

Appendix A – estimates and sensitivity analyses

The mathematical formulas used to estimate the change in BIR costs associated with various policies were derived in Appendix A. Appendix B presents the values input to the formulas for the estimates presented in the article (Article Table 2 & Figures 1, 2) and the sensitivity analyses.

We first used data in Tseng (2018)ⁱ, eTable 4 (“Detailed Cost Findings”) to disaggregate BIR costs of different patient encounters between fixed costs, clinical documentation costs, and non-clinical documentation costs (the sum of clinical and non-clinical documentation costs is the total variable costs).

Table A1: BIR costs by visit broken down into fixed and variable costs; clinical and non-clinical documentation costs; and used to calculate the ratios of fixed to variable costs and clinical to non-clinical costs

BIR Costs	Primary Care	Emergency Dept	Inpatient	Ambulatory Surgery	Inpatient Surgery
Total	\$20.49	\$61.54	\$124.26	\$170.40	\$215.10
Fixed Costs	\$6.10	\$19.57	\$45.84	\$39.72	\$57.43
Variable Costs	\$14.39	\$41.97	\$78.42	\$130.68	\$157.67
Clinical Documentation Costs	\$8.96	\$25.34	\$53.36	\$114.53	\$118.97
Non-clinical Documentation Costs	\$5.43	\$16.63	\$25.06	\$16.15	\$38.70
Ratio of Fixed to Variable Costs (s)	0.42	0.47	0.58	0.30	0.36
Ratio of Clinical to Non-Clinical documentation costs (r)	1.65	1.52	2.13	7.09	3.07

We then estimated the amount each type of provider visit contributes to total BIR costs by using visit volume data from the CDC. We modeled the impact of each policy on national administrative costs as the average of the provider- and visit-specific percent cost reductions weighted by the fraction of the total expenditure associated with each type of provider and visit. The parameters required to estimate the provider and visit specific percent cost changes and the estimates used are:

- The number (N) of private contracts each provider administers and the fraction (F) of total contracts the provider negotiates and renegotiates each year. Comprehensive, empirical data were not available on the number of private contracts that providers administer nor on the frequency with which the provider negotiates and renegotiates current or new contracts. The mean number of contracts per provider was estimated as 1000. Sensitivity analyses were conducted in which the number was varied between 10 and 10000. The mean frequency of negotiations and renegotiations was estimated as once every 4 years. Sensitivity analyses were conducted in which the number was varied between 3 years and 5 years.

- The ratio (r) of clinical to non-clinical documentations costs associated with the visit and the ratio (s) of fixed to variable costs associated with the visit. Provider visits were characterized into the types of visits examined in Tseng (2018). The ratio of clinical to non-clinical BIR costs and the ratio of fixed to variable costs associated with each type of visit were estimated using data from Tseng (2018). Sensitivity analyses were conducted in which each of the ratios was scaled up or down by a factor of 33%. These analyses also test the sensitivity of the model to the relative frequency and expenditure of each type of provider visit estimates (Appendix B Table 1) since, from the mathematical formulation of how reforms impact costs, the only difference between the visit types are the ratios r and s .
- The fraction of national BIR expenditures associated with each type of visit. The relative frequency of each type of visit was estimated using CDC data from 2010 and 2011, the latest consecutive years between which volume data for each type of visit were available. The relative cost associated with each type of visit was estimated using data from Tseng (2018). Sensitivity analyses were conducted in which the total expenditure associated with each type of visit was scaled up or down by 10%.

Point estimates

For the point estimates (Article Table 2 & Figures 1, 2) the inputs to the formulas are based on estimates of:

- The relative expenditure for each visit type (Appendix B Table 1)
- The relative the ratio of fixed to variable costs associated with each visit type (Appendix B Table 1)
- The use of $N = 10, 100, 1000,$ and 10000 as the number of contracts per provider for, respectively, 10%, 15%, 50%, and 25% of providers (Appendix B Table 2)

Table A2: Model input values used to determine the fraction of national BIR costs associated with various visit types

