Price Spillovers and Specialization in Health Care: The Case of Children's Hospitals
SUPPLEMENTAL ONLINE APPENDIX

In this appendix, we present results for several alternative regression specifications and samples, along with details of our dataset construction and procedure codes.

1 Construction of Dataset

Table 1 lists our procedures of interest and the CPT/ICD-9 codes used to identify these procedures in the data. Table 2 similarly lists the different categories and codes that we define as a "complication" in the data. We also consider readmission and mortality rates, all of which are infrequent as discussed in the main text.

We have access to the HCCI data over the period from January 2010 through October 2015. Over this time, we observe around 13 million inpatient claims and 55 million outpatient claims. After limiting to pediatric cases and aggregating the claims to the visit level, our data consist of around 460,000 inpatient stays and 3 million outpatient visits. Finally, after excluding newborns and focusing only on "routine procedures," our final analytic data consist of nearly 32,000 inpatient stays and 336,000 outpatient visits. A more detailed breakdown of our data is presented in Tables 3 and 4.

2 Alternative Specifications and Estimators

2.1 Results from Different Estimators

Our preferred estimator is that proposed in Callaway & Sant'Anna (2021), as discussed in the main text; however, we employ a residualized version of this estimator to better accommodate the

nature of our claims-level data. Since this is a slight modification of Callaway & Sant'Anna (2021), we present results from alternative estimators and specifications here:

1. Sun & Abraham (2021): We present regression results from the Sun and Abraham estimator, which is akin to a standard event study with heterogeneous event study coefficients for each treatment cohort. These results are presented in Figures 1-2. The results for CH entry in Figure 1 are similar to our initial findings; however, the Sun and Abraham estimator also suggests a negative effect of entry of NCH, particularly on other NCH prices (Figure 2).

2. Standard event study: We present standard event study graphs in Figures 3 and 4. These figures closely resemble those from the Sun and Abraham estimator.

3. Additional Callaway & Sant'Anna (2021) estimates: We consider an alternative first-step adjustment in which we residualize prices only using time-invariant fixed effects for procedure, hospital, location of procedure, and time. The goal of this analysis is to consider the sensitivity of our results to concerns regarding time-varying controls which may be directly affected by treatment. These results are presented in Figures 5 and 6 and closely match the baseline results in the main text.

2.2 Determination of Entry Events

Our results in the main paper identify CH and NCH entry simply by the emergence of routine pediatric claims in the data, without any minimum threshold for such claims per hospital. In this section, we consider the sensitivity of our results by imposing a minimum of 5 and 10 pediatric claims when defining entry.

Results based on a minimum of 5 claims are presented in Figures 7-10. Figures 7 and 8 describe our entry events over time under a minimum entry threshold of 5 claims, and Figures 9 and 10 present the dynamic treatment effect results analogous to those in the main text. Results based on a minimum of 10 claims are presented in Figures 11-14. Figures 11 and 12 again describe our entry events over time under a minimum entry threshold of 10 claims, and Figures 13 and 14 present the dynamic treatment effect results analogous to those in the main text.

Figures 9-14 further support our takeaways from the main text — CH are sufficiently differentiated such that they are largely unaffected by additional NCH competitors. Price competition instead arises only from other CH.

References

Callaway, Brantly, & Sant'Anna, Pedro H. C. 2021. Difference-in-Differences with multiple time periods. *Journal of Econometrics*, **225**(2), 200–230.

Sun, Liyang, & Abraham, Sarah. 2021. Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. *Journal of Econometrics*, **225**(2), 175–199.

