Effects of ESRD bundling on efficiency of U.S. dialysis centers

Dennis Cotter, MSE • David Barrus, PhD • Martin Ma, PhD • Jay Wish, MD • Mae Thamer, PhD • Mark Stephens

Introduction

In January 2011, major payment reforms were implemented by the Centers for Medicare and Medicaid Services (CMS) for the treatment of patients with End-Stage Renal Disease (ESRD) on dialysis. [1] These reforms focus on curtailing the rapid spending growth in the population of dialysis patients. The growth was largely due to the high utilization of injectable drugs, especially erythropoietin stimulating agents (ESAs).[2] The reforms include prospective bundled payments and pay-for-performance incentives in the effort to curb costs, while still incentivizing quality of care and improving the efficiency of the care delivered.

Both the General Accountability Office (GAO) and the U.S. Congress have requested an evaluation of the effects of the implementation of the ESRD Prospective Payment System (PPS) on patient care. However, the impact on dialysis center efficiency has not been published to date. Our study aim is to evaluate whether the 2011 PPS improved the efficiency of U.S. dialysis centers and to identify which providers demonstrated changes in their efficiency after the PPS implementation. We hypothesized that the new payment system would lead to increased efficiency during the periods immediately following ESRD PPS implementation after centers adapted their cost structure and practice patterns to stricter payment controls and potential penalties for not meeting quality of care standards.

Methods

- *Data sources*

The setting of this study was the 4,173 Medicare-certified, free-standing dialysis centers in the United States that offered in-center hemodialysis from 2010 through 2012. This sample comprised approximately 85% of all dialysis centers. Treatment data and cost and labor inputs of dialysis treatments were obtained from the 2010-2012 Medicare Renal Cost Reports[3] and Dialysis Facility Reports.[4] The socio-demographic data on the characteristics of residents in the neighborhoods where dialysis centers are located were obtained from the 2010 US Census.

- *Definitions*

Dialysis facility centers are faced with relatively fixed demand for patient care services for which they produce a fixed number of outputs such as dialysis treatments. The term "efficiency" in dialysis is best viewed from the perspective of technical efficiency. Technical efficiency encompasses the improvement in some inputs or outputs without worsening any other inputs or outputs.

Efficiencies are realized through minimizing inputs, such as machine costs, drug costs, etc., while maintaining a fixed level of output, measured by the number of dialysis sessions administered. In other words, a dialysis facility is more technically efficient if it can produce the same number of dialysis sessions with less drugs, staff, etc. In such an input-oriented model, the minimum inputs that a facility should require to produce its outputs is estimated from the best-practice frontier, as defined through appropriate benchmarking of technical efficiency over time. [5]

Meanwhile, changes in "productivity" are the result of the combination of changes in the relative technical efficiency of a unit and changes in the best practices frontier, e.g., through technological innovation. As the mix of clinics which attain the best practices frontier changes, there is a change in the minimum input requirements to produce a given level of outputs.[6]

An example of a technological innovation which could shift the best practices frontier would be adoption of newer generations of pharmacologic agents administered in the hemodialysis unit such as erythropoiesis stimulating agents and calcimimetics. A technically-efficient dialysis unit could fall behind if industry-

Mr. Cotter is president of Medical Technology and Practice Patterns Institute, Bethesda, Md., which, among other projects, focuses on the implications of ESRD Program payment policy. **Dr. Barrus** is chair of the economics department and Dr. **Ma** is assistant professor of economics at Brigham Young University-Idaho-(Rexburg). **Dr. Thamer** is the director of research at MTPPI. **Dr. Wish** is medical director of the outpatient hemodialysis unit at Indiana University Hospital and professor of clinical medicine at Indiana University School of Medicine in Indianapolis. He is also vice-chair of NN&I's Editorial Advisory Board. **Mr. Stephens** is the principal of Prima Health Analytics, Weymouth, Mass.

**Results of this preliminary study first appeared as a poster entitled Changes in Efficiency of U.S. Dialysis Centers amid Regulatory and Payment Reform presented at the 22nd annual meeting of the International Society for Pharmacoeconomics and Outcomes Research, Boston, Mass., May 23, 2017.*

leading innovations are not adopted. Hence, with no absolute change in technical efficiency, there could be a decline in relative productivity.

