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Cost Effectiveness of Anesthesia Providers and Implications of Scope of Practice in a Medicare Population

Executive Summary

- An updated version of a simulation model (Hogan, Furst Seifert, Moore, & Simonson, 2010) is introduced for estimating the costs of various anesthesia delivery models.
- The parameters of this cost-effectiveness model were updated to reflect the latest available data.
- The distribution of anesthesia delivery model types varies across states depending on several factors such as state scope of practice laws, facility policy, and supply of anesthesia providers.
- Using the anesthesia delivery-model distribution observed by state for Medicare, data revealed elimination of medical direction and supervisory delivery models, allowing certified registered nurse anesthetists to practice to the full extent of their training, substantially reduces costs associated with anesthesia delivery.

ANESTHESIOLOGY SERVICES in the United States are predominantly provided by two types of providers: certified registered nurse anesthetists (CRNAs) and anesthesiologists. CRNAs are advanced practice nurses who have earned a baccalaureate degree, practiced at least 1 year as an acute care nurse, and have successfully completed a graduate-level nurse anesthetist program. Anesthesiologists are physicians who have completed medical school, a clinical base year residency, and 3 years of residency in an anesthesia program.

Both types of providers are critical to the safe, efficient provision of anesthesia services, but are subject to different regulations. For example, anesthesiologists are licensed to practice independently in 50 states plus the District of Columbia. CRNAs, in contrast, are subject to state law requirements. Many states do not require CRNAs to be supervised by a physician. Some states require CRNAs to practice in collaboration or cooperation with a physician, or do not specifically require physician involvement. States that require CRNAs to be physician supervised do not necessarily require the physician be an anesthesiologist. In all situations, CRNAs are responsible for their clinical decisions concerning the provision of anesthesia.

As a result, anesthesia servic-

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ACKNOWLEDGMENTS: This research was funded by the American Association of Nurse Anesthetists Foundation. The views expressed here are those of the authors.

es can be delivered in a variety of delivery models that vary by the degree of autonomy in which CRNAs may deliver anesthesia, as well as other considerations. At one end of the spectrum, the CRNA may provide and bill for anesthesia services alone. At the other end, anesthesiologists may be the only providers administering and billing for anesthesia services in a particular practice setting. In between the two extremes, CRNAs can provide anesthesia services under physician oversight (medical direction or supervision). Under *medical direction,* an anesthesiologist directs from one to four CRNAs, and is present at specific stages of the anesthesia procedure. Under *supervision,* an anesthesiologist supervises four or more CRNAs at the facility, but is not necessarily present during the anesthesia procedure. Delivery models may vary by practice setting based on the preferences and beliefs of the particular hospital, outpatient clinic, or surgery center, and because of state-specific and federal laws and regulations regarding delivery and billing for services.

In this article, CRNAs who provide anesthesia for a patient under the care of an operating practitioner, but are neither supervised nor medically directed, are referred to as *independent.* CRNAs who provide anesthesia under the oversight of an anesthesiologist are either medically directed or supervised. Costs of services will vary across delivery settings and across delivery models within a setting. A cost simulation model developed in Hogan, Furst Seifert, Moore, and Simonson (2010) is used to evaluate both differences across delivery models and potential cost savings associated with a change in delivery model distribution. In particular, distribution of delivery model types vary across states, and this variation is associated with variations in state scope of practice (SOP) laws for administration of anesthesia and other factors, such as facility policy, contractual and employment arrangements, and supply of anesthesia providers. These SOP laws define the degree of physician involvement required when CRNAs administer anesthesia, and vary from direct supervision by a physician, to no requirement for supervision. Costs associated with different distributions of delivery model type are examined and related to state SOP laws.

This article has two goals. First, a brief exposition of the anesthesia provider cost-effectiveness simulation model (Hogan et al., 2010), highlighting recent updates to the parameters used in the model, is provided. Earlier results that CRNAs, acting independently, are the most cost-effective anesthesia delivery model is confirmed. Second, this model is applied to an actual distribution of anesthesia delivery models of procedures covered by Medicare. Provider-related delivery model costs associated with that distribution are estimated and compared to the costs when one moves to distribution of delivery models consisting of only two types: CRNAs acting independently and anesthesiologists acting alone. Results reveal there is the potential for significantly lower provider-related costs from moving to a distribution that eliminates fixed ratio delivery models.

