Validation of an algorithm to determine the primary care treatability of Emergency Department visits: supplementary methods and tables

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Two years of claims data (2011-2012) for a representative sample of Medicare beneficiaries was used to develop and validate the new measure. The Limited Data Set files made available by the Center for Medicare & Medicaid Services include claims for nearly all services paid for by Medicare (Part D drug claims are not available) including inpatient, outpatient, physician services, home health, durable medical equipment, hospice, and skilled nursing facilities. Information that could be used to identify individual beneficiaries has been stripped from the files according to HIPAA privacy rules. The data includes limited demographic information for all sampled beneficiaries, regardless of whether they received any medical care: beneficiary age (top-coded at 100 years of age), county of residence, gender and race, the reason for receipt of Medicare benefits (old age, end-stage renal disease, etc.), and indicators for receipt of state subsidies that serve as a proxy for dual eligibility for Medicare and Medicaid; the claim files include unencrypted physician and institution identifiers, procedure codes, and diagnosis codes, as well as submitted and paid charges. A nationwide five percent sample is included in the files; the sample is selected based on the Medicare identification number, ensuring that beneficiaries remain in the sample as long as they are receiving Medicare benefits. See CMS 2014 for further details.

Identifying ED visits in Medicare claims files

Emergency Department (ED) visits can appear in multiple Medicare claims files. In general, we expect to see at least two claims associated with each visit: an institutional claim and a physician claim. The first is submitted by the hospital in which the ED is located, while the second is submitted by the physician who treated the patient.

Using the Limited Data Set (LDS) for 2011 and 2012, we identified and matched all emergency department visits across the institutional and carrier files by patient ID and date, taking into account Medicare payment rules requiring bundling of outpatient and inpatient charges within 3 calendar days (the three-day payment window—further detail below). Note that there is no claim-level identifier that definitively groups claims in different files as belonging to the same ED visit—the user must create decision rules to determine which claims result from a single visit. In this study, ED visits were defined by the patient ID and the date of services provided. This slightly overcounts actual ED visits, as some patients spend the night in the ED, generating records of procedures performed on two separate days. The user may decide to group procedures taking place on adjacent days as belonging to the same ED visit, but this will slightly undercount actual ED visits, since some patients do visit the ED on multiple days in a row. There are no time stamps in Medicare data, so we cannot definitively address this problem.

ED visits were assembled from three Medicare administrative files: the Carrier file, the Inpatient file, and the Outpatient file. The first of these contains physician claims, while the others contain claims filed by institutions (e.g., hospitals). The type of information available in each file is different.

The Carrier file includes two sources of ED visits: the Line Place of Service code and the Line HCPCS code. The HCPCS code records the procedure for which the physician is charging Medicare. The Line Place of Service code is used in the carrier file to specify where the physician performed a procedure. Code 23 refers to the ED.

The Outpatient file also includes two sources of ED visits: the revenue center code and the HCPCS code. Revenue centers 450–459 and 981 are specific to the ED. See Table 1 for details. In addition, the Outpatient file includes the five ED-specific E&M codes.

The Inpatient file has less detail on ED visits because of the Medicare rules for payment for inpatient visits and related expenses. The Prospective Payment System (PPS) rules require that certain outpatient hospital services are bundled together into the single payment for an inpatient stay. Since 1991, diagnostic services provided by the hospital up to 3 calendar days before an

Table 1: Key Emergency Department revenue codes

Revenue Code	Definition
0450	Emergency room—general classification
0451	Emergency room—EMTALA emergency medical screening services
0452	Emergency room—ER beyond EMTALA screening
0456	Emergency room—urgent care
0459	Emergency room—other
0981	Professional fees—Emergency room

