment.

$$Qual^{m}_{i(j)r} = \alpha^{m}_{0} + \alpha^{m}_{1} HHVBP_{i(j)} + X_i\lambda^{m} + \delta^{m}_{r} + \epsilon^{m}_{i(j)r} \quad (1)$$

In Equation (1) and all other equations, I focus on how HHVBP affect performance in 2016 on the 16 dimensions of quality targeted by the program. Let i denote health agencies, j denote states, r denote randomization region strata, and m denote the 16 performance-based measures. The main variable of interest is HHVBP treatment, which is determined by whether an agency operates within one of the 9 states selected for the HHVBP program. HHVBP treatment is a binary variable, $HHVBP_j$, where agency i is 1 if it operates within a state j competing in HHVBP and 0 otherwise.

Equation (1) also includes a set of pre-intervention control variables, δ^{m}_{r} and X_i. Because randomization occurred within 9 regions of the US and the probability of any state of being selected differs across the regions (i.e., 16.7% to 20% chance, depending on the number of states in each region), I control for the randomization strata, where δ^{m}_{r} are fixed effects for the nine regions (Duflo, Glennerster, & Kremer, 2006). This is important because selection is only

random conditional on strata and not controlling for randomization strata could result in biased estimates from confounding (Angrist and Pischke 2009). Equation (1) also includes a set of pre-treatment control variables X_i. These covariates are chosen because they are likely to be highly correlated with future outcomes. The set of covariates, X_i, included in Equation (1) include agency i's 2015 performance on measure m, rural status, ownership status, freestanding status, total number of Medicare admissions, percent of admissions that were discharged from acute care; percent of admissions from the bottom income quartile of each state; and percent of admission that are associated with 10 to 20% lower profit margins for home health agencies (Centers for Medicare & Medicaid Services).

The estimand of interest is α_1^m, which is the average causal effect of HHVBP on agencies' performance on measure m, if random treatment assignment succeeded in constructing a valid counterfactual. The null hypothesis is $\alpha_1^m = 0$. If the policy is effective, then $\alpha_1^m > 0$. However, there are reasons to suspect that the policy had no effect.

One rationale for a null effect hypothesis is driven by the null findings from the evaluators contracted by CMS (Arbor Research Collaborative for Health and L&M Policy Research, 2018). Although the CMS contractors' evaluation methods differ from my planned approach, their findings are consistent with general research on pay-for-performance in health care. This research finds a lack of evidence that pay-for-performance have led to improved quality in the aggregate (Scott, Liu, & Yong, 2018).

A second rationale for my hypothesis is driven by the possibility of multitasking effects. Namely, if an agency faces heterogeneous gains from improvement across various measures of quality, then the agency may devote greater effort toward measures that yield greater gains rather than distributing effort uniformly. Increased effort toward some measures may result in less effort toward others, which could lead to deterioration in performance among the neglected measures. At the extremes, it could mean that aggregate performance remains unchanged despite agencies responding to the incentives (Sherry, 2016). At a lesser extreme, multitasking effects could lead to diminished aggregate effects.

Returning to the issue of bias in Equation (1), if imbalance between treatment and control groups exist for characteristics that have strong causal relationships with the outcomes of interest, then α_1^m is biased (Altman, 1985). Thus, in addition to estimating Equation (1) on the full sample, I also estimate Equation (1) on 16 propensity-score-matched samples (with one sample for each measure m). I use 1:1 propensity score matching without replacement to obtain a subset of agencies that are similar in the distribution of covariates that predict treatment assignment (Leuven & Sianesi, 2018). The covariates I used to create the matched samples include 2013 and 2014 lagged outcomes, rural status, ownership status, freestanding status, patient demographics (percent white, percent Hispanic, average age), percent of admissions that were discharged from acute care; percent of admissions from the bottom income quartile of each state; and percent of admission that are associated with 10 to 20% lower profit margins for home health agencies (Centers for Medicare & Medicaid Services). A comparison of balance shows that propensity score matching led to more similar groups of treatment and control agencies on pre-treatment characteristics than the full sample. (see Table 4 and 5 for a subset of comparisons; all 16 comparisons are available upon request).

It is possible that there are important unobservable characteristics that differ between treatment and control agencies since the propensity-score-matched samples are constructed from observables. Therefore, using the full sample, Equation (2) also examines the aggregate effect of the program on quality performance, but with a difference-in-differences approach. Assuming that trends and exogenous shocks affect the treatment and control agencies in the same way, conditioning on pre-treatment differences in outcomes between treatment and control agencies controls for pre-existing differences, both observed and unobserved, between the groups (Greene, 2018).

$$Qual_{ijrt}^{m} = \beta_0^m + \beta_1^m HHVBP_{i(j)} + \beta_2^m Post_t + \beta_3^m HHVBP_{i(j)} \times Post_t^m + X_i\lambda^m + \delta_r^m + \epsilon_{i(j)rt}^m \quad (2)$$

Let $Post_t = 1$ if period t occurs in 2016 and 0 if 2015. The estimand of interest in the difference-in-differences model is β_3^m, which estimates the treatment effect of the HHVBP program for each measure m.

Heterogeneous marginal gains from quality improvement

To test whether agencies with different expected gains from improvement respond differentially under the program, I use Equation (3) and (4).

$$Qual_{ijr}^{m} = \gamma_0^m + \gamma_1^m HHVBP_{i(j)} + \gamma_2^m Gains_i^m + \gamma_3^m HHVBP_{i(j)} \times Gains_i^m + X_i\lambda^m + \delta_r^m + \epsilon_{i(j)r}^m \quad (3)$$

Equation (3) is similar to Equation (1) but it includes a continuous variable $Gains_i^m$. The variable $Gains_i^m$ reflects the expected increase in Total Performance Score points if agency i improved its 2015 performance on measure m by a decile of performance ranks within each state; $Gains_i^m$ for control agencies is the expected marginal gains had they been participants in HHVBP.

