Published in final edited form as:

J Vasc Interv Radiol. 2016 February ; 27(2): 210–218. doi:10.1016/j.jvir.2015.10.024.

A Cross-Sectional Survey of Interventional Radiologists and Vascular Surgeons Regarding the Cost and Reimbursement of Common Devices and Procedures

Angela Wang, BA¹, Stephanie L. Dybul, BS¹, Parag J. Patel, MD, MS², Sean M. Tutton, MD, FSIR², Cheong J. Lee, MD³, and Sarah B. White, MD, MS²

¹Medical College of Wisconsin School of Medicine, Milwaukee, WI

²Department of Radiology, Division of Vascular & Interventional Radiology, Medical College of Wisconsin, Milwaukee, WI

³Department of Surgery, Division of Vascular Surgery, Medical College of Wisconsin, Wisconsin, Milwaukee, WI

Abstract

Purpose—To evaluate knowledge of interventional radiologists (IRs) and vascular surgeons (VSs) on the cost of common devices and procedures and to determine factors associated with differences in understanding.

Materials and Methods—An online survey was administered to US faculty IRs and VSs. Demographic information and physicians' opinions on hospital costs were elicited. Respondents were asked to estimate the average price of 15 commonly used devices and to estimate the work relative value units (wRVUs) and average Medicare reimbursements for 10 procedures. Answer estimates were deemed correct if values were $\pm 25\%$ of the actual costs. Multivariate logistical regression was used to calculate odds ratios and 95% confidence intervals.

Results—Of the 4,926 participants contacted, 1,090 (22.1%) completed the questionnaire. Overall, 19.8%, 22.8%, and 31.9% were accurate in price estimations of devices, Medicare reimbursement, and wRVUs for procedures. Physicians who thought themselves adequately educated about wRVUs were more accurate in predicting procedural costs in wRVUs than physicians who responded otherwise (odds ratio = 1.40, 95% confidence interval, 1.29–1.52; $P < .0001$). Estimation accuracies for procedures showed a positive trend in more experienced physicians (> 16 y), private practice physicians, and physicians who practice in rural areas.

Conclusions—This study suggests that IRs and VSs have limited knowledge regarding device costs. Given the current health care environment, more attention should be placed on cost education and awareness so that physicians can provide the most cost-effective care.

Corresponding Author: Sarah B White, MD, MS, sbwhite@mcw.edu.

Disclosures:

Neither of the other authors has identified a conflict of interest.

From the SIR 2015 Annual Meeting.

INTRODUCTION

As the United States expands health care coverage under the Affordable Care Act, increased attention has been placed on investigating medical device costs (1,2). Under these new policies, US health spending is projected to increase to \$5.01 trillion by 2022, whereas Medicare is estimated to deplete all assets by 2030 (3,4). With an aging population, services in the management of cardiovascular disease, trauma, and cancer will expect even greater utilization (5,6). Innovative minimally invasive therapies have been shown to decrease cost, by decreasing hospital length of stay and procedure recovery time (7–9). Additionally, new emphasis has been placed on physician decision making to decrease excess laboratory testing and to make informed choices on the use of commonly used devices (10). However, literature spanning the past 35 years suggests that physicians may have inadequate knowledge about the cost of frequently used devices and regularly performed procedures (11–13). Although research on physician cost knowledge has been performed in various fields, these studies are largely outdated and do not encompass procedural specialists (14–16). These specialties are uniquely positioned to regulate spending because they use tools and instruments that can often comprise most of the total variable operating expenses. For example, it was found that 62% of transarterial chemoembolization costs were attributed to expendable equipment, whereas 87.3% of charges from endovascular aortic aneurysm repair were attributed to the cost of the endografts (1,17). These expendable materials often vary widely in cost and provide a setting where physician choice can contribute to major cost savings (18). Thus, it is important to gauge the understanding of interventional radiologists (IRs) and vascular surgeons (VSs) of device costs to prevent the misuse of limited resources and to encourage physician-controlled cost containment. This study seeks to evaluate abilities of IRs and VSs to estimate the prices of common devices and reimbursement of procedures, determine factors associated with cost knowledge, and report on their opinions on hospital expenses.

MATERIALS AND METHODS

The institutional review board approved this cross-sectional study and waived informed consent.

Participants

A cross-sectional study was conducted between June 2014 and September 2014 among active IRs and VSs. All US faculty IRs who were members of the Society of Interventional Radiology (SIR) (N 1/4 3,074) and US faculty VSs who were members of the Society of Vascular Surgery (N 1/4 1,852) were invited to participate in a national survey. Survey links were sent via e-mail and conducted using SurveyMonkey (SurveyMonkey, Palo Alto, California). To ensure physician anonymity and security, the Survey-Monkey Gold Feature was used in addition to privacy and security software (including Secure Sockets Layer/Transport Security Layer encryption, Qualys security scans [Qualys, Inc, Redwood City, California], and firewall systems). Participation in the study was voluntary, and no personal identifying information was retained. Respondents were given 4 weeks to complete the

survey, and a reminder e-mail was sent at the end of each week (for a total of three reminder emails).