Source: http://www.resdac.org/cms-data/variables/revenue-center-code

inpatient admission are not separately reimbursed—they are considered to be covered by the single inpatient PPS payment. Nondiagnostic outpatient services "related to" a patient's inpatient stay are also bundled with the inpatient stay. From 1998 until 2010, "related to" was defined as having an exact 4-digit match on the ICD-9 diagnosis code assigned to the inpatient stay and to the outpatient services. Starting June 25, 2010, all outpatient nondiagnostic services are considered "related to" the inpatient stay, except for ambulance services and some renal dialysis services. For much more detail on this policy, see the Medicare Claims Processing Manual, Chapter 3, section 40.3.[1] The result of this rule is that hospitals do not submit bills to Medicare that outline each procedure performed as part of the stay (or in the three days before, where relevant). They do, however, provide limited information in the form of total charges by revenue center. We can identify emergency department visits related to an inpatient stay by looking for charges to the ED revenue centers from Table 1. Note that physicians may separately charge for their evaluation and management services in some circumstances, even though the hospital must wrap its ED charges into the inpatient stay. Thus, for some visits (22% of all ED visits identified in the sample), we see physician charges in the Carrier file and institutional charges in the Inpatient file.

In all, 73% of ED visits identified in the sample had both an institutional ED source (either inpatient or outpatient) and a physician ED source (i.e., from the carrier file) for an individual patient on a single day. An additional 5% had both a physician ED charge and an inpatient admission with ED charges within 3 days.

Outcomes

Two outcomes were used to validate the new algorithm in comparison to the Ballard version of the Billings/NYU algorithm: death (at 1 week and 1 month following the ED visit) and hospitalization (at 1 day and 1 week following the ED visit). These outcomes have the advantage of being available in the data set used for this study. They are not ideal for the purpose of discriminating between ED visits that could have been primary care treatable and those that are not, since they are quite serious outcomes. Nevertheless, these outcomes are useful for validating that visits identified as severe are indeed associated with either severity of illness (resulting in death) or need for more intensive care than can be provided in an outpatient setting (resulting in hospitalization).

Because the new algorithm uses hospitalization as a criterion in categorizing ED visits, an alternative version of the new algorithm was devised that uses only the E&M criteria. ED visits

1. Some hospitals are not subject to the 3-day window provision, including critical access hospitals, psychiatric hospitals/units, inpatient rehab facilities/units, long-term care hospitals, children's hospitals, and cancer hospitals. These facilities are instead subject to a 1-day window.

that resulted in an inpatient admission but have no record of an ED-specific E&M code are left uncategorized with this version of the new algorithm. These uncategorized visits represent 6–7% of ED visits.[2]

Validation sample

Validation analyses were performed on a subset of observed ED visits. Only beneficiaries who were covered by FFS Medicare parts A and B for all possible months of the year were included in the analysis, to ensure we had as much information as possible on medical care received. In general, beneficiaries were required to have 12 months of part A, 12 months of part B, and 0 months of HMO coverage. However, this rule would exclude people who died or who aged in to the program, resulting in partial years of coverage. To capture these valid partial years of coverage, two additional groups of beneficiaries were retained in the analysis: both groups had matching numbers of months (fewer than 12) of A and B coverage and no HMO coverage during the year. The aged-in group were 64 years old at the beginning of the year, while the group of beneficiaries who died had parts A and B coverage termination codes indicating death.

Some of the death information included in the denominator file was clearly in error. For example, approximately 22,000 people have a "valid date of death" flag in both 2011 and 2012 (suggesting they had died in both years). We did not want to lose any deaths that could be kept. In some cases, the two reports of death matched (e.g., both years' denominator files reported the same death date. These beneficiaries were retained in the analysis and the earlier, incorrect death flag was removed (in all of these cases, the death date reported in both denominator files was in 2012). In cases where two death dates were provided and the dates did not match, the beneficiaries were removed from the validation analysis.[3] Any ED visit that takes place after the stated date of death is also removed from the analyses.

Full analysis results

2. Visits uncategorized by the alternative version of the algorithm but categorized by the main version of the algorithm represent 6.8% of all ED visits identified in the sample and 6.2% of ED visits by people who were covered by FFS Medicare parts A and B for all possible months of the year, as defined for the validation sample below.

3. No ED visits were removed from the visit counts of all ED visits (N=2,644,545) for bad death dates or for not meeting coverage criteria.