As previously mentioned, the program uses 2015 and 2016 to determine financial rewards. To assess how much an agency improved on a measure, HHVBP compares an agency's performance in 2016 against the agency's 2015 performance. To determine how well an agency performed relative to its peers, the program compares each agency's performance rate in 2016 against the 2016 performance of other agencies within each state. Therefore, for agency i in 2015, it could estimate its expected marginal gains for measure m by considering how much its Total Performance Score would change if it improved its measure m by some increment, which I take to the increase in performance rank by a decile.

To construct the expected marginal gains variable, I employ a non-parametric approach to construct the measure-specific expected marginal gains variable for each agency, following the general approach outlined by Norton, Li, Das, and Chen (2018). First, I compute an initial Total Performance Score for each agency in my sample, for both control and treatment states, using their 2015 performance. Second, I compute an improved Total Performance Score for each agency in my sample as if the agency improved its performance rank by a decile for measure m. I do this by first ranking each agency within each state on their 2015 performance for measure m. I then assign each agency a new hypothetical performance rate that is taken from the performance rate of an agency that is one-decile higher in rank. For example, for a state with 100 agencies, the worst (100th) agency would receive a hypothetical decile-improved performance rate of the 90th ranked agency (10th worst). I then replicate CMS' procedure to calculate an improved Total Performance Score. Third, I take the difference between the improved Total Performance Score

and the initial Total Performance Score to arrive at the expected marginal gains variable for each agency and measure (Table 6 and 7).

The estimand of interest in Equation (3) is γ_3^m, which is the marginal effect of $Gains_i^m$ on measure m among HHVBP agencies. I hypothesize that $\gamma_3^m > 0$. Since γ_1^m is the effect of being in HHVBP for agencies with 0 expected marginal gains from improvement on measure m, I expect $\gamma_1^m = 0$.

I will also examine Equation (3) using propensity-score-matched samples for each of the 16 measures.

Finally, because I expect that the effect of HHVBP will be larger for agencies with larger expected marginal gains from improvement for measure m, I use a difference-in-difference-in-differences (DDD) approach in Equation (4) to capture the heterogeneity.

$$\begin{aligned} Qual_{ijrt}^m = {} & \theta_7^m\left(HHVBP_{i(j)} \times Post_t \times Gains_i^m\right) + \theta_6^m\left(HHVBP_{i(j)} \times Post_t\right) \\ & + \theta_5^m\left(HHVBP_{i(j)} \times Gains_i^m\right) + \theta_4^m(Post_t \times Gains_i^m) + \theta_3^m Gains_i^m + \theta_2^m Post_t \\ & + \theta_1^m Post_t + \theta_0 + X_i\lambda^m + \delta_r^m + \nu_{i(j)rt}^m \end{aligned} \quad (4)$$

The estimand of interest in the DDD model is θ_7^m, which estimates the marginal effect of the HHVBP program for agencies with positive $Gains_i^m$ on each measure m. I hypothesize that $\theta_7^m > 0$. I hypothesize that $\theta_6^m = 0$ since it is the treatment effect of HHVBP for agencies with no expected marginal gains from improvement on measure m.

Adjusting standard errors and p-values for experimental design and multiple inference

In all analyses, I will cluster the standard errors at the state level since treatment was assigned at the state level (Abadie, Athey, Imbens, & Wooldridge, 2017).

To account for multiple hypothesis testing, I will compute and report family-wise adjusted p-values for each outcome. I first group each of the 16 outcomes into 4 mutually exclusive domains: 1) clinical processes and agency self-reported, 2) clinical outcomes and agency self-reported, 3) patient experience surveys administered by third party survey vendors, and 4) health care utilization derived from Medicare administrative claims.

I divide measures into these four categories for two reasons. First, the measures within each domain examine related constructs (e.g., process of care vs. patient experience). Data also corroborate these domains. Changes in performance rates from 2014 to 2015, for instance, show that correlations are strongest for measures within domains. Second, measures within the four domains likely differ in response bias. Self-reported measures in domains 1 and 2 could suffer from response bias from the agency; third-party administered patient surveys are less likely to be manipulated by the agency but may suffer from patient response bias. Because claims-based measures, like in domain 4, are collected and calculated by CMS, they are less likely to suffer from both of these two types of bias.

I use these domains to address the multiple inference concern by controlling for the family-wise error rate while also accounting for state-level clustering. The adjusted p-values for each domain correspond to the probability that there is any overall effect of HHVBP on that domain. To

calculate the family-wise error rate adjusted p-values, I will use user-written Stata command `wyoung` (Reif, 2018) which is based on the free step-down algorithm of Westfall and Young (Westfall & Young, 1993).

The benefit of estimating outcome-specific treatment effects is that it is easier to interpret and does not implicitly weight any particular outcome. However, the tradeoff is decreased power. Thus, in addition to individual outcomes, I also provide indices of standardized treatment effects that summarize each domain. Combining summary treatment effects also reduce the multiple inference problem. I follow the steps outlined in Kling, Liebman, and Katz (2007) to construct the standardized treatment effects. I estimate the treatment effects for each outcome, standardize them, average them, while accounting for the covariance of the treatment effect estimates. The mean effect size for a given domain for a set of M outcomes is:

$$Standardized\ Treatment\ Effect = \sum_{m \in M} \frac{1}{M} \frac{\xi_m}{\sigma_m} \tag{5}$$

Where σ_k is the standard deviation of $Qual^m$ in the control group and ξ_m is the treatment effect estimate for measure m. I estimate seemingly unrelated regressions for all outcomes in a domain with errors clustered at the state level.

Power Calculations

I estimated power using simulations using Equation (4) (Kleinman and Huang 2017), for each measure m (Table 7) and each index using a DDD model. I used data from 2014 and 2015 and assumed a set percentage-point increase in measure performance for each measure. The treatment effect sizes correspond to θ_7^m .

References

Abadie, Alberto, Susan Athey, Guido W. Imbens, and Jeffrey Wooldridge. 2017. "When Should You Adjust Standard Errors for Clustering?" w24003. NBER Working Paper.

Altman, Douglas G. 1985. "Comparability of Randomised Groups." *The Statistician* 34 (1): 125–36. https://doi.org/10.2307/2987510.