Tables and Figures

Table 1: **Procedures and Codes**

Description	CPT Codes	ICD-9 Procedure Code
Routine Procedures		
Ear Tubes	69420, 69421, 69433, 69436	200, 2001, 2009
Tonsillectomy	42820, 42821, 42825, 42826, 42830, 42831, 42835, 42836	282, 283, 286
Appendectomy	44950, 44960, 44970	470, 4701, 4709
Inguinal Hernia	49491, 49492, 49495, 49496, 49500, 49501, 49505, 49507, 49520, 49521, 49525, 49529, 49595, 49650	171, 172, 530, 531
Circumcision	54150, 54160, 54161	640
Strabismus	67311, 67312, 67314, 67316, 67318	1511, 1512, 1513, 152, 1521, 1522, 154
Broken Arm	24500, 24505, 24515, 24516, 24530, 24535, 24538, 24545, 24546, 24560, 24565, 24566, 24575, 24576, 24577, 24579, 24582	7901, 7911, 7921, 7931
Umbilical Hernia	49570, 49572, 49580, 49582, 49585, 49587	534, 5342, 5349, 5441
Orchiopexy	54560, 54640, 54650, 54692	625
Spine	22800, 22802, 22804	810, 8100, 8103, 8105, 8108
Anti-Reflux	43280, 43327, 43328	4466, 4467
Knee Arthroscopy	27332, 27333, 29879, 29880, 29881, 29882, 29883, 29888	8006, 8016, 8026, 8036, 8046, 806, 8076, 8086, 8096, 8122, 8142, 8143, 8144, 8146, 8147
Gallbladder Removal	47562, 47563, 47564	5123

Table 2: **Codes for Selected Complications**

Description	ICD-9 Diagnosis Code
Wound Complications	99883, 99812, 99813, 9983, 9986
Superficial SSI	99832, 9985, 99851, 99859
Deep/organ SSI	99831, 56722, 99859
UTI	5990, 99664
Post-operative Renal Insufficiency	584*, 586*
Pneumonia	480*, 482*, 483*, 481, 484, 485, 486, 4870, 99731
Respiratory Failure	5185, 51882
Sepsis	038*, 78552, 7907, 99591, 9980
Deep Vein Thrombosis	4534*, 4539
Pulmonary Embolism	4151, 41519
Myocardial Infarction	4100*, 4101*
Cardiac Arrest	4275
Cerebrovascular Accident	99702
Intraoperative Complications	99811, 9982, 9984
System-specific Complications	9971 (cardiac), 9974 (GI), 9975 (Urinary)

Table 3: **Inpatient Claims Breakdown**

	2010	2011	2012	2013	2014	2015	Total
Full claims:							
All Conditions	2,625,146	2,487,174	2,472,447	2,298,198	1,967,087	1,440,078	13,290,130
Pediatric Only	975,257	943,603	951,983	903,378	809,319	575,078	5,158,618
With NPI	894,521	858,559	860,467	815,349	786,070	568,557	4,783,523
With Type of Bill[a]	891,490	855,238	856,870	811,727	781,999	566,710	4,764,034
Aggregate to Unique Visits:							
Unique admits[b]	81,344	84,153	82,293	79,648	77,906	56,325	461,669
Within 180 miles	78,573	81,711	80,079	77,574	75,608	54,800	448,345
Excluding transfers	78,129	81,312	79,629	77,189	75,180	54,496	445,935
Excluding outliers[c]	71,311	74,135	73,345	71,182	69,178	50,064	409,215
Specific Exclusions:							
Excluding Newborns	19,824	21,359	20,633	18,446	17,146	13,904	111,312
Excluding Missing HNPIs[d]	19,587	21,119	20,399	18,175	15,801	12,735	107,816
Routine procedure	7,141	6,429	5,958	4,932	4,334	2,929	31,723

[a]Claims limited to type of bill listed as "inpatient," "non-medical hospital," or "critical access hospital."

[b]Denotes claims aggregated to a single inpatient visit.

[c]Defined as visits with allowed amount/charge payment ratios below the 5th or above the 9th percentile.

[d]HNPI refers to a "consolidated NPI" provided by HCCI, which is intuitively similar to an AHA ID.