Survey Design

Because a validated survey does not exist on this subject, a new survey was created. A list of commonly performed procedures and commonly used devices was assembled after consulting with a team consisting of six IRs, one VS, and interventional radiology and vascular surgery technologists. From this list, 15 devices and 15 procedures were ultimately chosen for the survey based on the commonality of the devices in hospital stock rooms, vendor-reported frequency of device sales, and generally well-known procedures to both specialties. The specific numbers of devices and procedures were chosen to survey a wide range of items, while keeping the questionnaire to a manageable length. The 15 devices were common between the two specialties, and participants were asked to estimate the average retail costs of each device to the nearest dollar in a fill-in-the-blank format. Regarding procedures, five questions overlapped between the two specialties, five were specific to interventional radiology, and five were specific to vascular surgery, resulting 10 procedural questions per specialty. Physicians were also asked to estimate the average work relative value units (wRVUs) and average Medicare reimbursement rates to the nearest dollar for these procedures in a fill-in-the-blank format. Demographic information was also elicited. The full survey is provided in the Appendix.

Cost Determination

The reference values were determined using three methods. First, 2014 base retail prices and costs charged to the hospital before negotiations or discounts were obtained from various vendors. Retail prices were chosen from companies that commonly produce the device and averaged when appropriate for products made by more than one retailer. Base prices were chosen to represent actual cost to eliminate fluctuating vendor discount prices, which can vary significantly from one institution to the next (19). Second, wRVUs were determined using the 2014 National Physician Fee Schedule Relative Value File (January release), and multiple procedure payment reductions were accounted for in final adjustments (20). wRVUs were chosen as a method of assessing procedure costs to eliminate similar fluctuations in regional pricing. A wRVU is one of three components in the standardized physician payment and accounts for 48% of the total relative value units for each service. Practice expense and professional liability are the other two relative value unit types. Factors considered when determining the value of the wRVU for a service include the technical skill, physical effort, mental effort and judgment, and stress related to patient risk (21). Third, average Medicare reimbursement rates were calculated using the Medicare Current Procedural Terminology coding system, and the national average prices were used as the actual cost (22). This additional method to calculate procedural costs was chosen to compare physicians' knowledge of wRVUs versus dollar values.

Statistical Analysis

Data were analyzed per device or procedure, and each respondent's cost estimation was compared with the reference price. Physicians' estimates for the 15 devices and 10 procedures were determined correct if values were within 25% of the reference costs. The

25% error margin was used in this study because this range has been frequently cited in corresponding literature and provides a standard for comparison among specialties (16,23). Answers outside of the absolute error range were defined as overestimates or underestimates. The proportion of accurate responses was modeled statistically as binomial data. For example, if device X had a retail price of \$100, estimates between \$75 and \$125 were deemed correct, and answers outside of that range (absolute error range) were marked as incorrect. To determine cost knowledge of IRs and VSs, overall cost accuracies were calculated for devices, procedures in wRVUs, and procedures in Medicare dollars. Furthermore, to assess factors associated with this knowledge, we performed univariate and multivariate analyses.

Generalized linear models with logit link (logistic regression) were used for all analyses of accuracy, and generalized estimating equations were used to adjust for multiple responses per subject. All models included a variable to control for the varying difficulty of each device or procedure cost estimate (results not shown). Missing responses for questions were coded as a “missing” group to allow partially complete observations to be included in the analysis. Separate models for each question, group, and type were used for the estimates in Table 1. A multivariate analysis was developed to compare the simultaneous effects of the demographic questions. Pairwise comparisons of response levels were considered only if the variable was significant overall (step-down approach). Least squares mean estimates were transformed to probability (proportion accurate) estimates using the inverse link function. α values of < 0.05 were considered statistically significant. The analysis was performed using SAS version 9.3 (SAS Institute, Inc, Cary, North Carolina).

Descriptive histograms of the data typically showed strong right skew, with the mode below the actual cost. The analysis presented here classified cost estimates as accurate if within 25% of the actual cost and inaccurate otherwise. Resulting estimates and confidence intervals (CIs) of the proportion accurate do not depend on the accuracy of the actual costs.