- *Analysis technique*

The traditional way to analyze efficiency in this type of market is using data envelopment analysis (DEA). Based on precedence in this field,[7,8] we used an input-oriented variable-returns-to-scale DEA model to analyze the outputs, dialysis treatment session, and inputs, costs and personnel (FTE) for 2010, 2011, and 2012, and designated certain clinics as being technically efficient. These clinics receive a DEA score of 1.0, while clinics that are not technically efficient receive a score less than 1.0. The limitation of the DEA model is that it only analyzes one time period or year at a time. This does not allow for studying how technical efficiency and productivity changes over time.

The DEA-based Malmquist Productivity Index was the tool of choice for this study because it allows for analysis of technical efficiency, innovation, and productivity changes over time. The Index was used to compare DEA-based efficiency scores from 2010 to 2012. It combines the technical efficiency and the changes in technology, or shifts of the efficiency frontier, into one productivity index, and it traces changes in productivity from year to year. In this study freestanding dialysis facility output was measured by the number of dialysis treatment sessions, using multiple inputs, before and after the ESRD PPS reform.

The efficiency component of the Malmquist Index evaluates the clinic's costs of inputs, such as machines, technicians, etc., and determines which clinics are producing the most dialysis sessions at the lowest costs. The clinics that are on the "best-practice frontier" are efficient. The clinics that are not on the frontier are considered inefficient. Each year the distance between "efficient" clinics and the clinic of interest is measured. If the clinic of interest gets closer to the frontier, then the efficiency score of the Malmquist Index will be greater than 1.0 or, in other words, the clinic is catching up to the more efficient clinics. If, on the other hand, the clinic of interest gets further away from the frontier, then the efficiency score of the Malmquist Index will be less than 1.0. If there is no change from year to year, then a clinic will have a score around 1.0.

Table 1. Characteristics of sample freestanding dialysis facilities

Variable	Number (n=4173)	Mean (%)
Annual 4-Hour Hemodialysis Equivalent Sessions		12,238
Market Competition (2012)		
Hirschman-Herfindahl Index		0.677
% For Profits in Market		93.3%
Facility Characteristics (2012)		
Not affiliated-Independent	279	6.7%
Affiliated with Small Chain	232	5.6%
Affiliated with Mid-Sized Chain	418	10.0%
Affiliated with Large Chain	3,244	77.7%
For Profit	3,900	93.5%
Non-Profit	273	6.5%
Northeast Region	527	12.6%
Midwest Region	889	21.3%
South Region	1,988	47.6%
West Region	769	18.4%
Rural	406	9.7%
Suburban	610	14.6%
Urban	3,157	75.7%
Average Annual Costs*		
Admin & General Costs		$623,579
Drug Costs		$589,613
Medical Supply Costs		$288,073
Capital Costs		$218,008
Machine Costs		$103,439
Operations & Maintenance		$91,125
Other Costs		$67,391
Nursing FTEs		4.7
Dialysis Technician FTEs		6.5

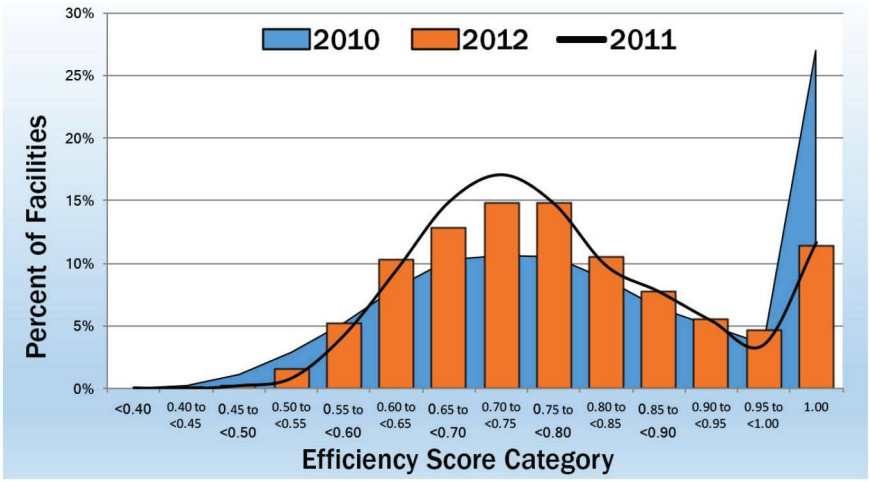
Adjusted to 2010 dollars

The technology (innovation) component of the Malmquist Index measures how the "best-practice frontier" moves from year to year. If the technology score of the Malmquist Index is greater than 1.0, then this indicates there has been innovation over time. But if the technology score of the Malmquist Index is less than 1.0, then there has been technological regression. A regression of technological innovation could be as simple as clinics not implementing the latest cost-saving techniques. A technology score of 1.0 indicates that innovation has not changed from one period to the next.

