Do Higher Health Insurance Reimbursements Encourage Antibiotic Innovation?: Evidence from Medicare's 2007 DRG Restructuring

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Research Question

Can higher insurance reimbursements in Medicare Part A for inpatients ailing from infections increase antibiotic patenting?

Motivation: The threat of AMR

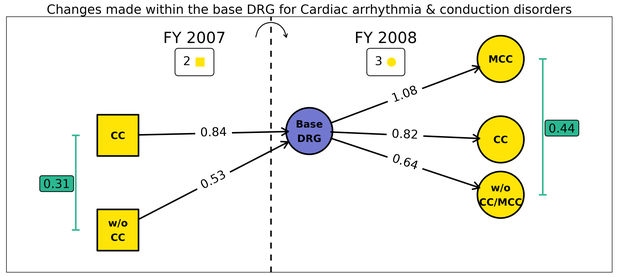
- Bacterial Antimicrobial Resistance (AMR) has been recognized as a public health threat with 1.27 million worldwide deaths in 2019 alone [4]. So, antibiotic innovation is needed.
- Incentivizing innovation outputs with "pull incentives" [3] such as insurance changes are being actively explored in the AMR space, for example, in the DISARM Act of 2021.
- Contributions:
  - I uniquely focus on antibiotic innovation.
    - Cook and Averett [2] study the impact of 2007 DRG restructuring policy on hospital upcoding but I study the impact on innovation.
    - Azoulay, Heggeness, and Kao [1] study the impact of Medicare on innovation. They focus on adjustments component but I focus on DRGs.
  - I develop a pipeline attributing patents to DRGs.

Background: CMS' 2007 DRG restructuring

The Centers for Medicare & Medicaid Services (CMS) prospectively sets the rate of reimbursement annually for a list of **Diagnostic-Related Groups (DRGs)**. In 2007, the CMS changed the DRG system adjusting for severity of illness.

An illustration of the 2007 DRG restructuring policy in Medicare Part A

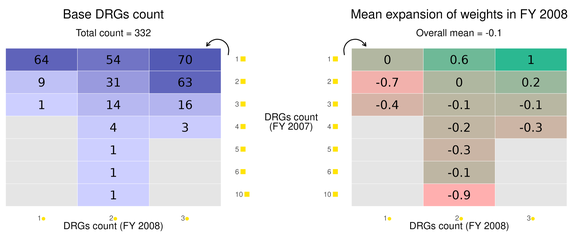
Changes made within the base DRG for Cardiac arrhythmia & conduction disorders



NOTE:
CC = Complication or Comorbidity
MCC = Major CC

SOURCE:
Final Rule for FY08 published in 72 Fed. Reg. 47130 (Aug. 22, 2007) by the Centers for Medicare & Medicaid Services

Summary of changes made in the 2007 DRG restructuring policy



SOURCE: Centers for Medicare & Medicaid

Data Summary

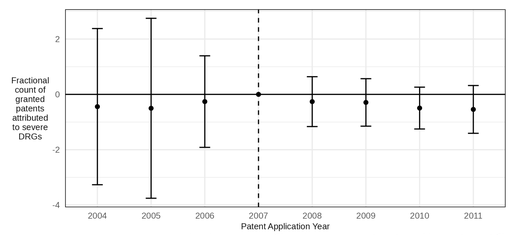
- I analyze 67 base DRGs related to infectious syndromes.
- Pipeline: Patents $\xrightarrow{\text{SureChEMBL}}$ MeSH codes $\xrightarrow{\text{UMLS}}$ ICD $\rightarrow$ DRG
- Study period:2004-11. But granted patents until 2021 indexed by application date are counted.
- Hospital charges taken from the Nationwide Inpatient Sample.

Table: Summary of variables measured

	Pre-policy percentiles					Post-policy percentiles				
Variable	0%	25%	50%	75%	100%	0%	25%	50%	75%	100%
Policy variable of interest										
DRG weight of most severe patient	0.3	0.8	1.1	1.4	8.2	0.4	1.2	1.5	2.1	9.3
Hospital Charges (real 2004 dollars) in most severe DRG										
Avg. per stay (in $1k)	4.1	14.9	19.0	26.4	139.1	8.1	27.0	33.4	43.2	214.4
Aggregate (in $1M)	25.5	394.4	1,272.2	3,082.1	18,096.5	45.5	211.6	723.0	2,219.3	10,433.2
Patents attributed to most severe DRG										
Fractionalized counts	0.0	1.2	3.2	18.2	489.3	0.0	1.5	3.7	20.7	553.5
Attributed via Claims/Abs./Title	0.0	0.1	0.4	2.5	114.1	0.0	0.1	0.4	2.3	98.0
Containing chemical compounds	0.0	1.1	3.2	16.6	464.8	0.0	1.4	3.7	16.4	559.3
Containing antibiotic compounds	0.0	0.1	0.2	1.1	30.7	0.0	0.1	0.3	1.5	41.4

