Supplementary Online Content

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eAppendix 1. Definitions and descriptions.

eAppendix 2. Statistical analysis (text with 6 tables).

This supplementary material has been provided by the authors to give readers additional information about their work.

eAppendix 1: Definitions and Descriptions

Hospital Charges: The total financial amount issued to the patient on the patient's bill for hospital services. Hospital charges are equal to the hospital cost plus the mark-up the hospital applies to each service or item they perform or provide. Hospital charges will equal hospital revenue only if all hospital bills are paid in full.

Daily Hospital Charges: The hospital charges issued to a patient divided by the patient's hospital length of stay**.**

Total Hospital Charges: The total amount issued to a patient, which is equivalent to the sum of each of the eight charge sub-categories: room and board charges; operating room charges; pharmacy charges; radiology charges; laboratory charges; supply charges; therapy charges; and other charges.

Daily Total Hospital Charges: Total hospital charges billed to a patient divided by the patient's hospital length of stay.

Room and Board Charges: Charges allocated to patient housing as defined by Medicare Inpatient Uniform Billing Charge Codes.

Daily and Board Charges: Room and board charges billed to a patient divided by the patient's hospital length of stay.

Operating Room Charges: Charges allocated to procedures performed in the operating room as defined by Medicare Inpatient Uniform Billing Charge Codes.

Daily Operating Room Charges: Operating room charges billed to a patient divided by the patient's hospital length of stay.

Pharmacy Charges: Charges allocated to patient medications and pharmacy related services as defined by Medicare Inpatient Uniform Billing Charge Codes.

Daily Pharmacy Charges: Pharmacy charges billed to a patient divided by the patient's hospital length of stay.

Radiology Charges: Charges allocated to imaging services provided to the patient as defined by Medicare Inpatient Uniform Billing Charge Codes

Daily Radiology Charges: Radiology charges billed to a patient divided by the patient's hospital length of stay.

Laboratory Charges: Charges allocated to laboratory and microbiology services provided to the patient as defined by Medicare Inpatient Uniform Billing Charge Codes.

Daily Laboratory Charges: Laboratory charges issued to a patient divided by the patient's hospital length of stay.

Supply Charges: Charges allocated to general supplies utilized by the patient as defined by Medicare Inpatient Uniform Billing Charge Codes.

Daily Supply Charges: Supply charges issued to a patient divided by the patient's hospital length of stay.

Therapy Charges: Charges allocated to patient's therapeutic needs as defined by Medicare Inpatient Uniform Billing Charge Codes.

Daily Therapy Charges: Therapy charges issued to a patient divided by the patient's hospital length of stay.

Other Charges: Other and miscellaneous charges allocated to the patient as defined by Medicare Inpatient Uniform Billing Charge Codes

Daily Other Charges: Other charges issued to a patient divided by the patient's hospital length of stay.

APR-DRG: "The APR-DRGs expand the basic DRG structure by adding four subclasses to each DRG. The addition of the four subclasses addresses patient differences relating to severity of illness and risk of mortality.

Severity of illness and risk of mortality relate to distinct patient attributes. For example, a patient with acute choledocholithiasis (acute gallstone attack) as the highest secondary diagnosis may be considered a major severity of illness but only a minor risk of mortality. The severity of illness is major since there is significant organ system dysfunction associated with acute choledocholithiasis. However, it is unlikely that the acute episode alone will result in patient mortality and thus, the risk of mortality for this patient is minor. If additional, more serious diagnoses are also present, patient severity of illness and risk of mortality may increase. For example, if peritonitis is present along with the acute choledocholithiasis, the patient may be considered an extreme severity of illness and a major risk of mortality. Since severity of illness and risk of mortality are distinct patient attributes, separate subclasses are assigned to a patient for severity of illness and risk of mortality. Thus, in the APR-DRG system a patient is assigned three distinct descriptors:

- The base APR-DRG (e.g., APR-DRG 194 Heart Failure or APR-DRG 440 Kidney Transplant)
- The severity of illness subclass
- The risk of mortality subclass

The four severity of illness subclasses and the four risk of mortality subclasses are numbered sequentially from 1 to 4 indicating respectively, minor, moderate, major, or extreme severity of illness or risk of mortality."[i]