RESULTS

Of 4,926 faculty, 1,090 (22.1%) responded to the survey (688 of 3,074 [22.4%] IRs and 402 of 1,852 [21.7%] VSs). Physician estimation accuracies for the previous three categories based on demographics and physician opinion are reported in Table 1. The number of physicians varied for each question based on the physicians who completed the questionnaire and the physicians who were included in the univariate analysis. Among all respondents, 19.8% were accurate in the cost estimations of devices, 22.8% were accurate in Medicare reimbursement, and 31.9% were accurate in wRVUs for procedures. Overall, physicians overestimated the costs of less expensive devices and underestimated the costs of more expensive devices and procedures.

Univariate Analysis

Table 2 represents the univariate analysis comparing estimation accuracies of IRs and VSs for devices. IRs were more accurate in estimating the cost of a Berenstein catheter ($P = .007$), whereas VSs were more accurate in estimating the costs of an abdominal aortic

aneurysm stent graft ($P < .001$) and micropuncture kit ($P = .007$). There were no significant differences in accuracies between IRs and VSs for the remaining devices.

Multivariate Analysis

For the multivariate analysis on device cost estimation accuracies, two subgroups of physicians performed statistically better. Physicians who reported having “average” self-assessed cost knowledge were significantly better at estimating device cost than physicians who rated themselves as having “poor,” “below average,” or “excellent” cost knowledge (odds ratio [OR] = 1.28, 95% CI, 1.05–1.56; OR = 1.16, 95% CI, 1.02–1.33; OR = 1.36, 95% CI, 1.04–1.76). Similarly, physicians who reported having “above average” self-assessed cost knowledge were significantly better at estimating device cost than physicians who rated themselves as having “poor,” “below average,” or “excellent” cost knowledge (OR = 1.45, 95% CI, 1.16–1.79; OR = 1.30, 95% CI, 1.12–1.52; OR = 1.52, 95% CI, 1.16–1.99).

Table 3 shows estimation accuracies of IRs and VSs for procedures. Better estimation accuracies for Medicare reimbursement of procedures were correlated with more experienced physicians and physicians in private practice. Physicians with 16–20 years of experience were statistically more accurate than physicians with 0–5, 6–10, and 11–15 years of experience (OR = 1.89, 95% CI, 1.27–2.78; OR = 1.72, 95% CI, 1.19–2.50; OR = 1.61, 95% CI, 1.10–2.38). Correspondingly, physicians in practice for ≥ 26 years were also significantly more accurate than physicians with 0–5, 6–10, and 11–15 years of experience (OR = 1.85, 95% CI, 1.23–2.78; OR = 1.72, 95% CI, 1.15–2.56; OR = 1.61, 95% CI, 1.06–2.44). Multivariate analysis further revealed that physicians in private practice were better at estimating Medicare reimbursement costs for procedures than physicians in nonprivate practice (including physicians in academic hospitals, nongovernmental public hospitals, and governmental hospitals). Specifically, physicians working in small aligned physician groups had the highest accuracy (32.8%) and had a 2.35 higher odds of making a correct Medicare cost estimate than their nonprivate practice counterparts (OR = 2.35, 95% CI, 1.64–3.37). Also, the odds of making an accurate Medicare cost estimate for large independent groups were 1.70 that of their nonprivate practice counterparts (OR = 1.70, 95% CI, 1.25–2.33).

Lastly, multivariate analysis on wRVU estimation accuracies revealed that physicians in rural and major metropolitan areas and physicians who reported feeling adequately educated on RVUs had higher estimation accuracies. Physicians in rural area practices and physicians in major metropolitan areas were the most accurate in predicting procedure costs in wRVUs. Physicians in rural areas had significantly better accuracy than physicians in small cities, suburban areas, and small towns (OR = 2.74, 95% CI, 1.03–7.34; OR = 3.51, 95% CI, 1.28–9.67; OR = 4.05, 95% CI, 1.38–11.88). Physicians in major metropolitan areas had significantly better accuracy than physicians in suburban areas only (OR = 1.38, 95% CI, 1.01–1.89). Additionally, physicians who reported feeling adequately educated on relative value units had more accurate cost estimates of procedures in wRVUs than physicians who indicated otherwise (OR = 1.40, 95% CI, 1.29–1.52).

Nonresponder Data

Although 1,090 physicians responded to the survey, some of these participants did not complete the entire questionnaire. There were 241 physicians excluded because they did not respond to the actual cost estimates portion of the survey and submitted only demographic information. Of participants, 724 of 839 (86.3%) responded to all 15 device items, 506 of 540 (93.7%) responded to all 10 Medicare items, and 539 of 578 (93.3%) responded to all 10 wRVU items.