Table 4: **Outpatient Claims Breakdown**

	2010	2011	2012	2013	2014	2015	Total
Full claims:							
All Conditions	8,424,848	9,304,755	9,761,181	9,778,564	9,058,887	8,320,846	54,649,081
Pediatric Only	2,786,359	3,049,836	3,171,140	3,142,754	2,875,340	2,694,525	17,719,954
With NPI	2,509,104	2,732,981	2,820,214	2,795,720	2,798,139	2,653,435	16,309,593
With Type of Bill[a]	1,353,283	2,024,754	2,750,845	2,721,227	2,720,499	2,588,237	14,158,845
Aggregate to Unique Visits:							
Unique admits[b]	287,806	443,624	610,644	600,505	599,372	549,476	3,091,427
Within 180 miles	266,355	421,934	588,294	578,435	576,198	530,341	2,961,557
Excluding outliers[c]	239,721	394,904	551,740	542,662	540,514	498,343	2,767,884
Specific Exclusions:							
Matching IP NPI[d]	233,923	385,444	537,644	528,522	524,733	483,404	2,693,670
Excluding Missing HNPIs[e]	207,838	349,294	488,715	481,702	450,180	408,463	2,386,192
Routine procedure	39,855	51,748	65,772	62,234	57,333	59,555	336,497

[a]Claims limited to type of bill listed as "hospital outpatient," "ambulatory surgery center," or "critical access hospital."

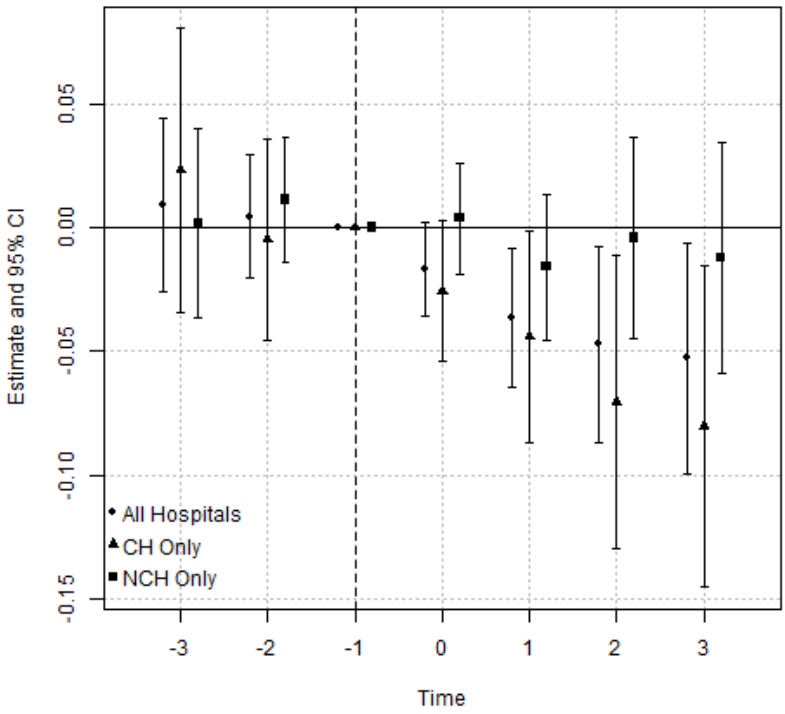
[b]Denotes claims aggregated to a single outpatient visit.

[c]Defined as visits with allowed amount/charge payment ratios below the 5th or above the 9th percentile.

[d]Our CH versus NCH designation excludes outpatient facilities that are not connected to a larger inpatient hospital. We therefore excluded all outpatient visits that cannot be matched to an NPI from the set of hospitals in the inpatient claims.

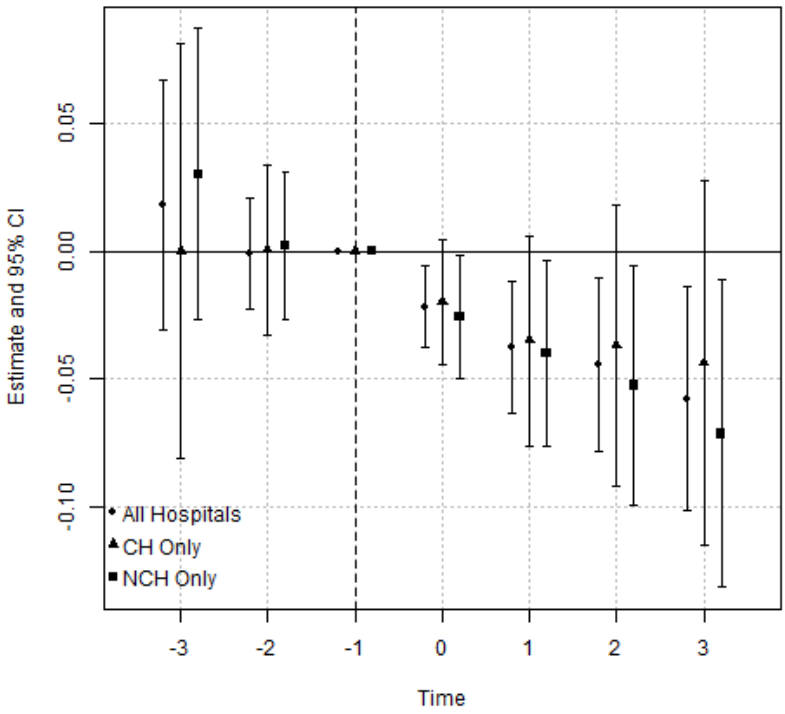
[e]HNPI refers to a "consolidated NPI" provided by HCCI, which is intuitively similar to an AHA ID.