Angrist, Joshua D., and Jorn-Steffen Pischke. 2009. *Mostly Harmless Econometrics: An Empiricist's Companion*. Princeton, NJ: Princton University Press.

Arbor Research Collaborative for Health, and L&M Policy Research. 2018. "Evaluation of the Home Health Value-Based Purchasing (HHVBP) Model: First Annual Report." https://innovation.cms.gov/initiatives/home-health-value-based-purchasing-model.

Bruhn, Miriam, and David McKenzie. 2009. "In Persuit of Balance: Randomization in Practice in Development Field Experiments." *American Economic Journal: Applied Economics* 1 (4): 200–232. https://doi.org/10.1257/app.1.4.200.

Centers for Medicare & Medicaid Services. n.d. "Report to Congress Medicare Home Health Study: An Investigation on Access to Care and Payment for Vulnerable Patient Populations." https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/HomeHealthPPS/Downloads/HH-Report-to-Congress.pdf.

Centers for Medicare & Medicaid Services. 2011. "Medicare Program; Hospital Inpatient Value-Based Purchasing Program. Final Rule." *Federal Register* 76 (88): 26490–547. http://www.ncbi.nlm.nih.gov/pubmed/21548401.

Centers for Medicare & Medicaid Services. 2015. "Medicare and Medicaid Programs; CY 2016 Home Health Prospective Payment System Rate Update; Home Health Value-Based Purchasing Model; and Home Health Quality Reporting Requirements. Final Rule." *Federal Register* 80 (214): 68623–719. http://www.ncbi.nlm.nih.gov/pubmed/26552111.

Centers for Medicare & Medicaid Services. 2017. "Medicare Program; Prospective Payment System and Consolidated Billing for Skilled Nursing Facilities for FY 2018, SNF Value-Based Purchasing Program, SNF Quality Reporting Program, Survey Team Composition, and Correction of the Performance Period for The." *Federal Register* 82 (149): 36530–634. http://www.ncbi.nlm.nih.gov/pubmed/28805359.

Centers for Medicare & Medicaid Services. 2018. "What Are the Value-Based Programs?" CMS.Gov. 2018. https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/Value-Based-Programs/Value-Based-Programs.html.

Centers for Medicare & Medicaid Services. 2019. "Home Health Compare Datasets." 2019.

Deaton, Angus, and Nancy Cartwright. 2018. "Understanding and Misunderstanding Randomized Controlled Trials." *Social Science & Medicine* 210: 2–21. https://doi.org/https://doi.org/10.1016/j.socscimed.2017.12.005.

Doran, Tim, Kristin A. Maurer, and Andrew M. Ryan. 2017. “Impact of Provider Incentives on Quality and Value of Health Care.” *Annual Review of Public Health* 38 (1): 449–65. https://doi.org/10.1146/annurev-publhealth-032315-021457.

Duflo, Esther, Rachel Glennerster, and Michael Kremer. 2006. “Using Randomization in Development Economics Research: A Toolkit.” *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.951841.

Figueroa, Jose F, Yusuke Tsugawa, Jie Zheng, E John Orav, and Ashish K Jha. 2016. “Association between the Value-Based Purchasing Pay for Performance Program and Patient Mortality in US Hospitals: Observational Study.” *BMJ*, May, i2214. https://doi.org/10.1136/bmj.i2214.

Golden, Brian R., and Frank A. Sloan. 2008. “Physician Pay for Performance: Alternative Perspectives.” In *Incentives and Choice in Health Care*, edited by Frank A. Sloan and Hirschel Kasper, 289–300. Cambridge, MA: MIT Press.

Greene, William H. 2018. *Econometric Analysis*. New York: Pearson.

Kleinman, Ken, and Susan S. Huang. 2017. “Calculating Power by Bootstrap, with an Application to Cluster-Randomized Trials.” *EGEMS* 4 (1): 1202. https://doi.org/10.13063/2327-9214.1202.

Kling, Jeffrey R, Jeffrey B Liebman, and Lawrence F Katz. 2007. “Experimental Analysis of Neighborhood Effects.” *Econometrica* 75 (1): 83–119. https://doi.org/10.1111/j.1468-0262.2007.00733.x.

Leuven, Edwin, and Barbara Sianesi. 2018. “PSMATCH2: Stata Module to Perform Full Mahalanobis and Propensity Score Matching, Common Support Graphing, and Covariate Imbalance Testing.” http://ideas.repec.org/c/boc/bocode/s432001.html.

Medicare Payment Advisory Commission. 2018. “Chapter 5: Encouraging Medicare Beneficiaries to Use Higher Quality Post-Acute Care Providers.”

Norton, Edward C., Jun Li, Anup Das, and Lena M. Chen. 2018. “Moneyball in Medicare.” *Journal of Health Economics*, August. https://doi.org/10.1016/j.jhealeco.2017.07.006.

Reif, Julian. 2018. “WYOUNG: Stata Module to Perform Multiple Testing Corrections.”

Rosenthal, M. B. 2006. “What Is the Empirical Basis for Paying for Quality in Health Care?” *Medical Care Research and Review* 63 (2): 135–57. https://doi.org/10.1177/1077558705285291.

Ryan, A. M., C. P. Tompkins, A. A. Markovitz, and H. R. Burstin. 2016. “Linking Spending and Quality Indicators to Measure Value and Efficiency in Health Care.” *Medical Care Research and Review*, May. https://doi.org/10.1177/1077558716650089.

Ryan, Andrew M., and Jan Blustein. 2011. “The Effect of the MassHealth Hospital Pay-for-

Performance Program on Quality." *Health Services Research* 46 (3): 712–28. https://doi.org/10.1111/j.1475-6773.2010.01224.x.

Ryan, Andrew M., Sam Krinsky, Kristin A. Maurer, and Justin B. Dimick. 2017. "Changes in Hospital Quality Associated with Hospital Value-Based Purchasing." *New England Journal of Medicine* 376 (24): 2358–66. https://doi.org/10.1056/NEJMsa1613412.

Scott, Anthony, Miao Liu, and Jongsay Yong. 2018. "Financial Incentives to Encourage Value-Based Health Care." *Medical Care Research and Review* 75 (1): 3–32. https://doi.org/10.1177/1077558716676594.