DISCUSSION

Limited information exists in the literature on physicians' understanding of costs in interventional radiology and vascular surgery. More recent studies in other fields, such as orthopedic surgery and emergency medicine, revealed that many physicians have limited knowledge of costs of health care devices and drugs (24,25). In these studies, orthopedic surgeons were correct in their cost estimations 21% of the time, and emergency physicians were correct in their cost estimations 17% of the time, mirroring device estimation accuracies of IRs and VSs in our study. However, these reports lack substantial analysis on how demographics and opinions were correlated with differences in cost comprehension.

In the present study, more accurate cost estimations were correlated with self-assessed knowledge, years of experience, working in private practice, and area of practice. Additionally, physicians who reported feeling adequately educated on wRVUs performed better than physicians who reported inadequate education. These results may suggest a component of cost exposure in physicians' understanding of health care spending. For example, physicians who work in private practice or rural areas may play a larger role in managing hospital expenses, and physicians who have been in practice for longer periods of time may be more familiar with how their hospitals negotiate contracts for device-related and procedure-related costs.

Cost exposure seems to play an important role in physicians' comprehension of health care costs; however, our survey indicated that only 24.1% of respondents claimed to have adequate access to hospital pricing information. Although 81.5% of the physicians believed that cost is moderately to very important in daily practice, almost all of these physicians (98.4%) indicated that they would choose to use less expensive tools. This discrepancy between physician opinions and their actual cost knowledge reveals a need for improved cost transparency and exposure.

Improving a physician's understanding of cost is crucial. In 2013, an article by Agrawal et al (26) suggested that at least 60% of health care expenses are regulated by physicians. Physician preferences often determine the quantity and specific type of devices a hospital purchases, and these preferences are heavily influenced by experience with devices and past exposures (27). However, many of these devices are unique and made by only one company. With the addition of confidentiality clauses that prohibit buyers from disclosing negotiated prices, medical device companies can control the health care market and inhibit the ability of physicians to cut costs, even when less expensive alternatives are available. Consequently,

the lack of competitive pricing information and skewed physician preferences drive costs up for hospitals and insurance companies.

Although policymakers are taking initial steps to improve medical price transparency, policies such as bundled payment plans, pay-for-performance, and gain sharing have been proposed to incentivize physician involvement and positive action (27,28). As Medicare reimbursement rates continue to decrease, physicians' workloads have seen steady increases (29). With bundled payments and pay-for-performance, where reimbursement is independent of materials used and time spent, physicians may be pressured to alter their practices to maintain compensation.

Although cost-conscious spending is a popular topic, few methods have been proposed and tested. A study in the New England Journal of Medicine revealed that providing physicians with cost information during the ordering process decreased the number and overall cost of tests obtained (30). However, a comparable study performed in radiology did not produce a meaningful change in the use of diagnostic imaging; this could be due to the fact that radiologists are not the ordering providers for many of the examinations (31). However, IRs have a direct impact on spending. For example, they can choose to use a small-diameter helical coil rather than a bioactive coil, which confers a significant price difference (18).

More recent efforts at providing physician cost education have seen positive outcomes (32). A program initiated by the Cleveland Clinic demonstrated the significance of cost education on lowering health care spending (33). By instructing physicians on the purchases and utilization of various tools and drugs, the hospital reported a savings of \$155 million over 3 years. Although additional research is needed to establish an effective means of improving physician cost awareness, realizing this area for improvement is the first step. By using the results from cost knowledge studies such as the present study, physicians, hospitals, and policymakers can hope to advance clinical practice through further investigation of why various groups of physicians are more cost aware than others and through better understanding of the physician's role in health care cost containment. Physicians can start to improve their cost knowledge by working with their societies, which publish coding and economic information regularly. In addition, the American Medical Association has resources available (34).

Limitations of this study include survey response bias, differences in physicians' interpretations of average retail prices, and variable device and procedure familiarity among physicians. First, although this study obtained 1,090 overall responses, the total response rate was 22.1%. Survey response biases have been proposed in the past, suggesting that there may be answer disparities between responders and nonresponders. Although efforts were made to analyze the entire population demographics for all physicians contacted in this survey (through SIR and Society of Vascular Surgery), corresponding data categories, such as years in practice, type of practice, and area of practice, were unavailable from either society. Therefore, data pertaining to differences between the responding population and the nonresponding population are unavailable. Nevertheless, it is common to see similar response rates in other cross-sectional studies within radiology, and some studies proposed that such a bias is relatively minute (35,36).

Second, it is unclear how physicians interpreted average retail prices for devices when their exposure profile may be exclusive to their respective workplaces. Some physicians may have access only to negotiated device prices without knowing the exact discount applied.

Although the survey emphasized “average retail cost” for each device and incorporated a $\pm 25\%$ error margin for cost analysis, some inaccuracies in physicians’ cost knowledge may still be expected in the data. However, compared with other, smaller cost studies mentioned previously, overall cost estimation accuracies were still comparable (24).