This article is organized as follows. First, the simulation model used to estimate provider costs associated with alternative anesthesia delivery models is briefly reviewed. A summary of the cost and revenue implications of different delivery model types is presented. Then, using Medicare claims data, a set of distributions of anesthesia delivery services across states is generated. Medicare requires that for billing purposes, anesthesia delivery for Medicare patients be consistent with the state SOP, and states are organized by degree of SOP restrictions. A change in costs of delivery of anesthesia services is evaluated under a scenario where fixed ratio delivery models, which include participation by both an anesthesiologist and a CRNA, are eliminated in favor of delivery models that are either anesthesiologists acting alone or CRNAs acting alone. Finally, simulated payments to anesthesiologists and CRNAs are compared by anesthesia delivery model, delivery setting, and SOP.

Methodology of Simulation Model

In cost-effectiveness analysis, output or product of the delivery model, including its quality as well as quantity, is held approximately constant (Negrusa, Hogan, Warner, Schroeder, & Pang, 2016). The total cost needed to provide the required anesthesia services is then compared across delivery models. The most cost-effective approach is the one that produces the output or service at the lowest cost, while maintaining quality. An economically viable model is one where the revenue generated exceeds the costs.

The cost effectiveness of anesthesia delivery services is largely assessed in a context of simulation analyses (e.g., Hogan et al., 2010; Quintana, Jones, & Baker, 2009). The purpose of the simulation model is to simulate costs and revenue that would likely occur under various anesthesia delivery models and settings. A total of seven different delivery models are considered:

1. CRNA practicing without an anesthesiologist involved in anesthesia delivery.
2. An anesthesiologist practicing alone.
3. Four medical direction model variants consisting of one anesthesiologist directing one, two, three, or four CRNAs.
4. A supervisory model where one anesthesiologist supervises four or more CRNAs.

A key distinction between a medical direction model and a supervisory model is that in the direction models an anesthesiologist must fulfill the seven requirements of the Tax Equity and Fiscal

Table 1.
Medicare Billing Rules

Delivery Model	CRNA	Anesthesiologist
Anesthesiologist alone		(BU+TU)*Conversion Factor
CRNA alone	(BU+TU)*Conversion Factor	
Medical direction	(BU+TU)*Conversion Factor*.5	(BU+TU)*Conversion Factor*.5
Supervisory	(BU+TU)*Conversion Factor*.5	Four units

NOTE: BU = base units, CRNA = certified registered nurse anesthetist, TU = time units

Responsibility Act of 1982 to medically direct a CRNA, while in the supervisory model the anesthesiologist is immediately present and available on the premises. These differences are captured in the simulations model along with differences across delivery settings.

Although the cost-effectiveness assessment relies on simulation of costs, the model also simulates revenue. Calculation of costs is straightforward and is based on the earnings or salary of CRNAs and anesthesiologists and the delivery model used to administer the service. Intuitively, in an anesthesia provider acting alone model, cost of providing a given anesthesia procedure is the implied cost of the provider's time. For example, if demand in a given day is unexpectedly low due to an anesthesiologist having idle time and completing fewer procedures, the implied cost per procedure relative to revenue will be greater. In this case, cost per procedure rises because cost of employing the provider for the day is allocated over fewer procedures. Reimbursement or revenue for the procedure depends on type of delivery model, as well as type of payer. Billing rules for Medicare Part B used in the simulations are illustrated in Table 1.

Additionally, the set-up for a simulation requires specifying a number of parameters that are taken into account during the simulations. The value of these parameters may be specific by the user, depending upon the particular case or scenario being analyzed. Key variables include:

Table 2.
Key Parameters Held Constant in Simulations

Facility Parameters		
Number of operating rooms per facility		12
Number of procedures per operating room	Inpatient	4
	Outpatient/ASC	7
Cost Parameters		
Anesthesiologist salary (Salary.com)		$350,000/year
CRNA salary (American Association of Nurse Anesthetists, 2009)		$170,00/year
Revenue Parameters		
Medicare Conversion Factor (Centers for Medicare & Medocade Services, 2015)		$22.61

ASC = ambulatory surgical center

- Demand: number of patients seeking an operation in a given day.
- Conversion factors per procedure by setting.
- Characteristics of the anesthesia procedure: base units (BU) and time units (TU). The former is a measure of complexity; the latter corresponds to duration of procedure. Both are essential in determining reimbursement amount for the procedure.