When the efficiency and technology portions of the Malmquist Index are put together, this indicates how productive clinics are from one period to the next. An example illustrates how the efficiency score and technology score are combined to create the Malmquist Productivity Index. If a clinic receives a year-over-year efficiency score of 1.042, this means that the clinic has done better at keeping costs down over time. This clinic is getting closer to the more efficient providers. In fact, efficiency has increased 4.2% over time.

Let's assume this same clinic gets a technology score of 0.94. This means that there has been some regression in innovation. The overall productivity index would be 0.98. This means that while the clinic is catching up

Figure 1. Relative efficiency score distributions, 2010—2012



to those on the frontier (efficiency score), there has been some technological regression (technology score). In other words, the clinic is not as productive as the previous year.

We used the Hirschman–Herfindahl index (HHI) as a measure of market concentration, constructed by summing the squared market shares of all dialysis companies in a given metropolitan/micropolitan statistical area (MSA), or county for non-MSA facilities.[9] The market share for each company was measured as the proportion of total dialysis treatments produced by the facilities owned by a company to the total number of dialysis treatments furnished by all facilities, including hospital-based facilities, in a given market. The values of HHI range from 0 to 1, and the higher the value, the more concentrated a market is.

Results

- *Dialysis Facility Characteristics*

The 2010 Renal Cost Reports database included 4,870 free-standing hemodialysis facilities, of which 588 were excluded due to missing data or cost outliers. Of the 4,282 remaining facilities 4,173 had data from 2010-2012.

The dialysis market from 2010 to 2012 was dominated by the two largest chains, which owned 78% of all freestanding facilities by 2012. Local market concentration was also high because of low competition, as measured by a mean Hirschman-Herfindahl Index of 0.677 in 2012. In this group, 93.5% of all free-standing facilities were for-profit, 93.3% were chain-affiliated, and 75.7% were located in urban areas. Nearly half of all facilities were located in the South census region (see Table 1).

- *Data Envelopment Analysis*

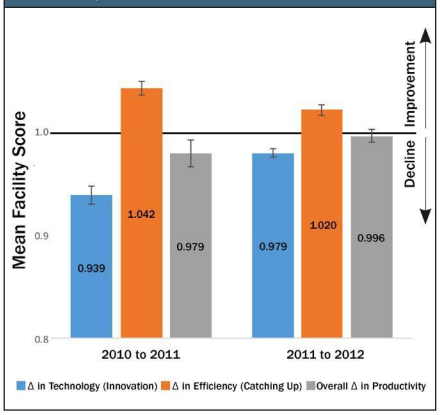
The distributions of efficiency scores from the DEA model changed significantly between 2010 and 2011-12. While in 2010, 26.9% of facilities attained the efficiency frontier (maximum relative efficiency, score = 1.0), by 2011-12, the percentage dropped to 11-12% (see Figure 1). About 36% of facilities were functioning efficiently (efficiency scores ≥.0.90) in 2010, dropping to only 21-22% efficiently operating facilities in 2011-12. The overall distribution of efficiency scores in 2011 and 2012 was more concentrated near the mean efficiency score (0.78 in both years) with fewer outlier facilities in the tails of the distributions.

- *Productivity changes after 2010*

The average Malmquist productivity score declined by -2.1% from 2010 to 2011 (95% CI: -3.4% to -0.8%) and was basically unchanged from 2011 to 2012 (mean productivity index score: 0.996, 95% CI 0.990-1.001). While the average facility saw some relative technical efficiency gains, the technology/innovation portion of the index declined in each year, 2011 and 2012, more than offsetting the average facility gain in technical efficiency (see Figure 2).

Some productivity gains were seen in 2011 for independent facilities and in facilities that were members of medium-sized or non-profit chains, and located in the Northeast region (see Table 2). For 2012, only the Western region showed a statistically-significant marginal productivity improvement (mean index score 1.016, 95% CI 1.004-1.027).

Figure 2. Average Malmquist Productivity Index Component Scores, 2011-2012 [6]



Discussion

This study found the US dialysis industry's response to the 2011 Medicare payment reforms was mixed. While there was a substantial "catching up" effect in some industry segments that had significantly lagged the efficiency frontier in 2010, the overall efficiency frontier regressed in the years 2011 to 2012. This was observed by the decline in the technology component of the overall Malmquist Index.

