Online Appendix

Health Care Demand Under Simple Prices: Evidence From Tiered Hospital Networks

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Appendix A: Additional Tables and Figures

Table A1—Inpatient admissions for hospital demand model

Mean age	41.6	–	–
% female	64.1	–	–
% chronic	34.6	–	–
% in tiered plans	65.6	–	–
	Non-tiered	Tier 1	Tier 2, 3
% of admits	34.4	31.2	68.8
Mean distance	15.1	11.5	15.9
Mean copay ($)	240.2	268	614.8

Summary statistics for admissions used to estimate the hospital demand model. Two-thirds of admissions are from enrollees in tiered plans. First column of second panel reports non-tiered plans' share of admissions and characteristics. Columns 2 and 3 report tiered plan admissions. Patients travel farther to hospitals in higher-copay tiers.

Table A2—Descriptions and prevalence of CCS diagnostic categories

Code	Description	Share
1	Infectious and parasitic diseases	1.9
2	Neoplasms	4.9
3	Endocrine; nutritional; and metabolic diseases and immunity disorders	3.9
4	Diseases of the blood and blood-forming organs	0.9
5	Mental illness	9.8
6	Diseases of the nervous system and sense organs	2.7
7	Diseases of the circulatory system	10.2
8	Diseases of the respiratory system	7.5
9	Diseases of the digestive system	10.0
10	Diseases of the genitourinary system	3.9
11	Complications of pregnancy; childbirth; and the puerperium	13.5
12	Diseases of the skin and subcutaneous tissue	2.1
13	Diseases of the musculoskeletal system and connective tissue	5.4
14	Congenital anomalies	0.5
15	Certain conditions originating in the perinatal period	13.1
16	Injury and poisoning	7.1
17	Symptoms; signs; and ill-defined conditions	2.1
18	Residual codes; unclassified; all E codes	0.3

Clinical Classifications Software (CCS) diagnostic categories. First column is Level 1 code (the broadest level), second column is description, third column is % share of nonelderly hospital discharges in Massachusetts.

Table A3—Distribution of hospitals across tiers, 2012

# of Hospitals in	HPHC	Tufts
Tier 1	28	39
Tier 2	20	2
Tier 3	13	20
Total	61	61

Counts of hospitals in each tier for a sample year. HPHC is Harvard Pilgrim. Satellite campuses are excluded.

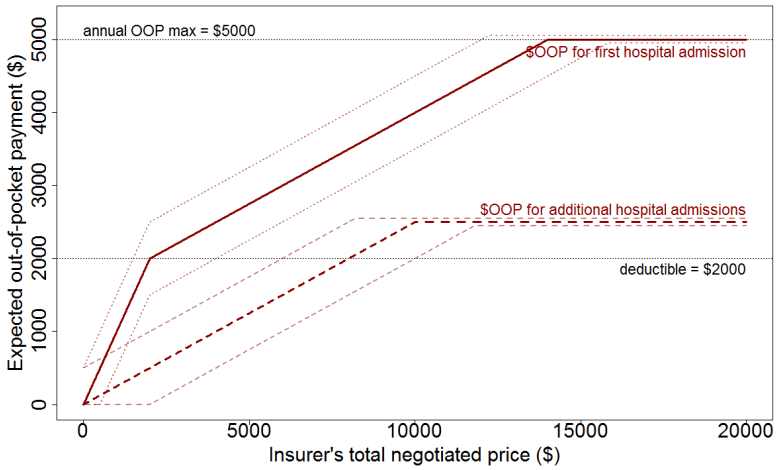
TABLE A4—HOSPITAL CHARACTERISTICS BY TIER, 2010-2014

	% of All Hospitals	Beds (tier means)	% of System Hospitals	% of AMCs	% of Boston HRR Hospitals	% of Non-Boston HRR Hospitals
Tier 1	51.6	240.9	41.1	32.5	54.7	44.1
Tier 2	23.9	286.7	22.2	30.8	22.5	26.8
Tier 3	24.5	318.2	36.7	36.8	22.8	29.1
Count	61.0	53.0	31.0	14.0	41.0	20.0

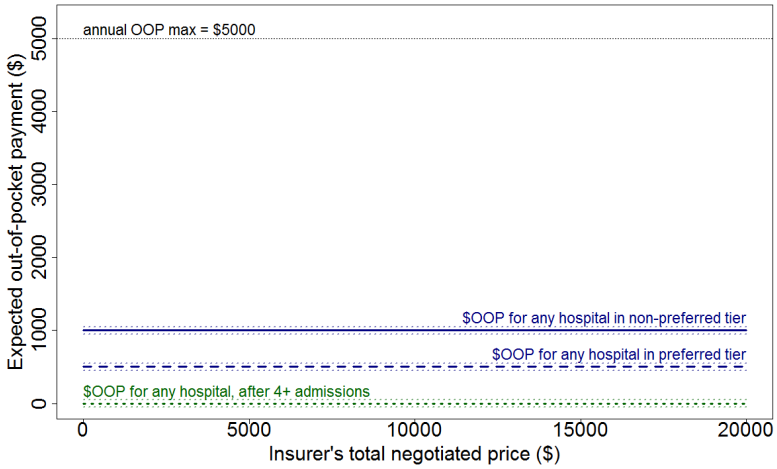
Hospital characteristics weighted by tier frequency across insurers and years. Final row reports hospital counts. Hospitals in the least preferred tier (tier 3) are larger and have a higher proportion of academic medical centers (AMCs). Hospitals both in and outside of Boston are present in all three tiers.