In the model, one can specify a distribution for demand, BU, and TU such that values are drawn randomly for each simulation (see Hogan et al., 2010 for details). One can simulate costs for different settings (inpatient, ambulatory surgery, outpatient) by specifying different distribution of demand, BU, and TU. In this analysis, empirically observed median values for TU and BU were used to distinguish among the different settings; however, for each simulation there is a random draw from BU and TU distribution within the different settings. Typical inpatient surgery generally has a greater TU per procedure than an outpatient facility. For a given simulation, each delivery model faces the same set of realized values of patient demand, BU, and TU assuming a number of operating rooms or stations. Additionally, one can specify the distribution of payers. In the application described below, the focus is on one payer – Medicare.

A number of simulations (30 for each practice settings) were conducted. The set-up for these simulations was the same and is shown in Table 2.

Similar to Hogan and colleagues (2010), the practice settings are defined by the characteristics of the procedures. Table 3

shows the median values for the number of anesthesia BU per procedure and the number of TU per procedure obtained from the Medicare 5% claims data for 2011-2012. (Observed means are generally higher due to the skewed distribution. Medians that more closely align with typical units observed in a setting [based on the feedback from the Technical Expert Panel], therefore, are preferred. TU and BU were cross-referenced with the dNHI Optum commercial claims data concluding that, with an exception of inpatient setting, TU are consistent across data sets. Since TU in the 5% Medicare data were implausibly low, after consultation with the practitioners, for inpatient setting median TU is reported from commercial claims data that are closer aligned to the units typically billed. Sensitivity was tested by simulating inpatient setting using TU from the Medicare data. Qualitatively, results are robust.)

For each setting-demand scenario, setting-specific claims data were used to define types and volume of anesthesia services provided at a typical setting over the course of 1 year, assuming typical hours and days of operation. Then, total cost was modeled to provide anesthesia services under each of the delivery models.

The first scenario compares the results from the seven delivery models in an inpatient setting. For comparison purposes, it was assumed each delivery model operates at a facility with 12 distinct locations (stations). Hence, in a medical direction 1:4 model, three anesthesiologists would be directing 12 CRNAs. The results are calculated at the annual basis assuming typical hours and days of operation.

Results of Simulation Model

Results from simulating the delivery models in an inpatient setting operating for 1 year under ideal conditions are presented in Table 4. Flow of patients is sufficient to conduct four procedures per day, on average, at each station. Revenues are based on the simulated flow of patients and Medicare billing rules. Revenue and cost per procedure will differ across settings (determined by demand and TU and BU distributions from which values are drawn).

Results indicate the CRNA acting independently model is the least costly per procedure and produces the greatest net revenue. The fixed ratio 1:1 delivery model is the most expensive.

The next scenario considers what may happen in an outpatient setting. Given substantially lower values of median TU for this type of facility, average demand for this setting was defined as seven procedures per day, on average, at each station. The results of outpatient surgery and ambulatory surgical center are shown in Tables 5 and 6, respectively, for total revenue, costs, and net revenue on a per procedure basis. The qualitative results are similar to the inpatient case.

Table 3.
Medicare Median Values for Procedures by Setting

Setting	BU	TU
Inpatient	6.0	8.3
Outpatient surgery	5.0	3.0
Ambulatory surgical center	5.0	2.0

BU = base units, TU = time units

Table 4.
Inpatient Setting with Average Demand (12 Stations)*

		Revenue	Costs	Revenue Minus Costs
Anesthesiologist alone		338.78	400.12	-61.34
CRNA alone		338.78	194.35	144.44
Medical direction	1:1	338.78	594.47	-255.68
	1:2	338.78	394.41	-55.62
	1:3	338.78	327.72	11.07
	1:4	338.78	294.38	44.41
Supervisory 1:5+		260.20	261.47	-1.27

* Four per station per day are defined as four anesthetics per anesthetizing location per day. The average across 30 simulations is presented.

CRNA = certified registered nurse anesthetist

Distribution of Medicare Anesthesia Procedures by Delivery Model Type

The simulations model provides cost estimates of operating each delivery model in isolation (under an assumption 100% of cases were performed under that delivery model). However, in practice state laws, as well as other factors, affect how anesthesia services are provided. Therefore, distribution of delivery models will vary across states depending on SOP laws and other established practices.

The 5% Medicare claims data for 2011-2012 were used to obtain a distribution of procedures by

delivery models and total number of procedures performed by delivery model, setting, and three categories of SOP. Only claims attributed to anesthesia services were analyzed (modifiers AA, AD, QK, QX, QY, QZ).