Sherry, Tisamarie B. 2016. "A Note on the Comparative Statics of Pay-for-Performance in Health Care." *Health Economics* 25 (5): 637–44. https://doi.org/10.1002/hec.3169.

Westfall, Peter H., and Stanley S. Young. 1993. *Resampling-Based Multiple Testing: Examples and Methods for p-Value Adjustment*. New York: Wiley.

Figures

Figure 1. Overview of measure scoring in the Home Health Value-Based Purchasing program.

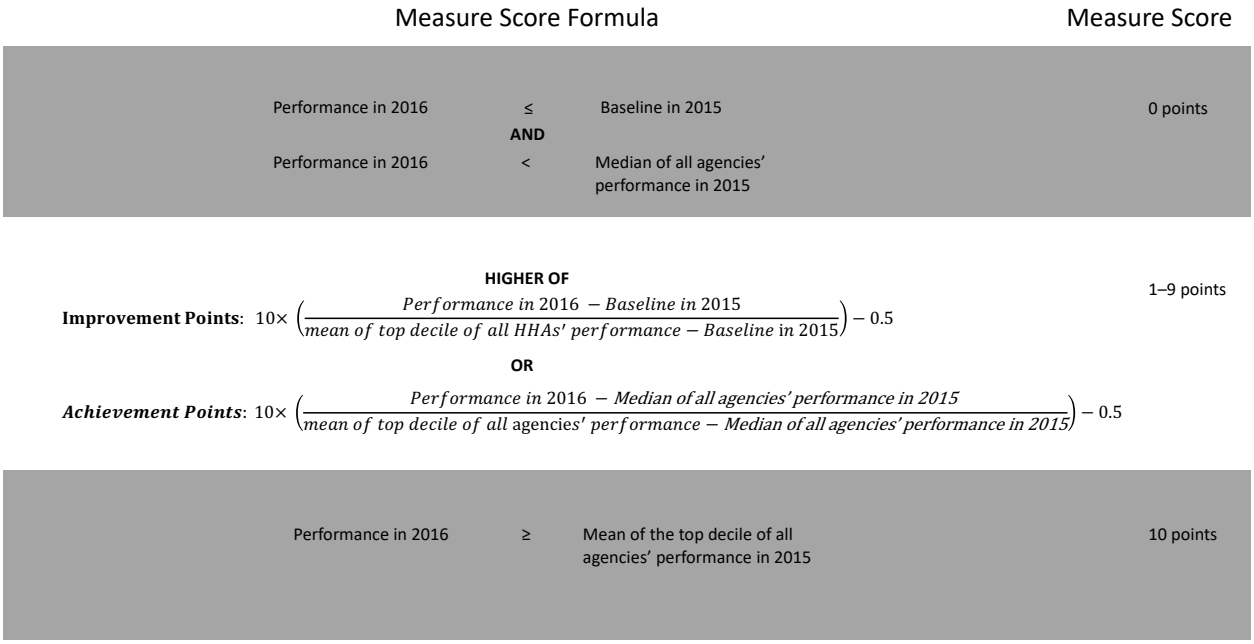
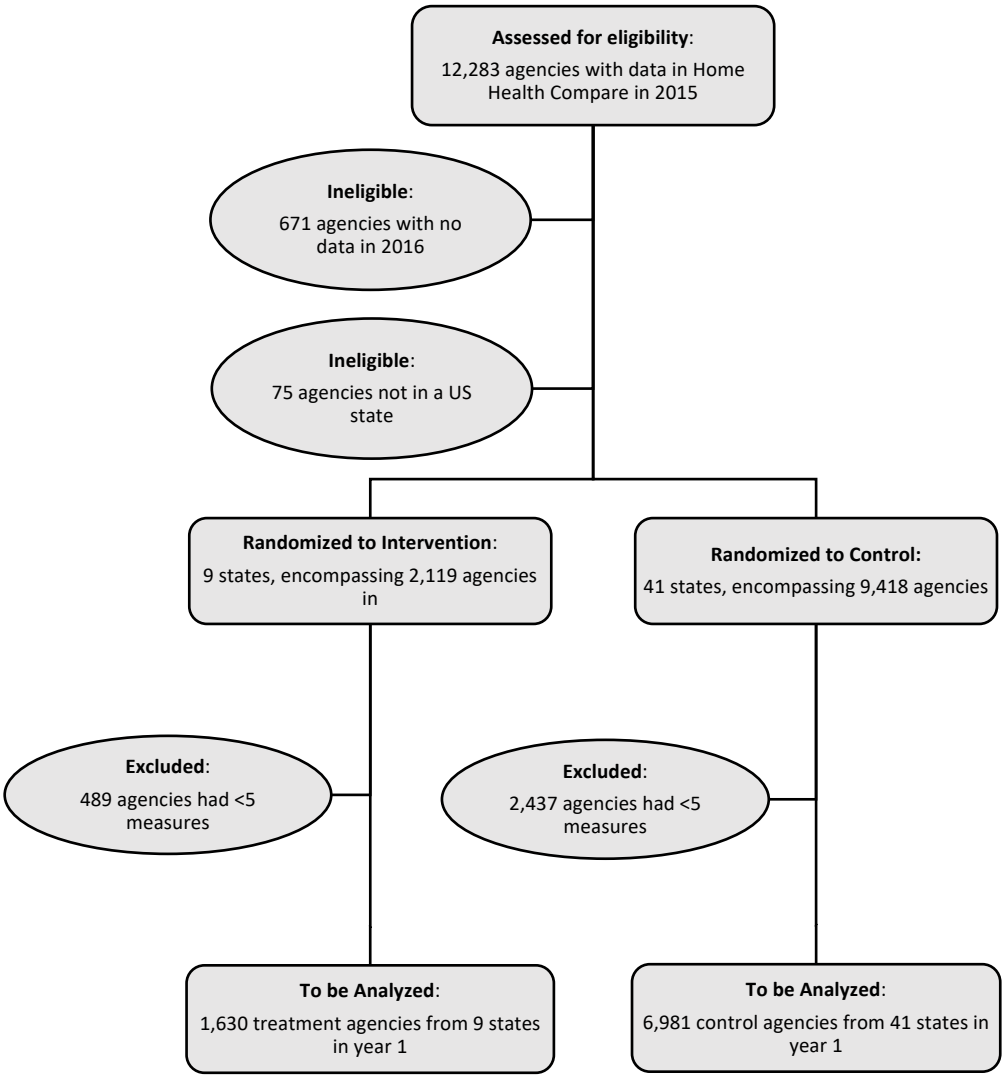


Figure 2. Home health agency eligibility and randomization the Home Health Value-Based Purchasing program.