FIGURE A1. CONSUMERS' EXPECTED OUT-OF-POCKET PRICE

(a) Plans using coinsurance

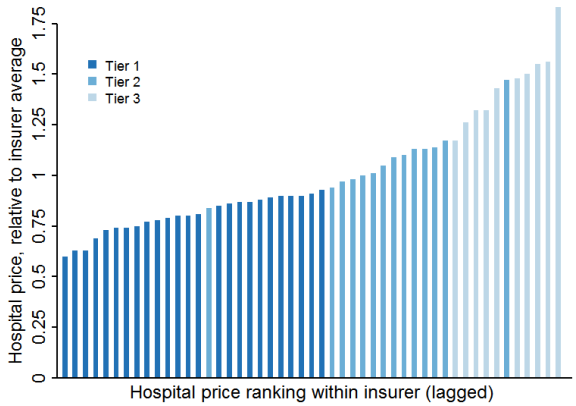


(b) Plans using tiered networks



Consumers' ex ante expectation about the out-of-pocket price of a hospital admission, as a function of the total price of care. The actual total price depends on the diagnosis, the quantity of care consumed, any complications that arise during the hospitalization, and the negotiated prices between the insurer and the hospital. Under coinsurance, the consumer must accurately forecast these quantities in order to correctly anticipate the out-of-pocket price, which is a fixed percentage of the total (up to the out-of-pocket maximum for the year). Under tiered networks with copays, the consumer only needs to know the tier of the hospital in order to correctly anticipate the out-of-pocket price.

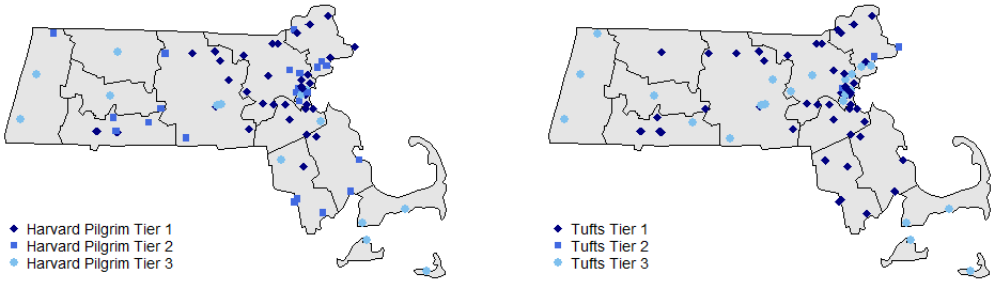
FIGURE A2. SAMPLE TIERING FORMULA (HARVARD PILGRIM)



Hospital prices as a multiple of the average negotiated price within Harvard Pilgrim's network, shaded by their tiers in the insurer's 2012 network. Insurers rank hospitals by their negotiated prices, and use the rankings to assign tiers (subject to ensuring adequate coverage of geographic regions).

FIGURE A3. MASSACHUSETTS INSURERS' HOSPITAL TIERS (2012)

(a) Harvard Pilgrim (b) Tufts



Maps of Harvard Pilgrim's and Tufts' tiered hospital networks in 2012. Each dot represents a general acute care hospital in Massachusetts. Contours represent Massachusetts counties. All hospitals are included in both insurers' tiered networks, but hospitals' tiers are not necessarily consistent across insurers.

FIGURE A4. SCREENSHOTS FROM HARVARD PILGRIM INDEPENDENCE PLAN DOCUMENTATION

(a) Hospital tier assignments

Participating hospitals and their tiers

Massachusetts

Hospital	Tier
Addison Gilbert Hospital	2
Anna Jaques Hospital	1
Athol Memorial Hospital	2
Baystate Franklin Medical Center	3
Baystate Mary Lane Hospital	2

(b) Out-of-pocket prices for each tier

Inpatient Hospital Care: Medical	
Tier 1	$250
Tier 2	$500
Tier 3	$750

Screenshots from the documentation for the highest-enrollment tiered-network plan in the data (Harvard Pilgrim Independence). Figure A4a shows the tier assignments of the first five hospitals, in alphabetical order, taken from Harvard Pilgrim's documentation. Figure A4b shows the copays associated with each tier, taken from the GIC's benefits description (the same information is also available in a slightly different form in Harvard Pilgrim's documentation). Screenshot margins have been modified for figure fit.