APR-DRG Complexity: The 1 to 4 subclass that accompanies each DRG in the APR-DRG system. The APR-DRG Complexity or Complexity Score is found by taking the lager of the severity of illness subclass and the risk of mortality subclass. [ii]

References

i. All Patient Refined Diagnosis Related Groups (APR-DRGs) Version 20.0: Methodology Overview. 3M Health Information Systems, 2003. (Accessed February 14, 2012 at http://www.hcup-us.ahrq.gov/db/nation/nis/APR-DRGsV20MethodologyOverviewandBibliography.pdf.)

ii. All Patient Refined Diagnosis Related Groups (APR-DRGs) Version 20.0: Methodology Overview. 3M Health Information Systems, 2003. (Accessed February 14, 2012 at http://www.hcup-us.ahrq.gov/db/nation/nis/APR-DRGsV20MethodologyOverviewandBibliography.pdf.)

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eAppendix 2: Statistical Analysis

This study attempts to answer the question whether the daily total charges and the length of stay (LOS) are significantly higher for patients with an SSI compared to patients undergoing the same NHSN defined procedure without an SSI. In the comparison of the two groups of patients, we want to adjust for the effects of the NHSN defined procedure the patient underwent or that the SSI is attributed to; the patient's admit APR-DRG, and the patient's admit APR-DRG Complexity.

The question can be addressed by the analysis of covariance (ANCOVA). However, before seeing which explanatory variables to add to the ANCOVA model, we want to examine the three nominal variables more closely. The nominal variables are the NHSN defined procedure, the admit APR-DRG, and the admit APR-DRG Complexity. The variable "Ruling" was a binomial variable which designated whether the patient had an SSI or did not have an SSI. If a patient had an SSI, the "Ruling" variable was populated with "Infected", if the patient did not have an SSI the "Ruling" variable was populated with "Not Infected". We calculate the number of patients on each level of each nominal variable. We notice that many levels of variable admit APR-DRG is underrepresented. No accurate statistical inference is possible for those levels. We therefore combine all the admit APR-DRG categories with less than 20 patients into one. We refer to this aggregate level as "0". Now the variable, admit APR-DRG has only 25 levels, each with at least 20 patients. (Appendix Table 1)

Next, we cross-tabulate the nominal variables NHSN defined procedure and Admit APR-DRG and the binomial variable Ruling to see if their combinations correspond to sufficiently many patients. Unfortunately that is not the case. Some combinations have 0 patients, some have 3. (Appendix Table 2)

The cross-tabulation results show that we cannot study any interaction effects between the nominal variables. In theory, such interactions could show if the effect of NHSN defined procedure or admit APR-DRG is different for infected and uninfected patients. However, we do not have enough statistical power for some of the combinations of levels. We could keep merging the least represented levels of NHSN defined procedure and admit APR-DRG. Then all the combinations of Ruling, NHSN defined procedure, and admit APR-DRG would have enough patients. However, this would be done at the expense of accuracy of estimating the main effects of the binomial variable Ruling, NHSN defined procedure, and admit APR-DRG; on daily total charges and LOS. Given this, we decide against any further mergers.

As the next step, we run the analysis of covariance for LOS. LOS is the dependent variable, variables Ruling, NHSN defined procedure, and Admit APR-DRG are the factors while admit APR-DRG Complexity acts as a numeric covariate. (Appendix Table 3 and Appendix table 4)

All the factors and the covariate are statistically significant. The p-values of the associated F-tests are well below the significance level of 5%. In particular, the p-value of Ruling is <0.001; hence the presence of an SSI significantly influences a patient's LOS. The regression coefficient of the patients with an SSI in the ANCOVA model is 3.449. This implies that, on average, patients with an SSI spend 3.449 more days than patients without an SSI. The 95% confidence interval for the extra LOS infected patients experience is (2.856, 4.042).