Visit type	Physician office visit	Emergency department visit	Inpatient hospitalization	Ambulatory surgery	Inpatient surgery*	Total
Per-visit cost, \$	20.49	61.54	124.26	170.4	215.1	
Number of non-federal visits in 2010*, thousands	1,008,802	108,598	28,757	28,600	7,247	1,182,004
Total cost, \$	20670353	6683121	3573345	4873440	1558830	37,359,088
Percent of total cost,%	55.33%	17.89%	9.56%	13.04%	4.17%	100%
Ratio fixed to variable costs (s) ⁺	0.42	0.47	0.58	0.30	0.36	
Ratio of clinical to non-clinical documentation costs (r) ⁺	1.65	1.52	2.13	7.09	3.07	
Percent of visits to provider with 10 contracts, %	10%	10%	10%	10%	10%	10%
Share of visits to provider with 100 contracts, %	15%	15%	15%	15%	15%	15%
Share of visits to provider with 1000 contracts, %	50%	50%	50%	50%	50%	50%
Share of visits to provider with 10000 contracts, %	25%	25%	25%	25%	25%	25%

* Inpatient surgery estimates are based on data from 2014 as data from 2010 were not available

⁺ Ratios estimated using data from Tseng 2018

Sensitivity estimates

Estimates producing results analogous to the point estimates (Article Table 2 & Figure 1) were generated by varying the inputs presented in Appendix B Table 2. Each subsection below presents a variant of Appendix B Table 2 in which the modified values are in bold. Appendix B Table 5 provides the original estimates of the cost reductions associated with the various scenarios as well as the estimates corresponding to each of the sensitivity analyses.

Sensitivity estimates of number of the ratios of fixed to variable and clinical to non-clinical documentation costs

Table A3: Sensitivity analyses of visit-specific changes to the ratio of fixed to variable costs and the ratio of clinical to non-clinical costs

		Physician office visit	Emergency department visit	Inpatient hospitalization	Ambulatory surgery	Inpatient surgery*	Change to ratio
Variant	Ratio						
Default	s	0.42	0.47	0.58	0.30	0.36	0%
	r	1.65	1.52	2.13	7.09	3.07	0%
1	s	0.57	0.62	0.78	0.41	0.49	+33%
	r	2.20	2.03	2.84	9.45	4.10	+33%
2	s	0.57	0.62	0.78	0.41	0.49	+33%
	r	1.65	1.52	2.13	7.09	3.07	0%
3	s	0.42	0.47	0.58	0.30	0.36	0%
	r	2.20	2.03	2.84	9.45	4.10	+33%
4	s	0.28	0.31	0.39	0.20	0.24	-33%
	r	1.10	1.02	1.42	4.73	2.05	-33%
5	s	0.28	0.31	0.39	0.20	0.24	-33%
	r	1.65	1.52	2.13	7.09	3.07	0%
6	s	0.42	0.47	0.58	0.30	0.36	0%
	r	1.10	1.02	1.42	4.73	2.05	-33%
7	s	0.57	0.62	0.78	0.41	0.49	+33%
	r	1.10	1.02	1.42	4.73	2.05	-33%
8	s	0.28	0.31	0.39	0.20	0.24	-33%
	r	2.20	2.03	2.84	9.45	4.10	+33%

* Inpatient surgery estimates are based on data from 2014 as data from 2010 were not available

+ Ratios estimated using data from Tseng 2018

Table A5: Changes in BIR costs are relatively stable under all sensitivity analyses considered

Variant	Scenario						
	Single payer optimistic	Single payer intermediate	Single payer pessimistic	Multi-payer Contract Complexity	Multi-Payer Architectural Complexity	Multi-Payer Both Contract Complexity and Architectural Complexity	Multi-Payer both minus single payer optimistic
Default	52.9%	43.0%	32.1%	50.0%	26.6%	63.3%	10%
s - increased, r - increased	53.4%	43.6%	32.8%	50.0%	26.8%	63.4%	10%
s - increased, r - same	57.0%	48.0%	38.1%	50.0%	28.7%	64.3%	7%
s - same, r - increased	48.8%	38.1%	26.3%	50.0%	24.6%	62.3%	13%
s - decreased, r - decreased	54.8%	45.3%	34.9%	50.0%	27.6%	63.8%	9%
s - decreased, r - same	47.8%	36.9%	24.9%	50.0%	24.1%	62.1%	14%
s - same, r - decreased	59.1%	50.5%	41.1%	50.0%	29.8%	64.9%	6%
s - increased, r - decreased	62.8%	55.0%	46.4%	50.0%	31.6%	65.8%	3%
s - decreased, r - increased	43.3%	31.4%	18.3%	50.0%	21.8%	60.9%	18%
N = 10	50.2%	39.7%	28.2%	50.0%	26.6%	63.3%	13%
N = 100	52.9%	43.1%	32.2%	50.0%	26.6%	63.3%	10%
N = 1000	53.2%	43.4%	32.6%	50.0%	26.6%	63.3%	10%
N = 10000	53.2%	43.4%	32.7%	50.0%	26.6%	63.3%	10%