Table A5—Hospital choice model

	(1) No FEs	(2) Main specif.	(3) + coinsurance
Hospital Choice			
Copay ($1,000s)	0.8305	-0.1953	-0.1874
	(0.0542)	(0.0700)	(0.0689)
Copay × std. income	0.1416	0.1819	0.1811
	(0.0526)	(0.0535)	(0.0539)
Distance (mi)	-0.1821	-0.1828	-0.1829
	(0.0026)	(0.0028)	(0.0027)
Distance^2	0.0005	0.0006	0.0006
	(0.0000)	(0.0000)	(0.0000)
Distance (mi) × Boston	-0.0831	-0.0763	-0.0786
	(0.0043)	(0.0054)	(0.0052)
Distance^2 × Boston	0.0007	0.0008	0.0008
	(0.0000)	(0.0000)	(0.0000)
Past use of hospital	4.9481	4.6785	4.6568
	(0.0600)	(0.0625)	(0.0612)
Age × distance	0.0001	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
Male × distance	0.0038	0.0024	0.0025
	(0.0016)	(0.0016)	(0.0015)
Chronic cond × distance	0.0222	0.0221	0.0223
	(0.0015)	(0.0016)	(0.0015)
Teaching × distance	0.0148	-0.0035	-0.0038
	(0.0015)	(0.0016)	(0.0015)
Beds × distance	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
Satellite hosp campus	-0.2782	2.1130	2.1324
	(0.0280)	(0.1774)	(0.1774)
Cardiac CCS × cath lab	1.0080	0.4828	0.4823
	(0.1077)	(0.1098)	(0.1076)
Obstetric CCS × NICU	0.8098	0.3314	0.3519
	(0.0343)	(0.0396)	(0.0385)
Nerv, circ, musc CCS × MRI	0.0508	-0.0332	-0.0594
	(0.0632)	(0.0807)	(0.0785)
Nerv CCS × neuro	1.6163	0.0370	0.0605
	(0.2635)	(0.3062)	(0.2966)
% good pain control × distance	-0.0021	-0.0051	-0.0054
	(0.0009)	(0.0008)	(0.0007)
% highly recommend × distance	0.0105	0.0047	0.0048
	(0.0007)	(0.0007)	(0.0006)
Hospital FEs	No	Yes	Yes
Pseudo R^2	0.579	0.625	0.621
Nadmits	29658	29658	31243
Nadmits_coins			1585

Multinomial logit model of hospital choice. All price coefficients scaled to $1,000s for ease of interpretation. Consumers dislike distance and high simple out-of-pocket prices (copays). Hospital quality and income variables are standardized.

Standard errors in parentheses, clustered by patient. Nadmits = total number of choice sets (admissions). Nadmits_coins = number of admissions using coinsurance.

TABLE A6—MEAN CHARACTERSITICS OF ADMISSIONS USING COPAYS VS. COINSURANCE

	Mean (copays)	Mean (coinsurance)	Diff.	p-value
Female	0.640	0.654	-0.014	0.239
Age at admission	41.571	39.119	2.452	0.000
Mean OOP price within choice set	330.007	599.353	-269.346	0.000
Std. dev. of OOP price within choice set	103.570	196.750	-93.180	0.000
Dx: obstetric or perinatal (CCS codes 11, 15)	0.275	0.371	-0.096	0.000
Dx: neoplasms and cancers (CCS code 2)	0.097	0.107	-0.010	0.172
Dx: circulatory system (CCS code 7)	0.075	0.078	-0.003	0.671
Dx: digestive system (CCS code 9)	0.086	0.090	-0.004	0.549
Dx: genitourinary system (CCS code 10)	0.059	0.056	0.003	0.621
Dx: musculoskeletal (CCS code 13)	0.062	0.044	0.018	0.003
Dx: injury and poisoning (CCS code 16)	0.057	0.051	0.006	0.288
Dx: all others	0.290	0.203	0.087	0.000

Table A7—Specification checks for hospital choice model

	(1) Select. on α	(2) High income	(3) New enrolt.
Hospital Choice			
Copay ($1,000s)	-0.2193	-0.3674	-0.2991
	(0.0738)	(0.2365)	(0.1382)
Copay × std. income	0.1853		0.1537
	(0.0536)		(0.1191)
Copay × selected non-tiered	0.1001		
	(0.1101)		
Distance (mi)	-0.1828	-0.1733	-0.2048
	(0.0028)	(0.0167)	(0.0042)
Distance^2	0.0006	0.0006	0.0006
	(0.0000)	(0.0001)	(0.0000)
Hospital FEs	Yes	Yes	Yes
Pseudo R^2	0.625	0.611	0.557
Nadmits	29658	1789	6324

Multinomial logit model of hospital choice. All copay coefficients scaled to $1,000s. Column (1) tests whether consumers select into tiered-network plans by price sensitivity. Column (2) tests whether high-income consumers (1.5 or more standard deviations above the mean) have a positive price coefficient. Column (3) tests whether consumers have a positive price coefficient when they first enroll in a tiered-network plan. Standard errors in parentheses, clustered by patient. Nadmits = number of choice sets (admissions).