Figure 1: **CH Entry Effects with SA Estimator**[a]



[a]Dynamic treatment effects estimated using Sun & Abraham (2021).

Figure 2: **NCH Entry Effects with SA Estimator**[a]



[a]Dynamic treatment effects estimated using Sun & Abraham (2021)

Figure 3: **CH Entry Effects with Standard Event Study**

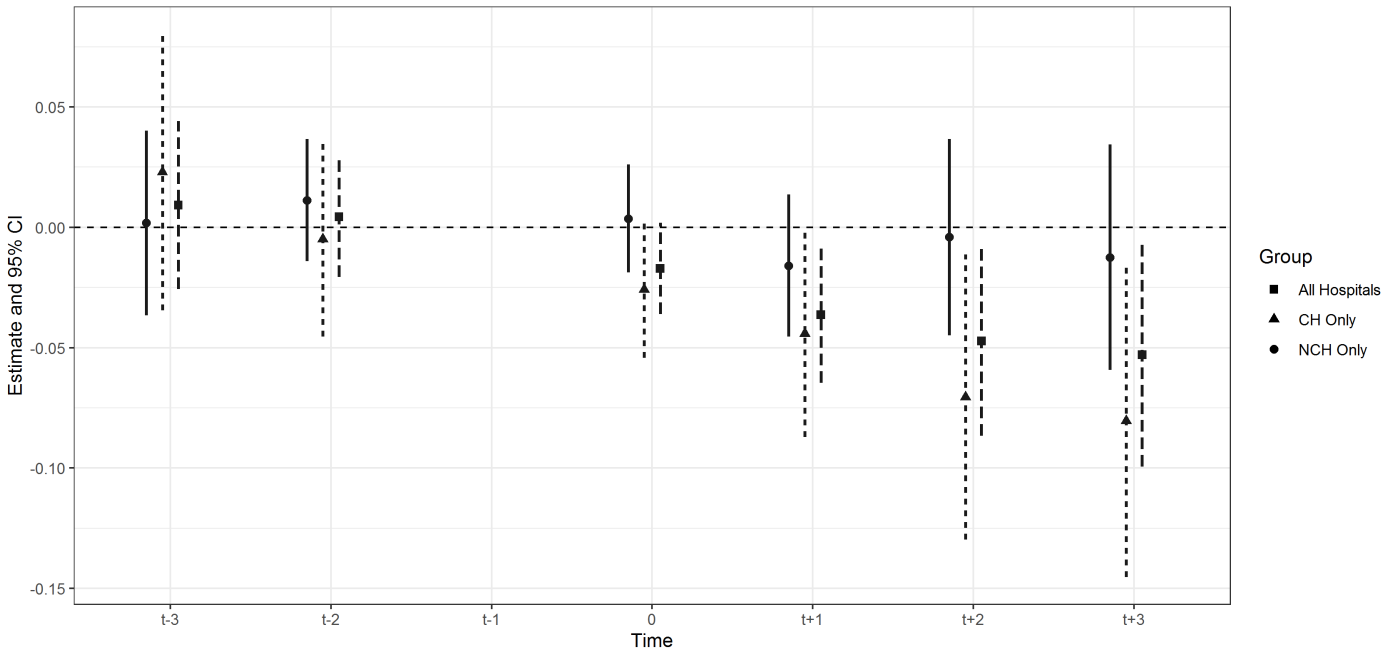


Figure 4: **NCH Entry Effects with Standard Event Study**

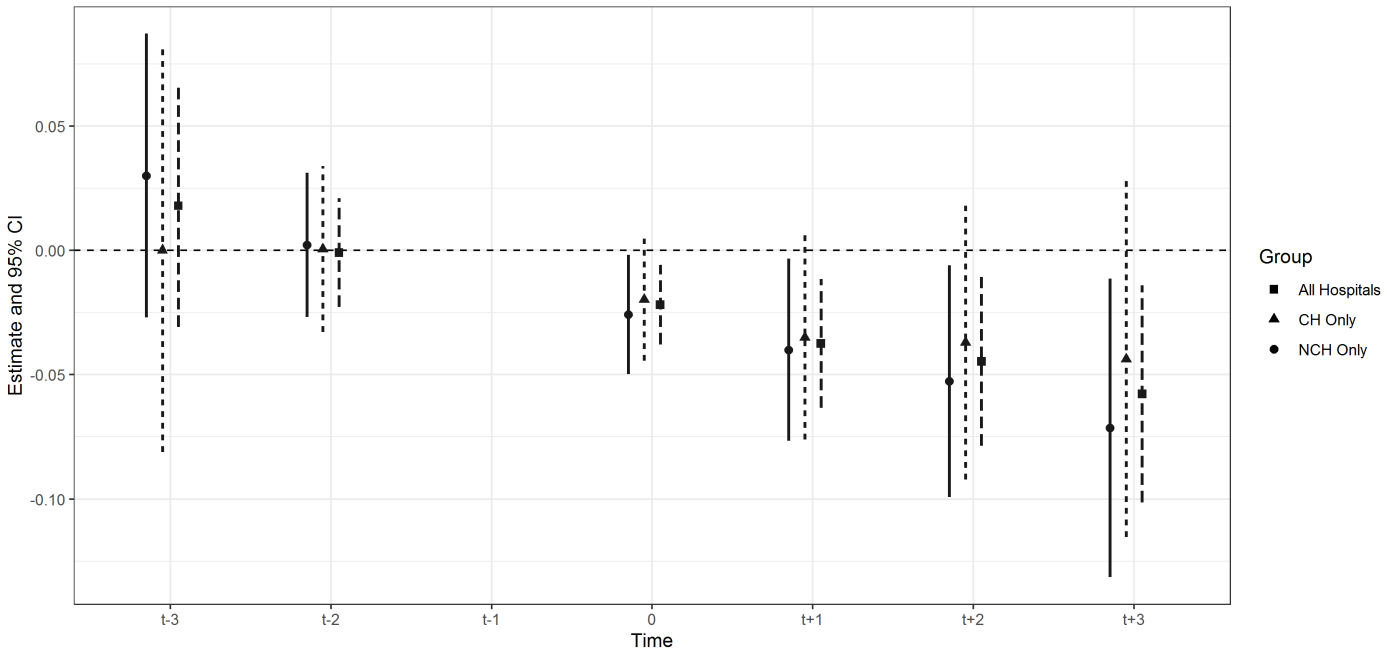


Figure 5: **CH Entry Effects Excluding