As the next step, we run the analysis of covariance for daily total charges; daily total charges acts as the dependent variable. Again variables Ruling, NHSN defined procedure, and Admit APR-DRG are the factors while admit APR-DRG Complexity is a numeric covariate. (Appendix Table 5 and Appendix Table 6)

In this run, all the variables are significant except Ruling; Ruling is the only insignificant predictor. The p-value related to ruling is 0.062, which falls above the significance level of 0.05. Given this, we accept the null hypothesis, stating that there is no difference in the average daily charges for patients with an SSI versus patients without an SSI. That is true after adjusting for the effects of NHSN defined procedure, admit APR-DRG, and admit APR-DRG Complexity; which are all highly statistically significant. To see the signs and magnitudes of the effects of admit APR-DRG Complexity as well as different levels of NHSN defined procedure and Admit APR-DRG, examine Appendix Table 6.

eAppendix 2 Table 1: Admit APR-DRG

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	154	.9	.9	.9
	20	141	.8	.8	1.7
	21	2938	16.9	16.9	18.6
	23	319	1.8	1.8	20.4
	89	50	.3	.3	20.7
	161	20	.1	.1	20.8
	162	92	.5	.5	21.4
	163	172	1.0	1.0	22.3
	165	620	3.6	3.6	25.9
	166	848	4.9	4.9	30.8
	221	238	1.4	1.4	32.2
	301	1623	9.3	9.3	41.5
	302	2359	13.6	13.6	55.0
	303	942	5.4	5.4	60.5
	304	1742	10.0	10.0	70.5
	310	867	5.0	5.0	75.5
	321	1370	7.9	7.9	83.3
	401	374	2.2	2.2	85.5
	540	2277	13.1	13.1	98.6
	680	45	.3	.3	98.8
	710	33	.2	.2	99.0
	711	55	.3	.3	99.4
	791	29	.2	.2	99.5
	912	36	.2	.2	99.7
	950	48	.3	.3	100.0
	Total	17392	100.0	100.0	

eAppendix 2 Table 2: Admit APR-DRG * Ruling Crosstabulation

		Ruling		Total
		Infected	Not Infected	
Admit APR-DRG	0	8	146	154
	20	1	140	141
	21	78	2860	2938
	23	23	296	319
	89	1	49	50
	161	0	20	20
	162	6	86	92
	163	2	170	172
	165	22	598	620
	166	30	818	848
	221	3	235	238
	301	32	1591	1623
	302	27	2332	2359
	303	53	889	942
	304	103	1639	1742
	310	21	846	867
	321	31	1339	1370
	401	10	364	374
	540	91	2186	2277
	680	1	44	45
	710	0	33	33
	711	0	55	55
	791	1	28	29
	912	1	35	36
	950	2	46	48
Total		547	16845	17392

eAppendix 2 Table 3: Tests of Between-Subjects Effects[¥]

Dependent Variable: LOS					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**P-value**
Corrected Model	274541.768[¥]	35	7844.051	163.828	<0.001
Intercept	1447.412	1	1447.412	30.230	<0.001
Ruling	6224.819	1	6224.819	130.009	<0.001
NHSN defined procedure	3265.570	9	362.841	7.578	<0.001
Admit APR-DRG	48868.769	24	2036.199	42.527	<0.001
Admit APR-DRG Complexity	98753.052	1	98753.052	2062.518	<0.001
Error	831002.870	17356	47.880		
Total	1765806.000	17392			
Corrected Total	1105544.638	17391			