Table A8—Hospital choice model (heterogeneity by condition type)

	(1) Chronic	(2) Obstetric
Hospital Choice		
Copay, with chronic condition ($1,000s)	0.0887	
	(0.0975)	
Copay (chronic) × std. income	0.3105	
	(0.0923)	
Copay, without chronic condition ($1,000s)	-0.3635	
	(0.0789)	
Copay (other) × std. income	0.1266	
	(0.0656)	
Copay, obstetric admissions ($1,000s)		-0.1392
		(0.0950)
Copay (obstetric) × std. income		0.0562
		(0.0829)
Copay, other admissions ($1,000s)		-0.2008
		(0.0839)
Copay (other) × std. income		0.2643
		(0.0701)
Hospital FEs	Yes	Yes
Pseudo R^2	0.606	0.605
Nadmits	29917	29917

Multinomial logit model of hospital choice. All copay coefficients scaled to $1,000s for ease of interpretation. Standard errors in parentheses, clustered by patient. Nadmits = number of choice sets (admissions).

TABLE A9—HOSPITAL CHOICE MODEL (ADMISSIONS THROUGH THE EMERGENCY DEPARTMENT)

	(1) ED sample
Hospital Choice	
Copay, with deferrable ED admission ($1,000s)	-0.4224
	(0.2289)
Copay (deferrable) × std. income	0.1285
	(0.2210)
Copay, with non-deferrable ED admission ($1,000s)	-0.4049
	(0.1627)
Copay (non-deferrable) × std. income	-0.1031
	(0.1514)
Distance (mi)	-0.2129
	(0.0084)
Distance^2	0.0009
	(0.0000)
Past use of hospital	3.4777
	(0.1144)
Hospital FEs	Yes
Pseudo R^2	0.660
Nadmits	5005

Multinomial logit model of hospital choice. All copay coefficients scaled to $1,000s for ease of interpretation. Standard errors in parentheses, clustered by patient. Nadmits = number of choice sets (admissions).

TABLE A10—HOSPITAL CHOICE MODEL (WITH CONTROL FUNCTION)

	(1) Pref. spec	(2) +IV sample	(3) IV deg1	(4) IV deg2	(5) IV deg3	(6) IV deg4	(7) IV deg5
Hospital Choice							
Copay ($1,000s)	-0.1953	-0.0403	-0.1580	-0.1445	-0.1899	-0.1576	-0.1899
	(0.0700)	(0.0892)	(0.0803)	(0.0800)	(0.0828)	(0.0839)	(0.0876)
Copay × std. income	0.1819	0.1961	0.2004	0.1987	0.1994	0.1975	0.1986
	(0.0535)	(0.0638)	(0.0694)	(0.0692)	(0.0692)	(0.0691)	(0.0692)
CF resid.			0.0007	0.0006	0.0016	0.0013	0.0020
			(0.0002)	(0.0002)	(0.0004)	(0.0005)	(0.0007)
(CF resid.)^2				-0.0000	-0.0000	-0.0000	-0.0000
				(0.0000)	(0.0000)	(0.0000)	(0.0000)
(CF resid.)^3					-0.0000	-0.0000	-0.0000
					(0.0000)	(0.0000)	(0.0000)
(CF resid.)^4						0.0000	0.0000
						(0.0000)	(0.0000)
(CF resid.)^5							0.0000
							(0.0000)
Distance (mi)	-0.1828	-0.1810	-0.1813	-0.1813	-0.1813	-0.1813	-0.1813
	(0.0028)	(0.0030)	(0.0023)	(0.0023)	(0.0023)	(0.0023)	(0.0023)
Distance^2	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Distance (mi) × Boston	-0.0763	-0.0766	-0.0762	-0.0762	-0.0761	-0.0762	-0.0762
	(0.0054)	(0.0058)	(0.0054)	(0.0054)	(0.0054)	(0.0054)	(0.0054)
Distance^2 × Boston	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Past use of hospital	4.6785	4.6166	3.7614	3.7623	3.7549	3.7577	3.7523
	(0.0625)	(0.0653)	(0.0436)	(0.0436)	(0.0438)	(0.0437)	(0.0432)
Hospital FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.625	0.630	0.611	0.611	0.611	0.611	0.611
Nadmits	29658	26319	26277	26277	26277	26277	26277

Nadmits = number of choice sets (admissions). All specifications estimated using multinomial logit.
Standard errors in parentheses, clustered by patient. IV columns estimated using a control function with boostrapped standard errors with 100 replications.

TABLE A11—HOSPITAL CHOICE MODEL WITH LEARNING

	(1) Enrolt. duration	(2) Enrolt. + time trend
Hospital Choice		
Copay × months enrolled	-0.0232	-0.0165
	(0.0041)	(0.0045)
Copay × left-censored enrolt.	0.0875	0.0644
	(0.1604)	(0.1613)
Copay × unknown enrolt.	-0.4069	-0.1278
	(0.1253)	(0.1491)
Copay × calendar months		-0.0172
		(0.0050)
Copay ($1,000s)	0.1950	0.5175
	(0.1103)	(0.1450)
Copay × std. income	0.1871	0.1963
	(0.0538)	(0.0541)
Hospital FEs	Yes	Yes
Pseudo R^2	0.625	0.625
Nadmits	29658	29658

Multinomial logit model of hospital choice. All copay coefficients scaled to $1,000s for ease of interpretation. Enrollment variables measure time since first enrolled in a tiered-network plan. Standard errors in parentheses, clustered by patient. Nadmits = number of choice sets (admissions).