Time-varying Controls**

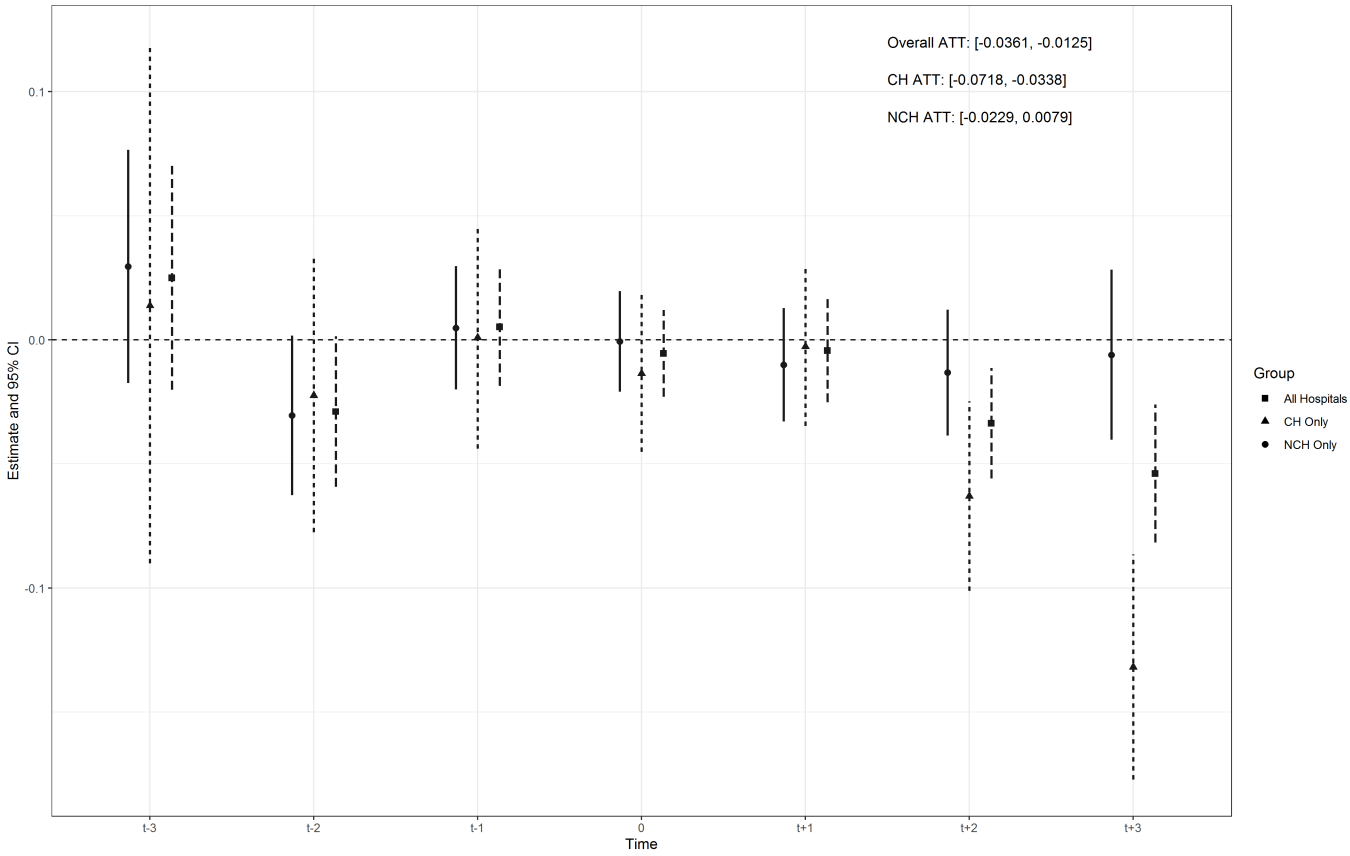


Figure 6: **NCH Entry Effects Excluding Time-varying Controls**

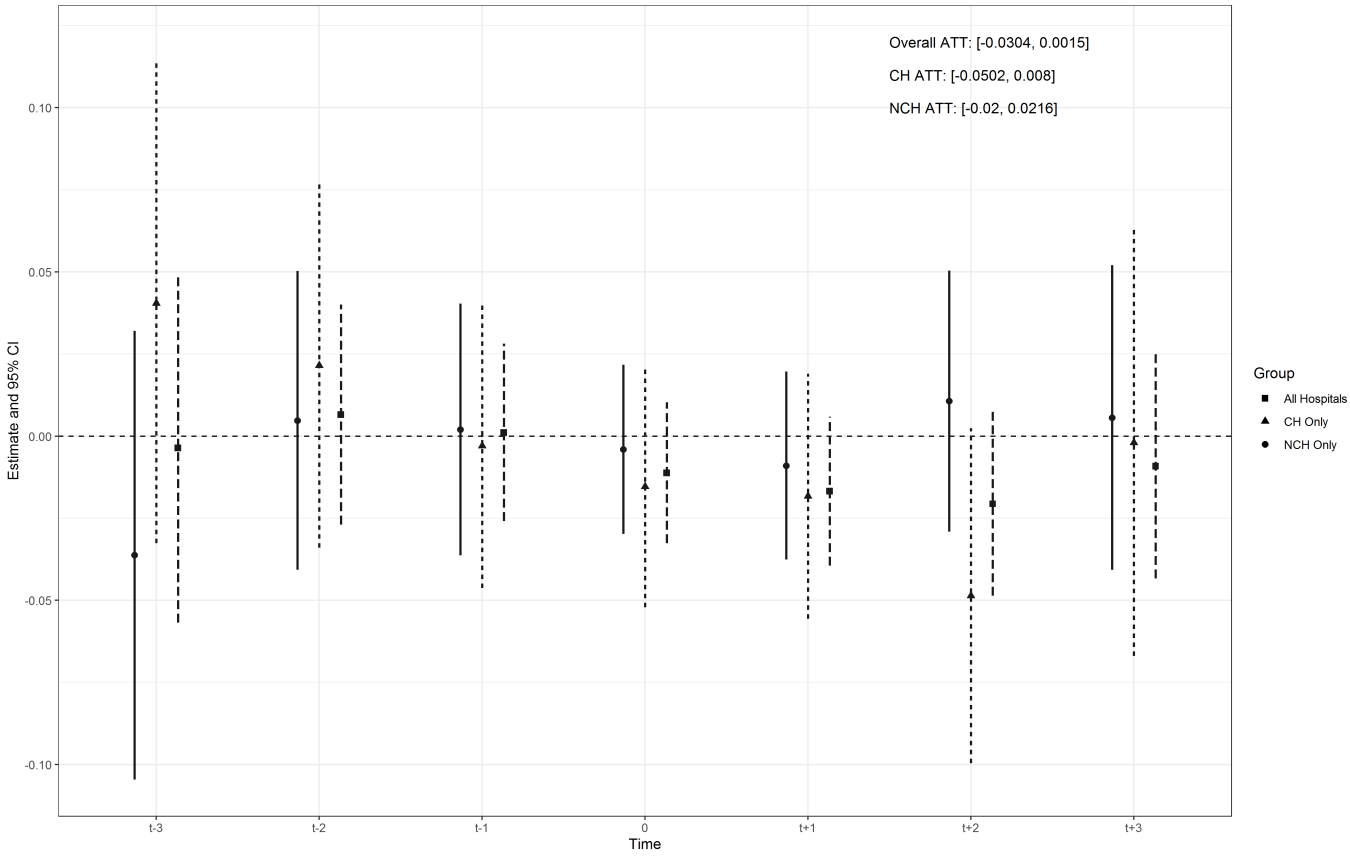