[¥] ***R Squared = .248 (Adjusted R Squared = .247)***

eAppendix 2 Table 4: Parameter Estimates

Dependent Variable: LOS						
					95% Confidence Interval	
Parameter	B	Std. Error	t	P-value	Lower Bound	Upper Bound
Intercept	1.542	1.155	1.336	0.182	-.721	3.806
[Ruling=Infected]	3.449	.302	11.402	<0.001	2.856	4.042
[Ruling=Not Infected] ¥	0	.	.	.	.	.
[NHSN defined procedure=CABG]	7.585	1.782	4.257	<0.001	4.092	11.078
[NHSN defined procedure=Colon]	-6.871	1.526	-4.503	<0.001	-9.861	-3.880
[NHSN defined procedure=CRAN]	.461	.622	.741	0.459	-.758	1.680
[NHSN defined procedure=CSEC]	-11.772	3.165	-3.720	<0.001	-17.975	-5.569
[NHSN defined procedure=FUSN]	.145	.328	.443	0.658	-.498	.789
[NHSN defined procedure=Hip]	-.432	1.681	-.257	0.797	-3.726	2.863
[NHSN defined procedure=Knee]	-.535	3.536	-.151	0.880	-7.466	6.396
[NHSN defined procedure=LAM]	-.011	.524	-.021	0.984	-1.037	1.016
[NHSN defined procedure=PED FUSN]	-.827	.433	-1.911	0.056	-1.675	.021
[NHSN defined procedure=RFUSN] ¥	0	.	.	.	.	.
[Admit APR-DRG= 0]	8.496	1.164	7.300	<0.001	6.215	10.778
[Admit APR-DRG= 20]	3.806	1.186	3.209	0.001	1.481	6.131
[Admit APR-DRG= 21]	-2.115	1.040	-2.034	0.042	-4.153	-.077
[Admit APR-DRG= 23]	-.570	1.131	-.504	0.614	-2.788	1.647
[Admit APR-DRG= 89]	-3.798	1.421	-2.673	0.008	-6.584	-1.013
[Admit APR-DRG= 161]	5.480	2.476	2.214	0.027	.628	10.332
[Admit APR-DRG= 162]	.048	2.062	.023	0.982	-3.995	4.090
[Admit APR-DRG= 163]	-3.245	1.995	-1.627	0.104	-7.155	.664
[Admit APR-DRG= 165]	-5.529	1.952	-2.832	0.004	-9.356	-1.703
[Admit APR-DRG= 166]	-7.737	1.947	-3.974	<0.001	-11.553	-3.921
[Admit APR-DRG= 221]	6.008	1.799	3.340	<0.001	2.482	9.534
[Admit APR-DRG= 301]	-2.880	1.781	-1.617	0.106	-6.372	.611
[Admit APR-DRG= 302]	-2.777	3.566	-.779	0.436	-9.767	4.213
[Admit APR-DRG= 303]	-.748	1.130	-.661	0.508	-2.963	1.468
[Admit APR-DRG= 304]	-1.175	1.109	-1.059	0.289	-3.349	.999
[Admit APR-DRG= 310]	-3.918	1.103	-3.552	<0.001	-6.081	-1.756
[Admit APR-DRG= 321]	-3.052	1.108	-2.755	0.005	-5.224	-.881
[Admit APR-DRG= 401]	-4.099	1.094	-3.746	<0.001	-6.244	-1.954
[Admit APR-DRG= 540]	9.105	3.286	2.771	0.005	2.664	15.547
[Admit APR-DRG= 680]	1.818	1.454	1.250	0.211	-1.032	4.668
[Admit APR-DRG= 710]	17.279	1.635	10.567	<0.001	14.074	20.484
[Admit APR-DRG= 711]	-2.094	1.380	-1.518	0.129	-4.799	.611
[Admit APR-DRG= 791]	.121	1.652	.073	0.942	-3.117	3.358
[Admit APR-DRG= 912]	.671	1.603	.418	0.676	-2.471	3.812

[Admit APR-DRG= 950]¥	0	.	.		.	.
Admit APR-DRG Complexity	3.252	.072	45.415	0.000	3.111	3.392

¥**This parameter is set to zero because it is redundant.**

eAppendix 2 Table 5: Tests of Between-Subjects Effects

Dependent Variable: Average Daily Charges					
Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**P-value**
Corrected Model	1.587E11	35	4.535E9	280.453	<0.001
Intercept	1.904E10	1	1.904E10	1177.303	<0.001
Ruling	5.628E7	1	5.628E7	3.480	0.062
NHSN defined procedure	8.233E9	9	9.147E8	56.563	<0.001
Admit APR-DRG	1.386E10	24	5.774E8	35.706	<0.001
Admit APR-DRG Complexity	4.539E9	1	4.539E9	280.657	<0.001
Error	2.807E11	17356	1.617E7		
Total	1.481E12	17392			
Corrected Total	4.394E11	17391			