Table A12—Own-price elasticities from hospital demand model (at median household income)

Hospitals	At observed copays	At $1,000 copays
Mean across hospitals in metro Boston	-0.052 (0.002)	-0.156 (0.006)
Mean across hospitals outside Boston	-0.037 (0.002)	-0.113 (0.006)
Metro Boston hospitals		
Beth Israel Deaconess Hospital - Milton	-0.044 (0.002)	-0.145 (0.005)
Beth Israel Deaconess Hospital - Needham	-0.055 (0.002)	-0.183 (0.007)
Beth Israel Deaconess Medical Center	-0.049 (0.002)	-0.131 (0.005)
Boston Medical Center	-0.045 (0.002)	-0.150 (0.005)
Brigham and Women's Faulkner Hospital	-0.061 (0.002)	-0.162 (0.006)
Brigham and Women's Hospital	-0.059 (0.002)	-0.124 (0.004)
Cambridge Health Alliance - Cambridge Campus	-0.043 (0.002)	-0.173 (0.006)
Cambridge Health Alliance - Somerville Campus	-0.048 (0.002)	-0.189 (0.007)
Cambridge Health Alliance - Whidden Campus	-0.048 (0.002)	-0.189 (0.007)
Lawrence Memorial Hospital	-0.054 (0.002)	-0.159 (0.006)
Massachusetts General Hospital	-0.063 (0.002)	-0.132 (0.005)
Melrose-Wakefield Hospital	-0.056 (0.002)	-0.149 (0.005)
Mount Auburn Hospital	-0.046 (0.002)	-0.136 (0.005)
Newton-Wellesley Hospital	-0.050 (0.002)	-0.147 (0.005)
Steward Carney Hospital	-0.047 (0.002)	-0.164 (0.006)
Steward St. Elizabeth's Medical Center	-0.063 (0.002)	-0.166 (0.006)
Tufts Medical Center	-0.052 (0.002)	-0.145 (0.005)

Own-price elasticities of demand for hospitals with respect to out-of-pocket price, calculated at the hospitals' observed copays and at a flat $1,000 copay, respectively. Standard errors in parentheses, calculated using 100 bootstrap replications.

Table A13—Cross-price elasticities from hospital demand model for select hospitals (at median household income)

	Brigham	MGH	Beth Israel	BMC	Cape Cod	Baystate	Cooley
Brigham and Women's Hospital	–	0.0057	0.0060	0.0012	0.0002	0.0001	0.0001
		(0.0002)	(0.0002)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Massachusetts General Hospital	0.0074	–	0.0050	0.0011	0.0003	0.0003	0.0002
	(0.0003)		(0.0002)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Beth Israel Deaconess Medical Center	0.0094	0.0061	–	0.0014	0.0002	0.0001	0.0001
	(0.0003)	(0.0002)		(0.0001)	(0.0000)	(0.0000)	(0.0000)
Boston Medical Center	0.0095	0.0068	0.0069	–	0.0002	0.0001	0.0001
	(0.0003)	(0.0002)	(0.0002)		(0.0000)	(0.0000)	(0.0000)
Cape Cod Hospital	0.0032	0.0037	0.0014	0.0003	–	0.0004	0.0003
	(0.0001)	(0.0001)	(0.0001)	(0.0000)		(0.0000)	(0.0000)
Baystate Medical Center	0.0003	0.0006	0.0001	0.0000	0.0001	–	0.0049
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)		(0.0002)
Cooley Dickinson Hospital	0.0006	0.0009	0.0002	0.0000	0.0001	0.0084	–
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0003)	

Coss-price elasticities of demand for row hospitals with respect to out-of-pocket price for column hospitals, calculated at the hospitals' observed copays. The first four (Brigham, MGH, Beth Israel, and BMC) are the key academic medical centers in Boston and are each other's closest substitutes. Cape Cod is geographically isolated in the eastern Massachussets and sends few patients to other hospitals. Baystate and Cooley are in western Massachusetts and compete with each other. All hospitals, even those outside Boston, are affected by prices at the flagship hospitals of the "star" Partners HealthCare system, Brigham and MGH. Standard errors in parentheses, calculated using 100 bootstrap replications.

Table A14—Enrollment in GIC plans

Plan	Share (%)	New policies	New enrollees	2009–2012 enrolt.
Fallon Direct	1.52	891	1,543	7,177
Fallon Select	3.78	1,286	2,684	11,167
Harvard Pilgrim Independence	36.42	16,358	36,444	96,103
Harvard Pilgrim Primary Choice	3.04	2,079	4,472	22,208
Health New England	9.54	3,443	6,451	29,312
Neighborhood Health Plan	1.71	924	1,645	7,552
Tufts Navigator	41.97	10,137	20,438	120,519
Tufts Spirit	1.16	1,228	2,577	13,775
UniCare Basic				
UniCare Community Choice				
UniCare PLUS				

GIC plan enrollment for employees and their dependents, excluding UniCare plans. Share is market share is at the end of fiscal year 2011 (June 2011). Enrollee and policy holder counts are for first-time GIC enrollees in 2009–June 2011. Final column is total number of unique enrollees in 2009–2012.