Tables

Table 1. Quality performance outcomes targeted in first year of HHVBP.

Outcomes examined in analysis
Panel A. Measures included in analysis
Self-reported outcomes measures
Improvement in Ambulation-Locomotion
Improvement in Bed Transferring
Improvement in Bathing
Improvement in Dyspnea
Improvement in Pain Interfering with Activity
Improvement in Management of Oral Medications
Self-reported process measures
Pneumococcal Polysaccharide Vaccine Ever Received
Influenza Immunization Received for Current Flu Season
Drug Education on All Medications Provided to Patient/Caregiver
Patient Survey
How often the home health team gave care in a professional way
How well did the home health team communicate with patients
Did the home health team discuss medicines, pain, and home safety with patients
How do patients rate the overall care from the home health agency
Would patients recommend the home health agency to friends and family
Administrative-claims measures
No unplanned Hospitalization
No Emergency Department Use without Hospitalization
Panel B. Measures not included in analysis
Self-reported outcomes measures
Discharged to Community
Pay-for-reporting measures
Influenza Vaccination Coverage for Home Health Personnel
Herpes zoster vaccination
Advance Care Plan

Notes: Performance-based measures are weighted equally toward Total Performance Scoring.

Table 2. Treatment and control states.

Randomly Selected States (Treatment)	States not Select (Control), by Region
Massachusetts (1 of 6)	Vermont, Maine, Connecticut, Rhode Island, New Hampshire
Maryland (1 of 5)	Delaware, New Jersey, Pennsylvania, New York
North Carolina (1 of 5)	Alabama, Georgia, South Carolina, Virginia
Florida (1 of 5)	Texas, Oklahoma, Louisiana, Mississippi
Washington (1 of 6)	Oregon, Arkansas, Hawaii, Wyoming, Idaho
Arizona (1 of 6)	New Mexico, California, Nevada, Utah, Colorado
Iowa (1 of 6)	North Dakota, South Dakota, Montana, Wisconsin, Minnesota
Nebraska (1 of 6)	Ohio, West Virginia, Indiana, Missouri, Kansas
Tennessee (1 of 5)	Illinois, Kentucky, Arizona, Michigan

Source: Home Health CY 2016 Final Rule

Table 3. Comparison of agencies on 2015 characteristics.

	Overall	
	Control (1)	Treatment (2)
Panel A. Organizational characteristics		
Number of states	41	9
Number of agencies	6,981	1,630
Ownership		
For-profit, percent	77.5	74.5
Not-for-profit, percent	18.1	18.6
Government, percent	4.4	6.9
Setting		
Freestanding, percent	89.5	89.6
Branches		
Operate branches, percent	16.5	18.5
Program participation		
Years of Medicare participation by 2016	16.6	17.7
Rural catchment areas		
Only serve metropolitan counties, percent	38.7	45.9
Services offered		
Physical therapy, percent	99.5	99.6
Occupational therapy, percent	95.7	96.0
Speech pathology, percent	92.8	89.8
Home health aide services, percent	96.5	98.5
Medical social services, percent	88.1	87.3

Notes: *** $P < 0.05$

Comparisons are adjusted for state-level clustered standard errors.

Source: Author's calculations using calendar year 2015 Home Health Compare and Provider of Service data.

Table 3. (Continued) Comparison of agencies on 2015 characteristics.

	Overall		
	Control (1)	Treatment (2)	
Panel B. Patient Characteristics			
Number of distinct patients admitted	638.7	872.9	***
Admissions by payer source			
Medicare FFS, percent	78.7	77.6	
Medicaid, percent	9.4	9.1	
Medicare Advantage, percent	15.7	16.0	
Private, percent	2.0	2.0	
Medicare admissions, 2015			
Average Age	75.3	77.1	***
Female, percent	61.7	61.8	
White, percent	67.4	74.8	***
Hispanic, percent	10.5	14.7	
Reside in low-income ZIP codes, percent	32.1	25.5	***
Lower-profit margin Medicare admissions			
Discharged from acute care, percent	52.9	55.6	
Poor control of clinical conditions, percent	6.7	4.5	***
Overall high risk, percent	32.3	32.7	
IV therapy or parenteral nutrition, percent	2.6	2.5	
Traumatic wounds or ulcers, percent	9.8	11.0	***
Significant bathing needs, percent	17.6	19.6	

Notes: *** P < 0.05; IV = Intravenous

Comparisons are adjusted for state-level clustered standard errors.

Source: Author's calculations using calendar year 2015 OASIS data.

Table 3. (Continued) Comparison of agencies on 2015 characteristics.

	Overall		
	Control (1)	Treatment (2)	
Panel C. Baseline quality performance.			
Self-reported outcomes measures			
Ambulation-Locomotion	63.2	65.6	
Bed Transferring	58.3	61.4	
Bathing	67.0	69.8	
Dyspnea	63.5	67.4	***
Pain Interfering with Activity	66.7	70.9	
Management of Oral Medications	52.3	52.7	
Self-reported process measures			
Pneumococcal Polysaccharide Vaccine	68.7	67.8	
Influenza Immunization	65.5	65.5	
Drug Education	94.9	94.4	
Patient Survey			
Professional care	88.6	88.7	
Communication with patients	85.9	85.8	
Specific care issues	83.5	82.8	
Overall care rating	84.5	84.4	
Would recommend agency	79.6	79.8	
Administrative-claims measures			
No unplanned Hospitalization	84.3	84.1	
No Emergency Department Use	87.5	88.0	

Notes: *** $P < 0.05$

Comparisons are adjusted for state-level clustered standard errors.