[¥] ***R Squared = .361 (Adjusted R Squared = .360)***

eAppendix 2 Table 6: Parameter Estimates

Dependent Variable: Average Daily Charges						
					95% Confidence Interval	
Parameter	B	Std. Error	t	P-value	Lower Bound	Upper Bound
Intercept	11205.203	671.087	16.697	<0.001	9889.804	12520.601
[Ruling=Infected]	-327.964	175.796	-1.866	0.062	-672.542	16.614
[Ruling=Not Infected] ¥	0					
[NHSN defined procedure=CABG]	-1739.368	1035.653	-1.679	0.093	-3769.353	290.616
[NHSN defined procedure=Colon]	-4546.348	886.748	-5.127	<0.001	-6284.462	-2808.233
[NHSN defined procedure=CRAN]	-1919.805	361.513	-5.310	<0.001	-2628.406	-1211.203
[NHSN defined procedure=CSEC]	-5231.813	1839.159	-2.845	0.004	-8836.751	-1626.876
[NHSN defined procedure=FUSN]	1404.252	190.700	7.364	<0.001	1030.462	1778.043
[NHSN defined procedure=Hip]	-3159.367	976.764	-3.235	0.001	-5073.922	-1244.812
[NHSN defined procedure=Knee]	-2735.805	2054.893	-1.331	0.183	-6763.602	1291.993
[NHSN defined procedure=LAM]	-3537.264	304.350	-11.622	<0.001	-4133.821	-2940.708
[NHSN defined procedure=PEDFUSN]	2312.124	251.470	9.194	<0.001	1819.218	2805.030
[NHSN defined procedure=RFUSN] ¥	0					
[Admit APR-DRG= 0]	-964.131	676.411	-1.425	0.154	-2289.964	361.702
[Admit APR-DRG= 20]	-1805.914	689.283	-2.620	0.008	-3156.978	-454.849
[Admit APR-DRG= 21]	1160.528	604.301	1.920	0.055	-23.963	2345.019
[Admit APR-DRG= 23]	-827.904	657.513	-1.259	0.208	-2116.696	460.888
[Admit APR-DRG= 89]	1920.256	825.965	2.325	0.020	301.281	3539.232
[Admit APR-DRG= 161]	7241.740	1438.688	5.034	<0.001	4421.766	10061.714
[Admit APR-DRG= 162]	-1648.422	1198.594	-1.375	0.169	-3997.787	700.943
[Admit APR-DRG= 163]	-1773.151	1159.223	-1.530	0.126	-4045.344	499.043
[Admit APR-DRG= 165]	-2072.567	1134.555	-1.827	0.068	-4296.408	151.275
[Admit APR-DRG= 166]	-2133.464	1131.483	-1.886	0.059	-4351.284	84.356
[Admit APR-DRG= 221]	-1975.857	1045.447	-1.890	0.059	-4025.038	73.324

[Admit APR-DRG= 301]	-281.977	1035.339	-.272	0.785	-2311.346	1747.392
[Admit APR-DRG= 302]	-497.050	2072.523	-.240	0.810	-4559.404	3565.304
[Admit APR-DRG= 303]	267.078	656.946	.407	0.684	-1020.601	1554.757
[Admit APR-DRG= 304]	-731.977	644.507	-1.136	0.256	-1995.276	531.321
[Admit APR-DRG= 310]	1117.836	641.131	1.744	0.081	-138.846	2374.518
[Admit APR-DRG= 321]	2527.869	643.979	3.925	<0.001	1265.606	3790.132
[Admit APR-DRG= 401]	1240.475	635.983	1.950	0.051	-6.116	2487.065
[Admit APR-DRG= 540]	-1645.215	1909.942	-.861	0.389	-5388.894	2098.464
[Admit APR-DRG= 680]	1094.011	845.060	1.295	0.195	-562.392	2750.414
[Admit APR-DRG= 710]	-1714.553	950.321	-1.804	0.071	-3577.278	148.172
[Admit APR-DRG= 711]	-3094.675	802.030	-3.859	<0.001	-4666.734	-1522.616
[Admit APR-DRG= 791]	-3044.153	959.927	-3.171	0.002	-4925.707	-1162.598
[Admit APR-DRG= 912]	-2431.936	931.532	-2.611	0.009	-4257.833	-606.039
[Admit APR-DRG= 950] ¥	0					
Admit APR-DRG Complexity	-697.074	41.609	-16.753	<0.001	-778.633	-615.516

¥ ***This parameter is set to zero because it is redundant.***