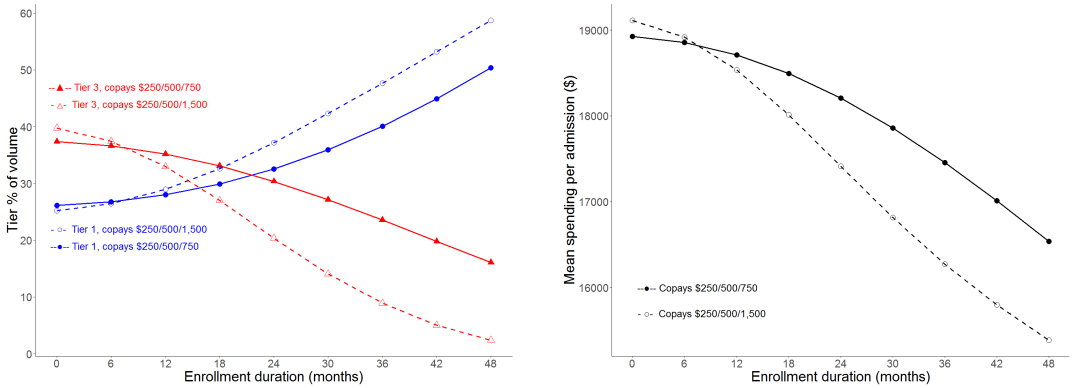
Appendix B: Data Preparation Details

Aggregation to the claim level: . — Like other medical claims databases, the unit of observation in the APCD is the claim line, which is the smallest unit of service for which an insurer or patient is billed separately from other units of service. A single hospital visit, for example, can have many claim lines for drugs, operating room supplies, anesthesia, and physician fees. In the analysis, I aggregate information across claim lines to the level of the hospital admission.

Identifying hospitals: . — The APCD includes provider identifiers as reported by insurers. An insurer typically uses multiple provider codes for each hospital, corresponding to various departments, facilities, or physician or nurse groups. I build a crosswalk between insurer-reported identifiers and a master list of hospitals using fuzzy matching on hospital names and addresses reported in the APCD. In addition, I conduct a final round of manual checks to correct errors and exclude mistakenly attributed onsite facilities or physician groups that are not involved in inpatient care. Insurers report identifiers for the service provider (where the patient is treated) and the billing provider (the business entity that submits the claim to the insurer); I use the service provider identifiers.

FIGURE A5. HOSPITAL SORTING WITH LEARNING (AT MEDIAN HOUSEHOLD INCOME)

(a) Fraction of patient volume in each tier (b) Mean total spending per admission



Projected hospital volumes and mean spending per admission over time using the learning estimates, using the Harvard Pilgrim Independence hospital network. Solid lines represent the plan's observed copay regime of $250, $500, and $750 for hospitals in tiers 1, 2, and 3, respectively. Dashed lines represent a regime where the copay for tier 3 is doubled from $750 to $1,500.

IDENTIFYING TIERED-NETWORK PLANS: . — The APCD includes insurer identifiers that can be mapped to names of Massachusetts insurers. In addition, it includes a variable indicating whether an insurance plan is a GIC plan. This indicator is defined correctly for most GIC plans, but fails to label as GIC-affiliated some plans whose characteristics and enrollment reveal them to be GIC plans. I label as GIC plans any plans offered by GIC insurers that match known GIC plan characteristics (networks and copays), share a large number of other GIC plans' enrollees across years, and have enrollment totals that match enrollments from the GIC. This procedure is sufficient to identify all GIC plans in the APCD and matches GIC enrollments within a small margin of error from the GIC's annual reports. For plans offered by HPHC and Tufts outside the GIC, I label as tiered any plan whose observed hospital copays are in round dollar amounts and match hospital tiers in those insurers' contemporaneous tiered networks.

DIAGNOSIS CLASSIFICATION: . — In the data, diagnoses and procedures are reported in the International Classification of Diseases, Clinical Modification (ICD-9) classification system, which consists of approximately 14,000 distinct diagnosis codes and 4,000 procedure codes. For each claim, the principal diagnosis is reported along with up to twelve secondary diagnoses. Similarly, for visits involving procedures, a principal procedure code is reported along with up to six secondary procedures. I assign diagnoses to diagnostic categories and severity levels using the Clinical Classifications Software (CCS) categorizations from the Agency for Healthcare Research and Quality. The CCS classification system assigns diagnosis codes to approximately 300 mutually exclusive diagnosis groups, which are

further aggregated into eighteen broad diagnostic categories. The CCS diagnostic categories are described and their prevalence in the Massachusetts nonelderly population given in Appendix Table A2.

Defining copays for unobserved alternatives: . — The APCD includes information on the out-of-pocket payment from the patient to the hospital. This information is sufficient to identify the copays for hospitals that consumers are observed to choose. To construct the copay vector for the other hospitals in a consumer's choice set, I assign each hospital to its corresponding tier in that insurer-year network. The copay corresponding to the tier is drawn from plan documentation (for GIC plans) or imputed tier copays (for plans outside the GIC).

Calculating distance:. — The APCD reports five-digit zip codes for patient home address. I geocode the patient zip codes and use them to calculate the driving distance from the centroid of the zip code to the hospital's full address. Driving distances are calculated using Bing Maps driving directions.