Source: Author's calculations using calendar year 2015 Home Health Compare Data.

Table 4. Comparison of agencies on 2015 characteristics among propensity-score-matched samples for a self-reported outcome and a self-reported process measure.

	Overall		Ambulation		Pneumonia Vaccine	
	Control (1)	Treatment (2)	Control (1)	Treatment (2)	Control (1)	Treatment (2)
Panel A. Organizational characteristics						
Number of states	41	9	41	9	40	9
Number of agencies	6,981	1,630	1,430	1,430	1,484	1,484
Ownership						
For-profit, percent	77.5	74.5	69.3	72.0	68.9	72.3
Not-for-profit, percent	18.1	18.6	22.4	20.6	22.5	20.1
Government, percent	4.4	6.9	8.3	7.5	8.6	7.6
Setting						
Freestanding, percent	89.5	89.6	87.8	88.5	87.2	88.6
Branches						
Operate branches, percent	16.5	18.5	15.6	20.4	15.8	20.0
Program participation						
Years of Medicare participation by 2016	16.6	17.7	19.2	19.3	19.4	19.1
Rural catchment areas						
Only serve metropolitan counties, percent	38.7	45.9	42.0	43.4	42.1	43.9
Services offered						
Physical therapy, percent	99.5	99.6	99.9	99.7 ***	99.9	99.7
Occupational therapy, percent	95.7	96.0	96.4	96.6	95.6	96.3
Speech pathology, percent	92.8	89.8	93.6	90.9	93.9	90.7
Home health aide services, percent	96.5	98.5	96.8	98.5 ***	96.6	98.5
Medical social services, percent	88.1	87.3	89.1	88.6	88.1	87.8

Notes: *** $P < 0.05$

Comparisons are adjusted for state-level clustered standard errors.

Source: Author's calculations using calendar year 2015 Home Health Compare and Provider of Service data.

Table 4. (Continued) Comparison of agencies on 2015 characteristics among propensity-score-matched samples for a self-reported outcome and a self-reported process measure.

	Overall		Ambulation		Pneumonia Vaccine	
	Control (1)	Treatment (2)	Control (1)	Treatment (2)	Control (1)	Treatment (2)
Panel B. Patient Characteristics						
Number of distinct patients admitted	638.7	872.9 ***	742.6	960.8 ***	709.4	934.1 ***
Admissions by payer source						
Medicare FFS, percent	78.7	77.6	77.8	78.8	77.0	78.6
Medicaid, percent	9.4	9.1	7.5	7.7	8.2	8.1
Medicare Advantage, percent	15.7	16.0	17.7	16.1	17.7	15.9
Private, percent	2.0	2.0	2.2	2.0	2.0	2.0
Medicare admissions, 2015						
Average Age	75.3	77.1 ***	77.4	77.4	77.4	77.3
Female, percent	61.7	61.8	62.5	62.1 ***	62.5	62.0 ***
White, percent	67.4	74.8 ***	78.6	76.5	78.1	76.2
Hispanic, percent	10.5	14.7	11.4	13.6	11.8	13.9
Reside in low-income ZIP codes, percent	32.1	25.5 ***	24.7	24.8	24.3	25.0
Lower-profit margin Medicare admissions						
Discharged from acute care, percent	52.9	55.6	59.8	57.5	59.4	57.2
Poor control of clinical conditions, percent	6.7	4.5 ***	5.3	4.5 ***	5.4	4.5
Overall high risk, percent	32.3	32.7	33.8	33.1	33.9	33.0
IV therapy or parenteral nutrition, percent	2.6	2.5	2.5	2.5 ***	2.3	2.6 ***
Traumatic wounds or ulcers, percent	9.8	11.0 ***	11.1	11.5	10.8	11.4
Significant bathing needs, percent	17.6	19.6	18.5	20.3	18.4	20.1

Notes: *** P < 0.05; IV = Intravenous

Comparisons are adjusted for state-level clustered standard errors.

Source: Author's calculations using calendar year 2015 OASIS data.

Table 4. (Continued) Comparison of agencies on 2015 characteristics among propensity-score-matched samples for a self-reported outcome measure and a self-reported process measure.

	Overall		Ambulation		Pneumonia Vaccine	
	Control (1)	Treatment (2)	Control (1)	Treatment (2)	Control (1)	Treatment (2)
Panel C. Baseline quality performance.						
Self-reported outcomes measures						
Ambulation-Locomotion	63.2	65.6	64.7	65.8	63.4	65.7
Bed Transferring	58.3	61.4	60.2	61.7	59.1	61.6
Bathing	67.0	69.8	68.8	70.3	67.2	70.2
Dyspnea	63.5	67.4 ***	66.2	67.9	64.8	67.7 ***
Pain Interfering with Activity	66.7	70.9	68.7	71.3	67.2	71.2
Management of Oral Medications	52.3	52.7	53.4	53.3	52.3	53.2
Self-reported process measures						
Pneumococcal Polysaccharide Vaccine	68.7	67.8	73.2	69.1	70.4	68.5
Influenza Immunization	65.5	65.5	69.6	66.6	67.1	66.1
Drug Education	94.9	94.4	95.6	94.7 ***	94.9	94.6
Patient Survey						
Professional care	88.6	88.7	88.4	88.9	88.3	88.8
Communication with patients	85.9	85.8	85.6	86.0	85.6	85.9
Specific care issues	83.5	82.8	83.3	83.0	83.0	82.9
Overall care rating	84.5	84.4	84.3	84.7	84.1	84.6
Would recommend agency	79.6	79.8	79.2	79.9	79.1	79.7
Administrative-claims measures						
No unplanned Hospitalization	84.3	84.1	84.2	84.1	84.1	84.1
No Emergency Department Use	87.5	88.0	87.4	87.9	87.4	88.0

Notes: *** $P < 0.05$

Comparisons are adjusted for state-level clustered standard errors.

Source: Author's calculations using calendar year 2015 Home Health Compare Data.