Reduced-form effect of policy on patenting

$$y_{gt} = \alpha_g + \alpha_t + \left[\sum_{\substack{t=2004 \\ t\neq 2007}}^{2011} \beta_t \times I_t \times MaxWt_{gt}\right] + \epsilon_{gt}$$

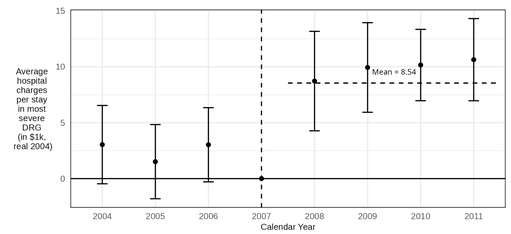


- Independent variable: DRG Weight of the most severe patient.
- Patents counts fractionalized to avoid double counting
- Dashed line indicates the reference year 2007.
- Base DRG and Year Fixed effects included.
- 95% confidence intervals with base-DRG-clustered SE.

I do not find a statistically significant effect.

First-stage effect of policy on price of stay

$$z_{gt} = \alpha_g + \alpha_t + \left[\sum_{\substack{t=2004 \\ t\neq 2007}}^{2011} \beta_t \times I_t \times MaxWt_{gt}\right] + \epsilon_{gt}$$

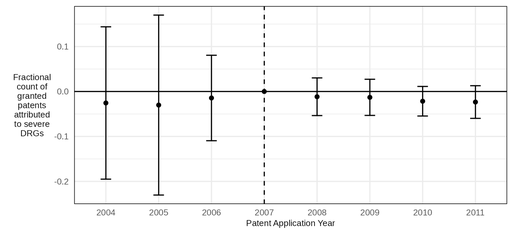


- Independent variable: DRG Weight of the most severe patient.
- Dashed line indicates the reference year 2007.
- Base DRG and Year Fixed effects included.
- 95% confidence intervals with base-DRG-clustered SE.

I observed an average increase in the average hospital charges per stay by $8,584 per annum for the most-severe patient across antibiotic base DRGs, 4 years post-policy.

Second-stage effect of price of stay on patenting

$$y_{gt} = \alpha_g + \alpha_t + \left[\sum_{\substack{t=2004 \\ t\neq 2007}}^{2011} \beta_t \times I_t \times z_{gt}\right] + \epsilon_{gt}$$



- Independent variable: Avg. Hospital Charges per stay (real 2004, $1k) instrumented by the weight of the most severe DRG in each base DRG.
- Patents counts fractionalized to avoid double counting
- Dashed line indicates the reference year 2007.
- Base DRG and Year Fixed effects included.
- 95% confidence intervals with base-DRG-clustered SE.

I still do not find a statistically significant effect.

Effect on alternative measures of patenting

Dep: Fractional count of granted patents attributed to severe DRGs containing...	...MeSH codes of antibiotic DRGs in claims or abstract or title only	...a chemical compound	...an antibiotic drug compound
Average hospital chargers per stay X 2008 (in real 2004, $1k)	-0.002 (0.006)	-0.011 (0.021)	-0.000 (0.001)
Average hospital chargers per stay X 2009 (in real 2004, $1k)	-0.001 (0.005)	-0.019 (0.021)	-0.002 (0.001)
Average hospital chargers per stay X 2010 (in real 2004, $1k)	0.001 (0.004)	-0.029 (0.022)	-0.001 (0.002)
Average hospital chargers per stay X 2011 (in real 2004, $1k)	-0.001 (0.003)	-0.038 (0.029)	-0.002 (0.005)
Observations	518	518	518
R2	0.99	0.98	0.97
Outcome Mean (SDev)	6.5 (17.3)	39.9 (98.5)	2.6 (6.5)

- Independent variable is instrumented by the weight of the most severe DRG in each base DRG.
- Patents counts fractionalized to avoid double counting.
- Data on chemical compounds sourced from SureChEMBL, and on antibiotic drug compounds from AntibioticDB.
- Base DRG and Year Fixed effects included.
- Standard errors clustered at base DRG level are shown.
- *** p<0.01, ** p<0.05, * p<0.1

No statistically significant effect in alternative measures either.

Conclusions

- Next steps: Measuring encouragement by adjusting for counterfactual weights.
- Conclusions: No evidence for impact of the 2007 DRG restructuring policy on patent outcomes within 4 years. This is despite a significant first-stage effect on price of stay.
- Weaknesses in this study: Short time-horizon; Hospital charges not disambiguated by cost center (drugs, lab tests, etc.).

References

[1] Pierre Azoulay, Misty Heggeness, and Jennifer Kao. In: *Research Policy* 54.2 (2025), p. 105163.
[2] Amanda Cook and Susan Averett. In: *Journal of Health Economics* 73 (2020), p. 102319.
[3] Michael Kremer and Rachel. Glennerster. eng. Princeton, NJ: Princeton University Press, 2004.
[4] Christopher J. L. Murray et al. English. In: *The Lancet* 399.10325 (2022). Publisher: Elsevier, pp. 629–655.