Appendix C: Additional Background

C1. History of Tiered Provider Networks

Plans with tiered provider networks were introduced in the early 2000s, as insurers sought new mechanisms for bolstering their bargaining power with respect to increasingly consolidated providers (Robinson, 2003; Sinaiko, 2012). Tiered networks allowed insurers to maintain some of the bargaining leverage associated with health maintenance organizations (HMOs), which used the threat of contract termination to drive down negotiated prices but which experienced a backlash of public opinion in the 1990s (Cutler, McClellan and Newhouse, 2000; Town and Vistnes, 2001; Ho, 2009). Detractors argued that HMOs' savings came at the expense of patient choice, access to care, and continuity of care (Martin, 2014).

Tiered provider networks combine the cost control mechanisms of narrow networks with patient choice and explicit price information for consumers. In a tiered network, almost all providers in the market remain in the consumer's choice set, but a higher out-of-pocket price is associated with the use of higher-priced providers. Providers are placed into non-overlapping groups, or *tiers*, that determine consumers' out-of-pocket prices for treatment. The out-of-pocket price faced by enrollees is then constant among providers within a tier, but varies across tiers. Throughout the paper, I distinguish between the out-of-pocket price faced by insured consumers and the full price negotiated between providers and insurers, which I call simply "price".

Advocates of tiered networks argue that they reduce health care spending through two mechanisms: the direct effect of steering consumers toward lower-priced providers (Sinaiko, 2012), and an indirect effect on prices (Fronstin, 2003; Robinson, 2003). If consumers indeed respond to the incentives in tiered provider networks, then non-preferred tier placement becomes an additional bargaining lever that insurers can use in price negotiations with providers. The usefulness of tiered networks as a bargaining chip for insurers therefore hinges on consumer responsiveness to out-of-pocket prices in tiered networks.

Since their introduction in the early 2000s, the penetration of tiered-network plan designs has continued to rise. Health care system experts, insurers and employers increasingly see the use of tiered networks and other value-based plan designs as integral to cost control (Robinson, 2003; KFF, 2014). Among the highest-enrollment health plans offered by very large employers, 38 percent of the highest-enrollment health plans now include a tiered provider network, with 54 percent of all employers expecting tiered networks to be a very effective or somewhat effective measure for health care cost reduction (KFF, 2014, 2015, 2016). On the Affordable Care Act insurance marketplaces, 5–6 percent of plans each year have used tiered networks (McKinsey, 2016), yet these plans accounted for a disproportionate 14 percent of enrollment in 2015 (HHS, 2016). Multiple states expect growth in tiered-network plans (KFF, 2014; McKinsey, 2015; KFF, 2015); moreover, some states have been directly involved in promoting the adoption of tiered provider networks.

C2. The Massachusetts Health Care Market

In 2006, Massachusetts passed a landmark health care overhaul which aimed to expand health insurance coverage and access to care. The Massachusetts reform subsequently served as the blueprint for the federal Patient Protection and Affordable Care Act (ACA) passed in 2010. Although the 2006 legislation succeeded in broadening insurance coverage in Massachusetts, policymakers remained concerned about the state's high overall health care spending. Not only was the state's per capita health care spending 15 percent higher than the national average, driven largely by high hospital spending, it had also grown faster than national health care spending since 2002 (DHCFP, 2010). Based on recommendations by the Massachusetts Division of Health Care Finance and Policy, the state implemented additional reforms aimed at measuring and reducing health care spending in 2010 and again in 2012 (Massachusetts, 2010, 2012*a*; Wrobel, Auerbach and Sadownik, 2014; CHIA, 2015*a*). These reforms included, among other provisions,[34] the creation of the All-Payer Claims Database used in this paper and requirements for insurers to offer value-based insurance designs (DHCFP, 2010).

[34]Other notable pieces of the legislation consisted of health care price transparency requirements and the encouragement of vertical integration between providers in the form accountable care organizations (created under the moniker "Alternative Quality Contract" (Song et al., 2012)).

Since 2011, Massachusetts legislation has required all large insurers to offer at least one narrow- or tiered-network plan in at least one geographic area (Massachusetts, 2010). The regulation does not require insurers to offer tiered-network plans; they may instead offer narrow-network plans. However, all three of the state's largest insurers—Blue Cross Blue Shield of Massachusetts, Harvard Pilgrim Health Care, and Tufts Health Plan—have offered both tiered- and narrow-network plans since before the regulation went into effect in 2011. These insurers now have 10–35 percent of their commercial enrollees in tiered-network plans. State regulation also outlines a method for insurers to calculate comparable prices across providers by adjusting for disease and patient mix; insurers are required to report these prices to the state's Center for Health Information and Analysis (CHIA) and are expected to use them for determining providers' network status.

Outside of state legislation, the push toward tiered networks in Massachusetts has been led by the Massachusetts Group Insurance Commission (GIC), which administers health insurance and other benefits for state and municipal employees, retirees, and their dependents.[35] The GIC insures some 300,000–350,000 individuals per year throughout my sample period, corresponding to approximately 8 percent of the total commercially insured population in Massachusetts. The volume of covered lives on the GIC, along with the substantial fraction of the state budget devoted to it, makes the GIC an important and active player in the Massachusetts health insurance landscape (DHCFP, 2010; Wrobel, Auerbach and Sadownik, 2014). The GIC was among the earliest adopters of tiered provider networks, introducing its first tiered hospital network plan in July 2003 and rolling out tiered physician networks in July 2006 (GIC, 2008, 2009).