Although items were selected to represent a wide range of standard devices and procedures, depending on the patient population and physician subspecialty, some respondents may have been unfamiliar with the items questioned. This variation in interpretation and understanding of survey questions may contribute to the complexity of this study.

In conclusion, most IRs and VSs believed that health care costs should be considered in clinical practice. However, actual device and procedural reimbursement cost knowledge was limited in both groups of physicians. Superior cost estimation accuracies were associated with self-assessed knowledge, years of experience, working in private practice, and area of practice—suggesting a positive correlation to cost exposure. As the US health care system continues to evolve, physicians require access to price transparency and fiscal education to make tangible cuts in health care expenditures. Although external policies encourage physician action, internal education on hospital value and efficacy may produce more long-lasting and patient-friendly results.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

We thank the Medical College of Wisconsin Interventional Radiology technologists for helping with survey creation, and Joy Gornal and Robert White from SIR for their help with survey administration and the MCW Statistics Department for their help with the statistical analysis. This project was supported in part by the National Center for Advancing Translational Sciences, National Institutes of Health, Grant No. 8UL1TR000055, and the SIR Foundation.

A.W. received grant funding for this project from the SIR Foundation. P.J.P. is a consultant for Cook, Inc (Bloomington, Indiana), Bard Medical Division (Covington, Georgia), Medtronic (Minneapolis, Minnesota), and Penumbra, Inc (Alameda, California). S.M.T. is a consultant for Benvenue Medical (Santa Clara, California). S.B.W. received a RSNA Scholar Grant and SIR Foundation Pilot Grant, research support from Siemens Medical Solutions (Malvern, Pennsylvania), and is a consultant for Guerbet LLC (Bloomington, Indiana) and IO-rad (Chicago, Illinois).

References

1. Beheshti MV, Meek J. Calculation of operating expenses for conventional transarterial chemoembolization in an academic medical center: a step toward defining the value of transarterial chemoembolization. *J Vasc Interv Radiol*. 2014; 25:567–574. [PubMed: 24462006]
2. Pennington MW, Grieve R, van der Meulen JH. Lifetime cost effectiveness of different brands of prosthesis used for total hip arthroplasty: a study using the NJR dataset. *Bone Joint J*. 2015; 97-B: 762–770. [PubMed: 26033055]

3. Cuckler GA, Sisko AM, Keehan SP, et al. National health expenditure projections, 2012–22: slow growth until coverage expands and economy improves. *Health Aff (Millwood)*. 2013; 32:1820–1831. [PubMed: 24047555]
4. Centers for Medicare & Medicaid Services. 2014 Annual report of the boards of trustees of the federal hospital insurance and federal supplementary medical insurance trust funds. Available at: <http://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/ReportsTrustFunds/Downloads/TR2014.pdf>. Accessed October 11, 2015
5. Levin DC, Rao VM, Parker L, Bonn J, Maitino AJ, Sunshine JH. The changing roles of radiologists, cardiologists, and vascular surgeons in percutaneous peripheral arterial interventions during a recent five-year interval. *J Am Coll Radiol*. 2005; 2:39–42. [PubMed: 17411758]
6. Becker GJ. 2000 RSNA annual oration in diagnostic radiology: the future of interventional radiology. *Radiology*. 2001; 220:281–292. [PubMed: 11477226]
7. Epstein AJ, Groeneveld PW, Harhay MO, Yang F, Polsky D. Impact of minimally invasive surgery on medical spending and employee absenteeism. *JAMA Surg*. 2013; 148:641–647. [PubMed: 23552709]
8. Itagaki MW, Talenfeld AD, Kwan SW, Brunner JW, Mortell KE, Brunner MC. Percutaneous vertebroplasty and kyphoplasty for pathologic vertebral fractures in the Medicare population: safer and less expensive than open surgery. *J Vasc Interv Radiol*. 2012; 23:1423–1429. [PubMed: 23101914]
9. Kwan SW, Mortell KE, Hippe DS, Brunner MC. An economic analysis of sublobar resection versus thermal ablation for early-stage non-small-cell lung cancer. *J Vasc Interv Radiol*. 2014; 25:1558–1564. [PubMed: 25130308]
10. Fisher ES, Bynum JP, Skinner JS. Slowing the growth of health care costs—lessons from regional variation. *N Engl J Med*. 2009; 360:849–852. [PubMed: 19246356]
11. Allan GM, Lexchin J. Physician awareness of diagnostic and nondrug therapeutic costs: a systematic review. *Int J Technol Assess Health Care*. 2008; 24:158–165. [PubMed: 18400118]
12. Allan GM, Lexchin J, Wiebe N. Physician awareness of drug cost: a systematic review. *PLoS Med*. 2007; 4:e283. [PubMed: 17896856]
13. Skipper JK, Smith G, Mulligan JL, Garg ML. Physicians' knowledge of cost: the case of diagnostic tests. *Inquiry*. 1976; 13:194–198. [PubMed: 132407]
14. Schlünzen L, Simonsen MS, Spangenberg NLM, Carlsson P. Cost consciousness among anaesthetic staff. *Acta Anaesthesiol Scand*. 1999; 43:202–205. [PubMed: 10027029]
15. Allan MG, Innes GD. Do family physicians know the costs of medical care? Survey in British Columbia. *Can Fam Physician*. 2004; 50:263–270. [PubMed: 15000338]
16. Innes G, Grafstein E, McGrogan J. Do emergency physicians know the costs of medical care? *CJEM*. 2000; 2:95–102. [PubMed: 17637131]
17. Rautio R, Keski-Nisula L, Paakkala T. Activity-based cost analysis in catheter-based angiography and interventional radiology. *Eur Radiol*. 2003; 13:1937–1945. [PubMed: 12942297]
18. Simon SD, Reig AS, James RF, Reddy P, Mericle RA. Relative cost comparison of embolic materials used for treatment of wide-necked intracranial aneurysms. *J Neurointerv Surg*. 2010; 2:163–167. [PubMed: 21990601]
19. Harvey HB, Prabhakar AM, Oklu R. Bringing transparency to physician-industry relationships: what the Physician Payment Sunshine Act will mean for interventional radiologists. *J Vasc Interv Radiol*. 2013; 24:1589–1592. quiz 1593. [PubMed: 24160819]
20. Centers for Medicare & Medicaid Services. 2014 National Physician Fee Schedule Relative Value File (January release). Available at: <http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/PhysicianFeeSched/>. Accessed October 11, 2015
21. American Medical Association. Overview of the RBRVS. Available at: <http://www.ama-assn.org/ama/pub/physician-resources/solutions-managing-your-practice/coding-billing-insurance/medicare/the-resource-based-relative-value-scale/overview-of-rbrvs.page>. Accessed October 11, 2015
22. Centers for Medicare & Medicaid Services. License for Use of Current Procedural Terminology, Fourth Edition (“CPTs”). Available at: <http://www.cms.gov/apps/physician-fee-schedule/license-agreement.aspx>. Accessed October 11, 2015