States were divided into three categories based on SOP: *Direction/Collaboration* (moderately restrictive), *Supervision* (most restrictive), and *No Supervision/Direction* (least restrictive) (Negrusa et al., 2016). A summary of distribution by delivery model, setting, and SOP is reported in Table 7. Relative to more restrictive states, the proportion of procedures performed by CRNAs alone is larger in least-restrictive states for all settings. Moreover, the proportion of procedures conducted by a fixed-ratio delivery model of anesthesiologist supervising or directing a CRNA is smallest in the least-restrictive states. That is, moderate and most-restrictive requirement states tend to have a large number of procedures performed under the Medical Direction 1:2-4 models. However, while it is clear there is a striking difference in mix of anesthesia delivery models between states with the least-restrictive SOP laws and the others, fixed-ratio delivery models are still observed, but less frequently, in the least-restrictive states.

Given the simulated average cost and revenue per procedure in a given setting presented earlier, number of procedures performed in Medicare data, and delivery model mix by setting and SOP, overall anesthesia services costs and revenue can be calculated by delivery model, setting, and SOP (see Table 8).

Table 5.
Outpatient Setting with Average Demand (Seven per Station/Day)

		Revenue	Costs	Revenue Minus Costs
Anesthesiologist alone		218.02	201.30	16.72
CRNA alone		218.02	97.77	120.25
Medical direction	1:1	218.02	299.07	-81.05
	1:2	218.02	198.42	19.60
	1:3	218.02	164.87	53.15
	1:4	218.02	148.10	69.92
Supervisory 1:5+		199.62	131.21	68.41

CRNA = certified registered nurse anesthetist

Table 6.
ASC with Average Demand (Seven per Station/Day)

		Revenue	Costs	Revenue Minus Costs
Anesthesiologist alone		193.76	198.29	-4.53
CRNA alone		193.76	96.31	97.45
Medical direction	1:1	193.76	294.60	-100.84
	1:2	193.76	195.45	-1.69
	1:3	193.76	162.41	31.35
	1:4	193.76	145.88	47.88
Supervisory 1:5+		188.13	227.08	-38.95

ASC = ambulatory surgical center, CRNA = certified registered nurse anesthetist

Table 7.
Distribution of Delivery Models by Scope of Practice

		Anesthesiologist Alone	CRNA Alone	Medical Direction		Supervision 1:>4
				1:1	1:2-4	
Outpatient	Moderate	20%	15%	36%	29%	0
	Most	21%	14%	36%	29%	0
	Least	41%	26%	19%	14%	0
Inpatient	Moderate	23%	10%	37%	29%	0.4%
	Most	20%	11%	39%	29%	0.4%
	Least	49%	17%	19%	14%	0.4%
ASC	Moderate	28%	32%	22%	18%	0.1%
	Most	27%	32%	23%	17%	0.4%
	Least	40%	42%	10%	7%	0.1%

ASC = ambulatory surgical center, CRNA = certified registered nurse anesthetist

Table 8.
Costs and Revenue by Setting and Scope of Practice

	Inpatient	Outpatient	ASC	Total
Moderate Restriction				
Costs	$59,894,911	$42,478,905	$18,886,766	$121,260,583
Revenue	$46,868,819	$43,863,655	$20,115,108	$110,847,582
Most Restrictive				
Costs	$85,378,919	$55,928,152	$31,470,490	$172,777,561
Revenue	$66,711,235	$57,444,482	$33,512,361	$157,668,078
Least Restrictive				
Costs	$36,998,431	$22,914,026	$14,136,347	$74,048,803
Revenue	$31,798,462	$26,561,266	$16,839,888	$75,199,616

ASC = ambulatory surgical center

Table 9.
Costs and Revenue of Anesthesia Delivery by Scope of Practice and Scenario (in billions)

		Current Delivery Model Distribution (status quo)	Alternative Scenario: Substitute CRNA-only Model for All Fixed Ratio Delivery Models
Costs	Moderate restriction	2.4	1.4
	Most restrictive	3.5	2.0
	Least restrictive	1.5	1.1
	Total (% of initial)	**7.4 (100%)**	**4.5 (62%)**
Revenue	Moderate restriction	2.2	2.2
	Most restrictive	3.2	3.2
	Least restrictive	1.5	1.5
	Total (% of initial)	**6.9 (100%)**	**6.9 (100%)**

Total costs under the observed distribution of delivery models for the 5% sample were $368,086,947 while total revenue under Medicare billing rules were $343,715,276 for 2011-2012. Extrapolating from the 5% sample, an estimate of total costs for the 2011-2012 Medicare anesthesia procedures were approximately $7.4 billion, while revenue was about $6.9 billion. Given the distributions of the delivery models, net revenue was negative for some settings.