Massachusetts requires insurers operating tiered-network plans to "clearly and conspicuously indicate" consumers' out-of-pocket prices for each tier (Massachusetts, 2012*b*). Insurers provide this information to enrollees as part of the schedule of benefits documentation for each plan. At the insurer level, they also publish lists of hospitals and their network tiers each year, which can be easily accessed through their websites for the current year. These lists include each hospital's tier, so consumers do not need to search for multiple providers' network status in order to comparison-shop. This is in contrast to the difficulty of learning out-of-pocket prices for hospital care in advance in traditional plan types: even savvy consumers who ask for price quotes typically get poor response rates (Bebinger, 2014).

C3. The Massachusetts Group Insurance Commission

The Massachusetts Group Insurance Commission (GIC) is the benefits administrator for the state of Massachusetts, some municipalities, and a number of other public entities. It insures some 300,000–350,000 people per year during my sam-

[35]This is the same employer group studied by Gruber and McKnight (2016) in evaluating the impact of narrow networks and by Sinaiko and Rosenthal (2014) in studying patient response to physician tiering.

ple period, consisting of GIC-covered employees, retirees, and their dependents. My sample of GIC enrollees observed in the APCD includes approximately 90,000 state and municipal employees and 120,000 dependents. The remaining individuals insured through the GIC are retired government employees and their surviving spouses. The demographic characteristics for the GIC enrollees in my sample are shown in Table C1. Approximately 60 percent of primary enrollees insure their dependents as well. The majority of the primary enrollees live in the Boston area or elsewhere in eastern Massachusetts. Approximately half of the enrollees are first observed in the GIC prior to the start of the medical claims data in 2009. The remaining individuals insured through the GIC are retired government employees and their surviving spouses.

The demographic characteristics for the GIC enrollees in my sample are shown in Table C1. Approximately 60 percent of primary enrollees insure their dependents as well. The majority of the primary enrollees live in the Boston area or elsewhere in eastern Massachusetts. Approximately half of the enrollees are first observed in the GIC prior to the start of the medical claims data in 2009.

Table C1—Characteristics of GIC health insurance enrollees

	Individuals	Families
% of households	39.5	60.5
% of total enrollment	17.8	82.2
Median family size	1	3
Mean family size	1	3.2
% female	59.5	50.3
Mean age	48.1	35.7
Median age	49	39
% entering before 2009	47.3	56.2
% Western Mass.	19.8	18.2
% Central Mass.	12.2	13.1
% Northeast Mass.	28.1	29.4
% Metro Boston	25.4	20
% Southeast Mass.	14.6	19.3

Summary statistics for Massachusetts Group Insurance Commission (GIC) health insurance enrollees. Column 1 is single enrollees; column 2 is enrollees with dependents. 60% of enrolled households include dependents, who are typically younger than primary enrollees. Approximately half of households are enrolled in the GIC prior to the start of the data in 2009.

I use data on the GIC's health plan offerings, premiums, and plan characteristics

such as deductibles for GIC fiscal years 2009–2011, which cover the calendar period July 2008–June 2012.[36] The plan offerings and their premiums for a sample enrollment year are described in Table 1. The employee portion of premium contributions is 25 percent of the total premium.[37] Two levels of premiums are set for each plan: one for individual coverage and another for family coverage (defined as two or more enrollees), with no variation in these two premium amounts across the entire state for each fiscal year. Plan characteristics, such as out-of-pocket prices and hospital networks, change over time. Plans on the GIC use copays, which are fixed dollar amounts paid out-of-pocket by consumers when they use health care. For example, inpatient copays in the Harvard Pilgrim Independence plan start at a flat $300 per admission in fiscal year 2009, move to a tiered structure of $250/$500/$750 across the three hospital tiers in 2010, and increase to $275/$500/$1,500 in 2016.

Plans on the GIC market are fairly standardized: deductible levels, prescription drug copays, and some other plan characteristics vary little or not at all across plans within a fiscal year. This type of standardization is found in many health insurance markets, including Medigap, state health insurance exchanges, and large employers (Starc, 2014; Ericson and Starc, 2015; Handel, 2013). Such markets can shed light on plan competition on the health insurance exchanges set up under the Affordable Care Act. The primary differences between plans on the GIC come from the insurer brands, provider networks, and copay structures for physician and hospital care.

[36]Data from July 2012 onward excluded because the GIC implemented a premium discount program that affected employees differently depending on characteristics I do not observe in the APCD (Gruber and McKnight, 2016). The plan demand analysis therefore relies on GIC data through June 2012.

[37]Employees hired prior to July 2003 only pay 20 percent of the total premium cost. In the analyses, I therefore exclude GIC enrollees who were enrolled prior to 2007 (the earliest enrollment data in the APCD) in order to reduce noise in premium measurement.