One explanation for the mixed response could be that some facilities

may have anticipated PPS reforms by implementing efficiency measures prior to 2011. The relatively high number of facilities at the efficiency frontier in 2010, and general broader dispersion of efficiency scores below the frontier suggest that 2010 may have been a period of time when the level of preparation for the payment reforms was already well underway across the industry.

Additionally, the exigencies of the payment reforms, once implemented, may have proven less draconian than expected. This could have resulted in some relaxing of innovation and/or efficiency on the part of the most efficient providers beginning in 2011, while other industry segments began to catch up to the leaders through both a "lowering of the bar" as well as improving their own relative efficiency.

Limitations

As with any observational retrospective study, there are several important study limitations, including in this case the absence of input measures to adjust for variability in patient case mix (i.e., input requirements) across facilities, and the possibility of selection bias due to the fact that some facilities were excluded because of missing data.

Conclusions

Contrary to our hypothesis, the US dialysis industry did not appear to realize short-term gains in productivity in response to the 2011 Medicare payment reforms, as compared to the year just prior to reform. We believe pre-emptive measures to improve efficiency might have been implemented by some centers before 2011 which could have affected our findings.

Future work in our analyses will incorporate quality of care dimensions and case-mix adjustment in the measurement of efficiency and productivity over a longer timeframe before and after implementation of the 2011 ESRD PPS reforms.

Table 2. Malmquist Productivity Index Scores by market segment

Market Segment	2010 to 2011 Mean (SD)	2011 to 2012 Mean (SD)
All Facilities	0.979 (0.426)	0.996 (0.191)
Independent (Unaffiliated)	1.070 (0.516)	1.014 (0.399)
Small Dialysis Organization	0.996 (0.279)	0.988 (0.211)
Medium Dialysis Organization	1.025 (0.249)	0.939 (0.249)
Large Dialysis Organization	0.960 (0.450)	1.002 (0.147)
Non-Profit	1.011 (0.222)	0.874 (0.151)
For Profit	0.977 (0.437)	1.004 (0.191)
Rural	0.926 (0.201)	0.994 (0.348)
Suburban	0.956 (0.231)	0.995 (0.161)
Urban	0.990 (0.474)	0.996 (0.166)
Midwest Region	0.927 (0.201)	0.992 (0.160)
Northeast Region	1.108 (1.023)	0.974 (0.165)
South Region	0.960 (0.241)	0.995 (0.218)
West Region	1.000 (0.240)	1.016 (0.162)

Acknowledgements

This study was sponsored by a grant from the Agency for Healthcare Research and Quality (AHRQ). R01 HS024190-01A1 – *Impact of the ESRD PPS reform on efficiency of dialysis providers and the impact on quality of care and patient outcomes*. The data used originated from the Centers for Medicaid & Medicare Services (CMS). The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as the official policy or interpretation of the US government. Furthermore, there are no disclaimers for any of the authors to report. All authors participated in the design, analysis, interpretation, writing, and/or editing of this study and have seen and approved the final version. Dennis Cotter, as first author, had full access to all of the data in the study and had final responsibility for the decision to submit for publication. *NN&I*

References

1. Centers for Medicare and Medicaid Services, ESRD Prospective Payment System 2011 Final Rule, Regulation No. CMS-1418-F
2. Thamer M, Zhang Y, Kaufman J, Cotter D, Dong F, Hernán MA. Dialysis facility ownership and epoetin dosing in patients receiving hemodialysis. JAMA. 2007 Apr 18;297(15):1667-74.
3. CMS. 2017. Renal Cost Reports. CMS-Form-265-94, CMS-Form-265-11
4. Dialysis Facility Reports, accessed at dialysisdata.org, 2017
5. Cooper WW et al. Handbook on Data Envelopment Analysis. Springer Publishers, 2004
6. Caves DW et al. The economic theory of index numbers and the measurement of input, output, and productivity Econometrica 11:6 1393-1414, 1982
7. Ozgen H, Ozcan YA. A national study of efficiency for dialysis centers: An examination of market competition and facility characteristics for production of multiple dialysis outputs. Health Serv Res. 2002; 37:711-732
8. Shreay S et al. Efficiency of U.S. dialysis centers: An updated examination of facility characteristics that influence production of dialysis treatments. Health Serv Res. 49:838-857, 2014
9. Whinston MD. Lectures on Antitrust Economics. Cambridge, MA: The MIT Press, 2006