23. Rock TA, Xiao R, Fieldston E. General pediatric attending physicians' and residents' knowledge of inpatient hospital finances. *Pediatrics*. 2013; 131:1072–1080. [PubMed: 23713110]
24. Okike K, O'Toole RV, Pollak AN, et al. Survey finds few orthopedic surgeons know the costs of the devices they implant. *Health Aff (Millwood)*. 2014; 33:103–109. [PubMed: 24395941]
25. Broadwater-Hollifield C, Gren LH, Porucznik CA, Youngquist ST, Sundwall DN, Madsen TE. Emergency physician knowledge of reimbursement rates associated with emergency medical care. *Am J Emerg Med*. 2014; 32:498–506. [PubMed: 24657227]
26. Agrawal S, Taitzman J, Cassel C. Educating physicians about responsible management of finite resources. *JAMA*. 2013; 309:1115–1116. [PubMed: 23512056]
27. Pauly MV, Burns LR. Price transparency for medical devices. *Health Aff (Millwood)*. 2008; 27:1544–1553. [PubMed: 18997210]
28. David Prologo J, Meltzer CC. Health care reform in the United States: an opportunity for interventional radiologists. *J Vasc Interv Radiol*. 2014; 25:881–887. [PubMed: 24788208]
29. The Physicians Foundation. 2015. Available at: <http://www.physiciansfoundation.org/news/the-physicians-foundation-releases-2015-physician-watch-list/>. Accessed October 11, 2015
30. Tierney WM, Miller ME, McDonald CJ. The effect on test ordering of informing physicians of the charges for outpatient diagnostic tests. *N Engl J Med*. 1990; 322:1499–1504. [PubMed: 2186274]
31. Durand DJ, Feldman LS, Lewin JS, Brotman DJ. Provider cost transparency alone has no impact on inpatient imaging utilization. *J Am Coll Radiol*. 2013; 10:108–113. [PubMed: 23273974]
32. Tucker, ME. Education, feedback cut unnecessary lab testing. *Medscape*. Apr 2. 2015 Available at: <http://www.medscape.com/viewarticle/842501>. Accessed October 11, 2015
33. Cosgrove, T. The kindest cut: how one hospital lowered costs by making doctors more budget conscious. *Time*. Feb 20. 2013 Available at: <http://healthland.time.com/2013/02/20/the-kindest-cut-how-one-hospital-lowered-costs-by-making-doctors-more-budget-conscious/>. Accessed October 11, 2015
34. American Medical Association. The Medicare physician payment schedule. Available at: <http://www.ama-assn.org/ama/pub/physician-resources/solutions-managing-your-practice/coding-billing-insurance/medicare/the-medicare-physician-payment-schedule.page>? Accessed October 11, 2015
35. Lynskey GE 3rd, Powell DK, Dixon RG, Silberzweig JE. Radiation protection in interventional radiology: survey results of attitudes and use. *J Vasc Interv Radiol*. 2013; 24:1547–1551.e1543. [PubMed: 23876553]
36. Willis GB, Smith T, Lee HJ. Do additional recontacts to increase response rate improve physician survey data quality? *Med Care*. 2013; 51:945–948. [PubMed: 23969583]