Table 2: Predictive validity of Minnesota Algorithm (without inpatient criterion) and Billings/Ballard algorithm: hospitalization within 1 day and 1 week from ED visit

	(1) 1 day	(2) 1 day	(3) 1 week	(4) 1 week
Minnesota Algorithm				
Primary Care Treatable (ref)	1		1	
ED Care needed	11.70		7.681	
	[11.49,11.91]		[7.566,7.797]	
Unclassified	1.519		1.372	
	[1.473,1.566]		[1.336,1.409]	
Unclassified: inpatient only	121.7		78.09	
	[117.0,126.6]		[74.93,81.39]	
Billings/Ballard Algorithm				
Nonemergent (ref)		1		1
Emergent		6.717		5.259
		[6.647,6.788]		[5.208,5.311]
Intermediate		2.170		1.855
		[2.124,2.217]		[1.818,1.892]
Special category		2.183		2.100
		[2.075,2.296]		[2.002,2.203]
Unclassified		0.678		0.740
		[0.654,0.704]		[0.716,0.765]
Race				
White (ref)	1	1	1	1
Unknown	1.003	1.032	0.978	1.006
	[0.910,1.106]	[0.929,1.147]	[0.885,1.080]	[0.907,1.117]
Black	0.892	0.915	0.887	0.907
	[0.878,0.907]	[0.900,0.931]	[0.873,0.902]	[0.892,0.922]
Other	1.046	1.091	1.017	1.057
	[1.002,1.091]	[1.044,1.140]	[0.972,1.063]	[1.010,1.107]
Asian	1.192	1.256	1.134	1.192
	[1.147,1.238]	[1.207,1.307]	[1.092,1.178]	[1.146,1.239]
Hispanic	1.004	1.060	0.976	1.028
	[0.972,1.037]	[1.026,1.096]	[0.945,1.009]	[0.994,1.063]
North American Native	0.917	0.814	0.928	0.829
	[0.865,0.972]	[0.770,0.861]	[0.876,0.983]	[0.785,0.875]
Age (2011)	1.019	1.018	1.017	1.016
	[1.019,1.020]	[1.018,1.019]	[1.017,1.017]	[1.016,1.016]
Female	0.921	0.951	0.933	0.963
	[0.913,0.930]	[0.942,0.960]	[0.925,0.942]	[0.953,0.972]
HCC score	1.383	1.354	1.441	1.413
	[1.378,1.388]	[1.349,1.359]	[1.435,1.447]	[1.407,1.418]
Medicaid	0.916	0.887	0.926	0.898
	[0.906,0.926]	[0.877,0.896]	[0.916,0.936]	[0.888,0.908]
Observations	2,448,112	2,448,112	2,448,112	2,448,112

Exponentiated coefficients; 95% confidence intervals in brackets
All ORs significant at p<0.001

Table 3: Predictive validity of Minnesota Algorithm and Billings/Ballard algorithm: death at 1 week and 1 month from ED visit

	(1) 1 week	(2) 1 week	(3) 1 month	(4) 1 month
Minnesota Algorithm				
Primary Care Treatable (ref)	1		1	
ED Care needed	3.704		3.084	
	[3.523,3.895]		[2.986,3.186]	
Unclassified	3.450		2.969	
	[3.214,3.704]		[2.814,3.133]	
Billings/Ballard Algorithm				
Nonemergent (ref)		1		1
Emergent		5.164		3.032
		[4.946,5.391]		[2.959,3.106]
Intermediate		1.541		1.566
		[1.408,1.687]		[1.492,1.644]
Special category		2.418		1.808
		[2.059,2.839]		[1.638,1.995]
Unclassified		4.389		2.786
		[4.067,4.737]		[2.638,2.942]
Race				
White (ref)	1	1	1	1
Unknown	0.984	0.986	0.951	0.955
	[0.784,1.235]	[0.786,1.237]	[0.771,1.172]	[0.775,1.176]
Black	0.879	0.896	0.836	0.847
	[0.848,0.911]	[0.865,0.929]	[0.810,0.862]	[0.821,0.874]
Other	1.194	1.211	1.071	1.086
	[1.075,1.325]	[1.091,1.344]	[0.979,1.171]	[0.993,1.187]
Asian	1.041	1.054	0.965	0.978
	[0.951,1.140]	[0.963,1.154]	[0.892,1.044]	[0.903,1.059]
Hispanic	0.803	0.831	0.753	0.776
	[0.737,0.874]	[0.763,0.904]	[0.699,0.811]	[0.721,0.835]
North American Native	0.987	0.942	1.016	0.963
	[0.856,1.138]	[0.817,1.085]	[0.903,1.144]	[0.857,1.082]
Age (2011)	1.046	1.045	1.052	1.051
	[1.045,1.047]	[1.044,1.046]	[1.051,1.053]	[1.050,1.052]
Female	0.747	0.760	0.766	0.778
	[0.731,0.764]	[0.744,0.777]	[0.752,0.780]	[0.764,0.792]
HCC score	1.234	1.215	1.335	1.323
	[1.229,1.239]	[1.210,1.220]	[1.330,1.340]	[1.318,1.328]
Medicaid	0.962	0.958	0.950	0.944
	[0.937,0.988]	[0.933,0.984]	[0.929,0.971]	[0.923,0.965]
Observations	2,448,112	2,448,112	2,448,112	2,448,112