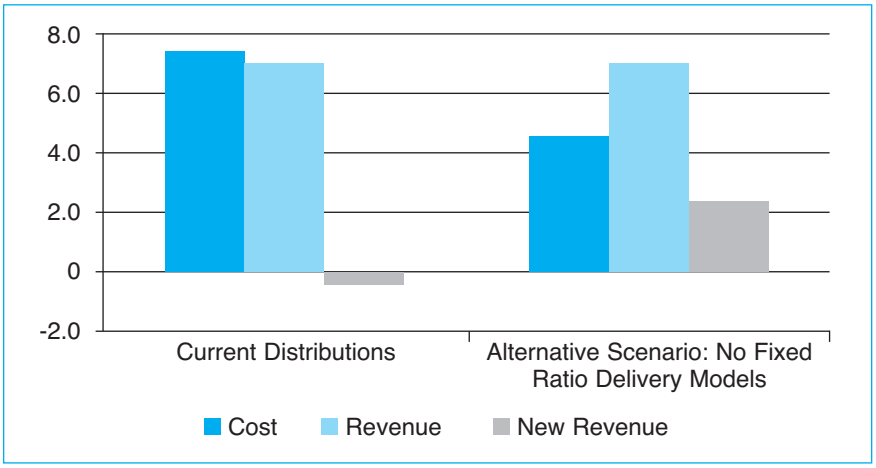
Results of Simulation of Potential Savings Due to Changes in Delivery Model Distribution

Next, researchers evaluated a potential change in costs, revenue, and net revenue due to a change in the mix of delivery models that could be implemented. Specifically, starting with distribution of procedures observed in the Medicare 5% sample, change in costs and revenue in anesthesia services was calculated under an alternative scenario. In particular, "What would be the costs and revenue associated with the observed 2011-2012 anesthesia delivery procedures if, across all states and settings, procedures conducted under fixed ratio models were, in fact, conducted by CRNAs alone, with the number of procedures conducted by anesthesiologists alone remaining the same?" The result of this scenario is summarized in Table 9. This case leads to substantial decreases in overall costs of anesthesia service provision (a reduction of about 38% relative to the status quo). The decrease is achieved due to savings gained via:

1. Elimination of the most expensive fixed ratio 1:1 delivery model that accounts for a relatively large number of cases (10%-39% of cases depending on setting and SOP).
2. Elimination of the fixed ratio 1:2-4 delivery model which is relatively expensive and represents a relatively small number of cases (7%-29% depending on setting and SOP).

Despite a negligible change in revenue generated by elimination of the two previously mentioned expensive delivery models, net revenues are maximized under

Figure 1.
Net Revenue by Scenario (in billions)



this scenario. Figure 1 shows net revenue for the "status quo" or current empirical distributions as well as the alternative scenario.

Under the fixed-ratio delivery models, the CRNA is present for the entire procedure, while the anesthesiologist is present for only a portion of the procedure. Hence, since the CRNA is there for the entire procedure in any case, substitution of a CRNA-only delivery model for all procedures conducted using fixed-ratio delivery models is feasible. Extrapolating from the results of the 5% Medicare sample, if all fixed-ratio delivery models are replaced by CRNA-only models, total costs would fall from about $7.4 billion to about $4.5 billion, a savings of approximately $2.9 billion in provider salary costs.

Discussion

A model that can assess cost, revenue, and net revenue associated with alternative models of anesthesia delivery, first introduced by Hogan and associates (2010), has been updated. This model is applied to evaluate strategies that can lead to a reduction in costs of anesthesia service provision. This analysis relies on empirical distribution of anesthesia service provision across states obtained from Medicare claims data, and shows large variation in distributions not only across state SOP, but also within states with the same SOP. In particular, researchers considered the possibility of eliminating fixed-ratio delivery models in favor of "CRNA alone," while keeping the share of procedures done by "anesthesiologist alone" at the current level. Such change can potentially reduce total costs by about 38%.

Conclusion

"Now is the time to eliminate the outdated regulations and organizational and cultural barriers that limit the ability of nurses to practice to the full extent of their education, training, and competence" (Institute of Medicine, 2010, p. 4).

This analysis, applying a cost-effectiveness model of anesthesia delivery, suggests costs associated with anesthesia delivery can be reduced significantly by eliminating directional and supervisory models of anesthesia delivery, and allowing CRNAs to practice to the full extent of their training. In many states, this would require changes in scope of practice laws, as well as changes in the customs of some hospitals and ambulatory surgical centers. Adherence to custom and to restrictive laws come at the price of higher costs and, possibly, reduced access to care. **$**

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