Table 1**Physician Demographics and Estimation Accuracies**

Demographic Variables	Physicians (n)	Percent within 25% Estimation (95% CI)		
		Devices	Medicare	wRVUs
Years in practice				
0–5	163	16.9 (15.4–18.6)	16.4(13.2–20.3)	30.9 (26.6–35.5)
6–10	143	19.5 (17.8–21.3)	22.6(18.5–27.3)	28.4 (24.0–33.2)
11–15	160	16.9 (15.5–18.5)	21.9 (17.7–26.8)	38.0 (33.1–43.1)
16–20	143	17.9 (16.3–19.8)	30.2 (25.2–35.7)	27.0 (22.3–32.2)
21–25	117	20.5 (18.4–22.7)	24.8(19.9–30.5)	36.6 (31.1–42.5)
26	115	17.7 (15.6–20.0)	30.3 (25.0–36.1)	33.3 (27.7–39.4)
Area of practice				
Major metropolitan area	447	18.0 (16.9–19.1)	23.2 (20.5–26.2)	32.8 (30.0–35.7)
Small city	228	18.6 (17.2–20.0)	23.0 (19.5–26.8)	33.5 (29.6–37.7)
Suburban area	112	17.8 (15.9–19.9)	27.0 (21.7–32.9)	26.7 (21.6–32.6)
Small town	45	18.4 (15.4–21.9)	25.8 (18.8–34.3)	25.3 (17.3–35.4)
Rural area	11	23.3 (20.1–26.7)	27.2 (16.8–40.9)	55.9 (31.1–78.1]
Type of practice				
Academic	291	18.0 (16.8–19.3)	20.3 (17.2–23.7)	35.7 (32.5–39.0)
Nongovernmental public	62	17.8 (15.0–21.0)	24.3 (18.3–31.5)	37.1 (29.4–45.5)
Governmental	34	21.5 (18.0–25.5)	16.0 (9.3–26.0)	32.2 (24.2–41.3)
Private practice	431	18.1 (17.1–19.1)	26.9 (24.1–29.9)	28.1 (25.2–31.3)
Other	28	18.9 (15.8–22.5)	22.7 (14.5–33.8)	35.6 (23.0–50.6)
Type of private practice				
Accountable Care Organizations	26	16.3 (13.0–20.1)	16.6 (10.4–25.4)	38.8 (25.4–54.0)
Large independent groups	219	18.8 (17.4–20.3)	24.9 (21.2–29.1)	26.9 (23.1–31.2)
Community health centers	20	17.2 (13.8–21.2)	21.9 (11.9–36.7)	23.5 (11.8–41.3)
Large aligned groups	77	18.5 (16.3–21.1)	22.3 (16.2–30.0)	35.1 (28.5–42.3)
Small aligned groups	137	17.8 (16.1–19.7)	32.4 (27.7–37.6)	26.7 (22.1–32.0)
Nonprivate practice	228	18.1 (16.7–19.6)	15.1 (12.2–18.5)	30.1 (26.4–34.1)
Prior surgical cost education				
Yes	96	20.2 (18.1–22.4)	22.7 (16.6–30.2)	38.3 (32.3–44.8)
No	751	18.0 (17.1–18.8)	23.9 (21.8–26.0)	31.3 (29.1–33.6)
Self-rated cost knowledge				
Poor	65	15.1 (12.8–17.6)	22.2 (16.3–29.6)	22.2 (16.3–29.6)
Below average	147	16.4 (14.8–18.1)	19.1 (15.5–23.4)	19.1 (15.5–23.4)
Average	389	18.6 (17.5–19.7)	23.7 (21.0–26.6)	23.7 (21.0–26.6)
Above average	205	20.5 (19.0–22.0)	25.7 (21.5–30.3)	25.7 (21.5–30.3)
Excellent	39	15.2 (12.2–18.8)	32.8 (23.4–43.9)	32.8 (23.4–43.9)
Feel educated about RVUs				
Yes	338	18.3 (17.2–19.5)	26.4 (23.1–30.0)	38.4 (35.3–41.7)
No	509	18.1 (17.2–19.1)	22.0 (19.7–24.4)	26.8 (24.3–29.6)