Exponentiated coefficients; 95% confidence intervals in brackets
All ORs significant at $p<0.001$

Table 4: Predictive validity of Minnesota Algorithm and Billings/Ballard algorithm **excluding cardiac arrest**: death within 1 week and 1 month of ED visit

	(1) 1 week	(2) 1 week	(3) 1 month	(4) 1 month
Minnesota Algorithm				
Primary Care Treatable (ref)	1		1	
ED Care needed	4.134		3.144	
	[3.900,4.381]		[3.038,3.253]	
Unclassified	4.275		3.161	
	[3.954,4.623]		[2.990,3.342]	
Billings/Ballard Algorithm				
Nonemergent (ref)		1		1
Emergent		4.182		2.766
		[4.005,4.366]		[2.700,2.834]
Intermediate		1.508		1.553
		[1.377,1.651]		[1.479,1.630]
Special category		2.378		1.794
		[2.024,2.793]		[1.625,1.981]
Unclassified		4.260		2.751
		[3.945,4.600]		[2.604,2.907]
Race				
White (ref)	1	1	1	1
Unknown	0.988	0.991	0.950	0.955
	[0.775,1.258]	[0.779,1.261]	[0.765,1.180]	[0.770,1.185]
Black	0.785	0.798	0.796	0.806
	[0.754,0.817]	[0.766,0.831]	[0.770,0.823]	[0.780,0.833]
Other	1.138	1.155	1.041	1.056
	[1.013,1.278]	[1.029,1.297]	[0.948,1.143]	[0.962,1.160]
Asian	1.005	1.019	0.946	0.960
	[0.911,1.110]	[0.924,1.125]	[0.872,1.027]	[0.884,1.042]
Hispanic	0.763	0.789	0.733	0.754
	[0.694,0.839]	[0.718,0.867]	[0.678,0.792]	[0.698,0.814]
North American Native	0.987	0.927	1.019	0.959
	[0.847,1.150]	[0.796,1.080]	[0.901,1.151]	[0.850,1.081]
Age (2011)	1.051	1.050	1.054	1.053
	[1.050,1.052]	[1.049,1.051]	[1.053,1.055]	[1.052,1.054]
Female	0.791	0.806	0.785	0.798
	[0.772,0.810]	[0.787,0.825]	[0.770,0.800]	[0.783,0.813]
HCC score	1.263	1.248	1.352	1.342
	[1.258,1.268]	[1.243,1.253]	[1.346,1.357]	[1.337,1.347]
Medicaid	0.966	0.961	0.952	0.945
	[0.939,0.995]	[0.934,0.989]	[0.930,0.974]	[0.924,0.968]
Observations	2,440,998	2,440,998	2,440,998	2,440,998

Exponentiated coefficients; 95% confidence intervals in brackets
All ORs significant at $p<0.001$

References

Centers for Medicare & Medicaid Services [CMS]. 2014. "Standard Analytic Files — LDS." Accessed December 16. http://www.cms.gov/Research-Statistics-Data-and-Systems/Files-for-Order/LimitedDataSets/StandardAnalyticalFiles.html.