Table 5. Comparison of agencies on 2015 characteristics among propensity-score-matched samples for a patient experience measure and a claims-based performance measure.

	Overall		Professional Care		Hospitalization		
	Control (1)	Treatment (2)	Control (1)	Treatment (2)	Control (1)	Treatment (2)	
Panel A. Organizational characteristics							
Number of states	41	9	40	9	40	9	
Number of agencies	6,981	1,630	964	964	1,377	1,377	
Ownership							
For-profit, percent	77.5	74.5	63.9	66.1	69.4	71.7	
Not-for-profit, percent	18.1	18.6	28.5	26.2	22.5	21.0	
Government, percent	4.4	6.9	7.6	7.7	8.1	7.3	
Setting							
Freestanding, percent	89.5	89.6	85.3	85.9	86.9	87.9	
Branches							
Operate branches, percent	16.5	18.5	22.5	27.9	16.8	20.9	
Program participation							
Years of Medicare participation by 2016	16.6	17.7	22.6	23.3	19.6	19.5	
Rural catchment areas							
Only serve metropolitan counties, percent	38.7	45.9	34.0	34.9	41.3	43.1	
Services offered							
Physical therapy, percent	99.5	99.6	100.0	99.8	99.8	99.8	
Occupational therapy, percent	95.7	96.0	97.8	97.3	96.7	96.6	
Speech pathology, percent	92.8	89.8	94.6	94.9	93.8	91.8	
Home health aide services, percent	96.5	98.5	97.9	98.4	96.5	98.6	***
Medical social services, percent	88.1	87.3	91.6	92.6	89.3	89.0	

Notes: *** P < 0.05

Comparisons are adjusted for state-level clustered standard errors.

Source: Author's calculations using calendar year 2015 Home Health Compare and Provider of Service data.

Table 5. (Continued) Comparison of agencies on 2015 characteristics among propensity-score-matched samples for a patient experience measure and a claims-based performance measure.

	Overall		Professional Care		Hospitalization	
	Control (1)	Treatment (2)	Control (1)	Treatment (2)	Control (1)	Treatment (2)
Panel B. Patient Characteristics						
Number of distinct patients admitted	638.7	872.9 ***	1047.0	1307.4 ***	821.5	987.3 ***
Admissions by payer source						
Medicare FFS, percent	78.7	77.6	74.0	76.6	78.5	80.4
Medicaid, percent	9.4	9.1	7.8	7.5	7.3	6.9
Medicare Advantage, percent	15.7	16.0	20.6	18.1	17.1	15.1
Private, percent	2.0	2.0	2.8	1.9 ***	2.2	2.0
Medicare admissions, 2015						
Average Age	75.3	77.1 ***	77.3	77.3	77.5	77.5
Female, percent	61.7	61.8	62.5	61.5 ***	62.7	62.2 ***
White, percent	67.4	74.8 ***	84.5	84.8	78.6	77.5
Hispanic, percent	10.5	14.7	5.0	4.8	11.5	12.5
Reside in low-income ZIP codes, percent	32.1	25.5 ***	19.6	20.2	24.0	24.3
Lower-profit margin Medicare admissions						
Discharged from acute care, percent	52.9	55.6	64.5	64.3	59.3	58.0
Poor control of clinical conditions, percent	6.7	4.5 ***	5.1	4.8 ***	5.4	4.5 ***
Overall high risk, percent	32.3	32.7	37.6	37.2	34.1	33.5
IV therapy or parenteral nutrition, percent	2.6	2.5	2.5	2.7	2.4	2.5 ***
Traumatic wounds or ulcers, percent	9.8	11.0 ***	12.4	12.9	10.9	11.5
Significant bathing needs, percent	17.6	19.6	20.9	21.9	18.8	20.3

Notes: *** P < 0.05; IV = Intravenous

Comparisons are adjusted for state-level clustered standard errors.

Source: Author's calculations using calendar year 2015 OASIS data.

Table 5. (Continued) Comparison of agencies on 2015 characteristics among propensity-score-matched samples for a patient experience measure and a claims-based performance measure.

	Overall		Professional Care		Hospitalization	
	Control (1)	Treatment (2)	Control (1)	Treatment (2)	Control (1)	Treatment (2)
Panel C. Baseline quality performance.						
Self-reported outcomes measures						
Ambulation-Locomotion	63.2	65.6	65.2	66.3	64.1	66.0
Bed Transferring	58.3	61.4	61.5	63.1	59.9	62.0
Bathing	67.0	69.8	69.4	71.0	68.2	70.5
Dyspnea	63.5	67.4 ***	67.5	70.4 ***	65.5	68.0 ***
Pain Interfering with Activity	66.7	70.9	68.3	70.3	68.1	71.3
Management of Oral Medications	52.3	52.7	54.6	56.3	53.1	53.7
Self-reported process measures						
Pneumococcal Polysaccharide Vaccine	68.7	67.8	76.1	74.7	73.0	69.5
Influenza Immunization	65.5	65.5	71.2	70.7	69.1	66.9
Drug Education	94.9	94.4	95.7	95.0	95.2	94.7
Patient Survey						
Professional care	88.6	88.7	88.7	88.7	88.4	89.0
Communication with patients	85.9	85.8	86.0	85.9	85.5	86.0
Specific care issues	83.5	82.8	83.4	83.0	83.0	83.0
Overall care rating	84.5	84.4	84.6	84.5	84.0	84.7
Would recommend agency	79.6	79.8	79.7	79.9	79.2	79.9
Administrative-claims measures						
No unplanned Hospitalization	84.3	84.1	83.8	83.8	84.0	84.0
No Emergency Department Use	87.5	88.0	87.2	87.3	87.5	87.9

Notes: *** $P < 0.05$

Comparisons are adjusted for state-level clustered standard errors.

Source: Author's calculations using calendar year 2015 Home Health Compare Data.

Table 6. Expected marginal gains from improvement among self-reported measures targeted by the Home Health Value-Based Purchasing program.