Demographic Variables	Physicians (n)	Percent within 25% Estimation (95% CI)		
		Devices	Medicare	wRVUs
Cost consideration on tool use				
Never	14	12.0 (8.5–16.8)	16.7 (8.0–31.6)	16.7(8.0–31.6)
Rarely	106	17.8 (15.9–19.9)	20.2 (15.6–25.7)	20.2 (15.6–25.7)
Sometimes	352	18.0 (16.9–19.1)	23.1 (20.2–26.2)	23.1 (20.2–26.2)
Often	312	18.8 (17.5–20.1)	24.6 (21.4–28.1)	24.6 (21.4–28.1)
Always	64	18.7 (16.2–21.5)	31.2 (23.6–39.9)	31.2 (23.6–39.9)
How important is device cost				
Not important	18	13.6 (9.9–18.4)	20.3 (11.8–32.6)	17.4 (7.3–36.0)
Slightly important	136	18.4(16.7–20.3)	20.7 (16.6–25.4)	30.0 (25.3–35.1)
Moderately important	349	18.6 (17.5–19.9)	25.6 (22.6–29.0)	31.8 (28.8–34.9)
Very important	275	18.0 (16.8–19.3)	22.7 (19.4–26.3)	33.6 (29.8–37.7)
Extremely important	68	17.9 (15.6–20.5)	26.8 (20.3–34.5)	34.2 (26.9–42.4)
Has access to hospital costs				
Yes	208	19.4(17.9–20.9)	26.1 (22.1–30.5)	36.7 (32.4–41.3)
No	636	17.9 (17.0–18.8)	23.1 (20.9–25.4)	30.6 (28.2–33.0)
Would choose to use less expensive tool if similar quality				
Yes	827	18.2 (17.4–19.0)	23.9 (21.9–26.0)	32.0 (29.9–34.2)
No	14	21.1 (16.0–27.4)	21.0 (11.1–36.0)	32.4 (16.1–54.6)

CI = confidence interval; RVU = relative value unit; wRVU = work relative value unit.

Table 2

Physician Device Estimation Accuracies and Comparisons

Devices	Percent of within 25% Estimation Accuracy		<i>P</i> Value Comparing IRs and VSs
	IR	VS	
Dorado percutaneous transluminal angioplasty balloon	21.0	22.1	.710
Berenstein catheter (5 F)	23.1	15.1	.007*
Volcano digital IVUS catheter	16.6	20.1	.111
Renegade HI-FLO microcatheter kit with wire (Transend)	7.6	10.9	.121
Complete self-expanding vascular bare metal stent system	15.6	13.0	.337
Express SD balloon expandable bare metal stent	18.2	13.6	.095
AAA stent graft, standard two-piece	14.3	52.3	< .001*
Rosen guide wire (180 cm)	5.1	2.6	.097
Terumo Glidewire (180 cm)	25.5	20.1	.082
Micropuncture kit	18.7	26.9	.007*
Tornado pushable embolization coil	13.6	10.9	.280
Helical detachable interlocking coil	21.9	22.8	.785
IVC filter	23.6	22.7	.751
Balloon insufflator pump	26.1	27.4	.687
Anglo-Seal closure device	36.0	35.8	.956

AAA = abdominal aortic aneurysm; IR = interventional radiologist; IVC — inferior vena cava; IVUS = intravascular ultrasound; VS = vascular surgeon.

* Statistically significant.

Table 3**Physician Procedure Estimation Accuracies and Comparisons**

Procedures	wRVU	Medicare Cost (\$)
EVAR, standard two-piece	31	1,372
IVC filter placement	5	250
Superficial femoral artery (bare metal) stent	10	533
Endovascular laser treatment for varicose veins	7	367
Internal iliac artery embolization	14	741
Radiofrequency/microwave ablation (liver)	19	805
Hepatic transarterial chemoembolization, with drug-eluting beads	18	931
Cholecystostomy tube placement	5	343
PICC placement	3	130
Transjugular intrahepatic portosystemic shunt	17	875
Creation of dialysis AV loop graft	12	690
Carotid endarterectomy	21	1,200
Femoral-popliteal bypass	28	1,540
Open AAA repair	35	1,882
First rib resection	10	651

AAA = abdominal aortic aneurysm; AV = arteriovenous; EVAR = endovascular aortic repair; IVC = inferior vena cava; PICC = peripherally inserted central catheter; wRVU = work relative value unit.