	Agencies with Measure (1)	2015 Performance Rate, out of 100 (2)	Change in Expected Performance Rate, out 100 (3)	Change in Expected Gains, out of 100 (4)
Panel A. Self-reported outcome measures				
Improvement in Ambulation-Locomotion				
N (Percent of sample with 0 TPS change)	8,383 (4%)			
Mean (SD)		63.7 (12.7)	5.2 (4.5)	1.03 (0.80)
Median (IQR)		64.7 (14.3)	3.7 (3.7)	0.81 (0.75)
Improvement in Bed Transferring				
N	8,254 (4%)			
Mean (SD)		58.9 (14.3)	6.0 (5.3)	1.00 (0.77)
Median (IQR)		60.3 (16.8)	4.3 (3.8)	0.79 (0.73)
Improvement in Bathing				
N	8,412 (4%)			
Mean (SD)		67.5 (14.2)	5.4 (4.3)	1.09 (0.76)
Median (IQR)		69.3 (15.7)	4.3 (4.0)	0.91 (0.72)
Improvement in Dyspnea				
N	8,128 (4%)			
Mean (SD)		64.2 (18.1)	6.3 (5.1)	1.12 (0.68)
Median (IQR)		68.1 (20.3)	4.8 (4.6)	0.97 (0.71)
Improvement in Pain Interfering with Activity				
N	8,321 (5%)			
Mean (SD)		67.5 (16.8)	5.6 (4.2)	1.06 (0.72)
Median (IQR)		68.9 (19.0)	4.5 (3.2)	0.94 (0.80)
Improvement in Management of Oral Medications				
N	8,121 (4%)			
Mean (SD)		52.4 (14.5)	6.4 (5.8)	1.02 (0.74)
Median (IQR)		53.5 (17.2)	4.3 (4.2)	0.83 (0.70)
Panel B. Self-reported process measures				
Pneumococcal Polysaccharide Vaccine Ever Received				
N (% with no changes in TPS even with decile improvement)	8,578 (4%)			
Mean (SD)		68.5 (22.9)	7.4 (6.1)	1.33 (0.78)
Median (IQR)		75.0 (27.3)	5.6 (4.6)	1.21 (0.67)
Influenza Immunization Received for Current Flu Season				
N	8,476 (4%)			
Mean (SD)		65.5 (19.4)	7.0 (5.4)	1.23 (0.74)
Median (IQR)		69.7 (22.4)	5.2 (4.4)	1.11 (0.71)
Drug Education on All Medications Provided to Patient/Caregiver				
N	8,584 (35%)			
Mean (SD)		94.8 (8.1)	2.3 (5.3)	3.19 (3.84)
Median (IQR)		97.5 (5.4)	0.8 (1.4)	1.33 (6.25)

Notes: There are 50 states represented for each measure.
Source: Author's calculations from 2015 Home Health Compare data.

Table 7. Expected marginal gains from improvement among patient-survey and claims-based measures targeted by the Home Health Value-Based Purchasing program.

	Agencies with Measure (1)	2015 Performance Rate, out of 100 (2)	Change in Expected Performance Rate, out 100 (3)	Change in Expected Gains, out of 100 (4)
Panel A. Patient-survey measures				
How often the home health team gave care in a professional way				
N	5,517 (14%)			
Mean (SD)		88.6 (4.1)	1.6 (1.5)	0.82 (0.73)
Median (IQR)		89.0 (5.0)	1.0 (1.0)	0.73 (0.72)
How well did the home health team communicate with patients				
N	5,517 (9%)			
Mean (SD)		85.7 (4.8)	1.9 (1.8)	0.86 (0.69)
Median (IQR)		86.0 (6.0)	1.0 (1.0)	0.67 (0.68)
Did the home health team discuss medicines, pain, and home safety with patients				
N	5,517 (6%)			
Mean (SD)		83.3 (5.9)	2.3 (2.0)	0.86 (0.73)
Median (IQR)		84.0 (7.0)	2.0 (2.0)	0.66 (0.67)
How do patients rate the overall care from the home health agency				
N	5,517 (5%)			
Mean (SD)		84.4 (6.5)	2.5 (2.2)	0.84 (0.65)
Median (IQR)		85.0 (8.0)	2.0 (2.0)	0.67 (0.61)
Would patients recommend the home health agency to friends and family				
N	5,517 (4%)			
Mean (SD)		79.5 (8.2)	3.1 (2.7)	0.85 (0.65)
Median (IQR)		81.0 (10.0)	2.0 (2.0)	0.69 (0.65)
Panel B. Administrative-claims measures				
Unplanned Hospitalization (expressed as none)				
N	7,791 (4%)			
Mean (SD)		84.3 (4.0)	1.9 (1.9)	1.01 (0.85)
Median (IQR)		84.2 (4.5)	1.1 (1.0)	0.76 (0.84)
Emergency Department Use without Hospitalization (expressed as none)				
N	7,791 (4%)			
Mean (SD)		87.6 (4.1)	1.7 (1.5)	1.04 (0.81)
Median (IQR)		87.7 (5.0)	1.2 (0.9)	0.82 (0.81)

Notes: There are 50 states represented for each measure.
Source: Author's calculations from 2015 Home Health Compare data.

Table 7. Power estimates

	DDD		Treatment Index	
	Effect size (1)	Power (2)	Effect size (3)	Power (4)
Self-reported outcomes measures			1	100.0
Ambulation-Locomotion	3	99.9		
Bed Transferring	3	98.7		
Bathing	3	99.9		
Dyspnea	3	95.6		
Pain Interfering with Activity	3	85.1		
Management of Oral Medications	3	93.7		
Self-reported process measures			1	96.6
Pneumococcal Polysaccharide Vaccine	3	76.5		
Influenza Immunization	3	92.2		
Drug Education	3	100.0		
Patient Survey			1	35.0
Professional care	3	100.0		
Communication with patients	3	100.0		
Specific care issues	3	98.4		
Overall care rating	3	98.0		
Would recommend agency	3	75.5		
Administrative-claims measures			1	99.6
No unplanned Hospitalization	3	100.0		
No Emergency Department Use	3	100.0		

Notes: Power is estimated from simulations using data from 2014 and 2015.