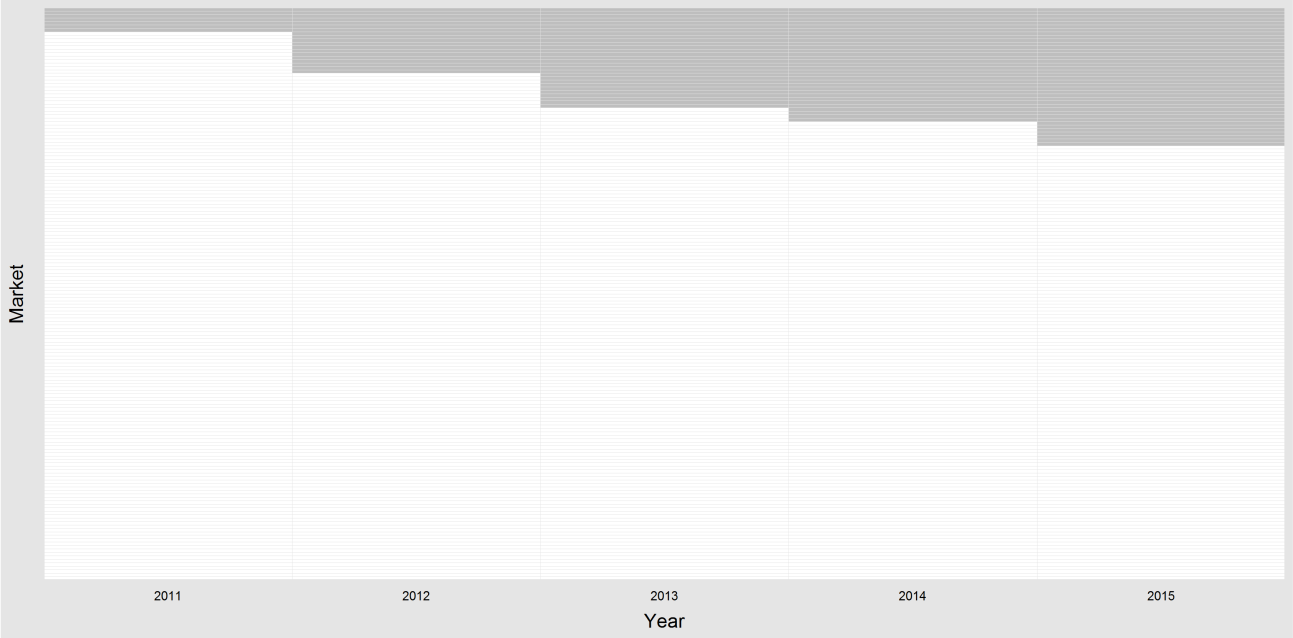
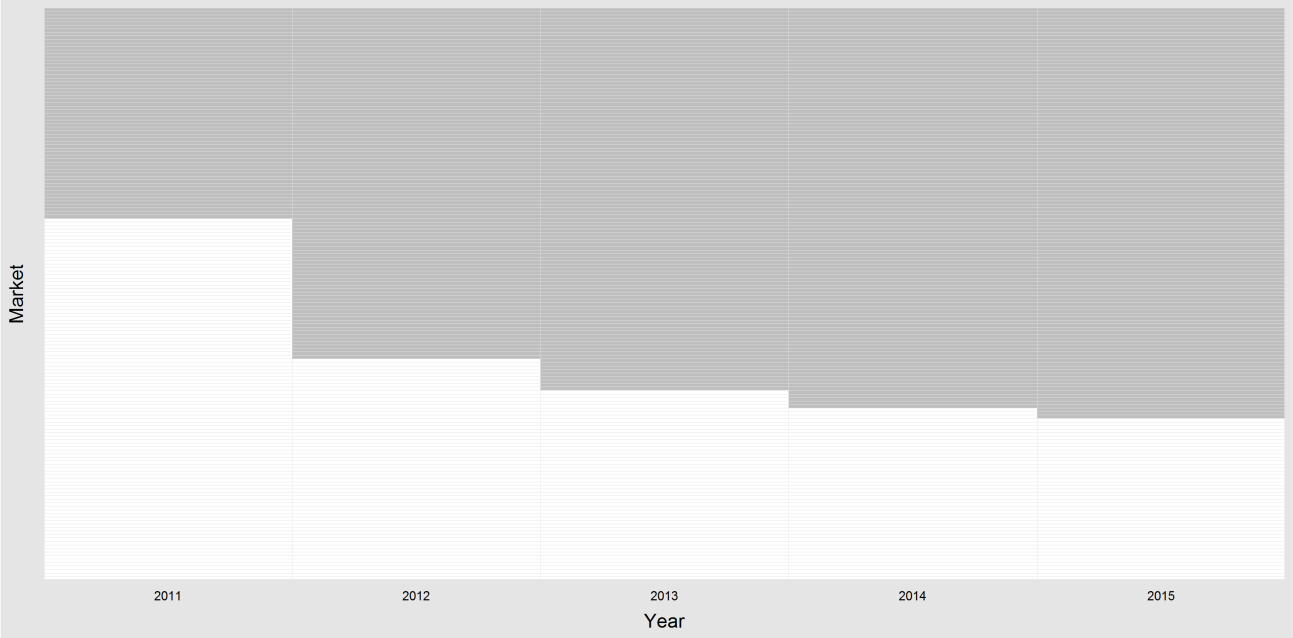


Figure 7: **CH Entry Events with Minimum 5-claim Threshold**[a]



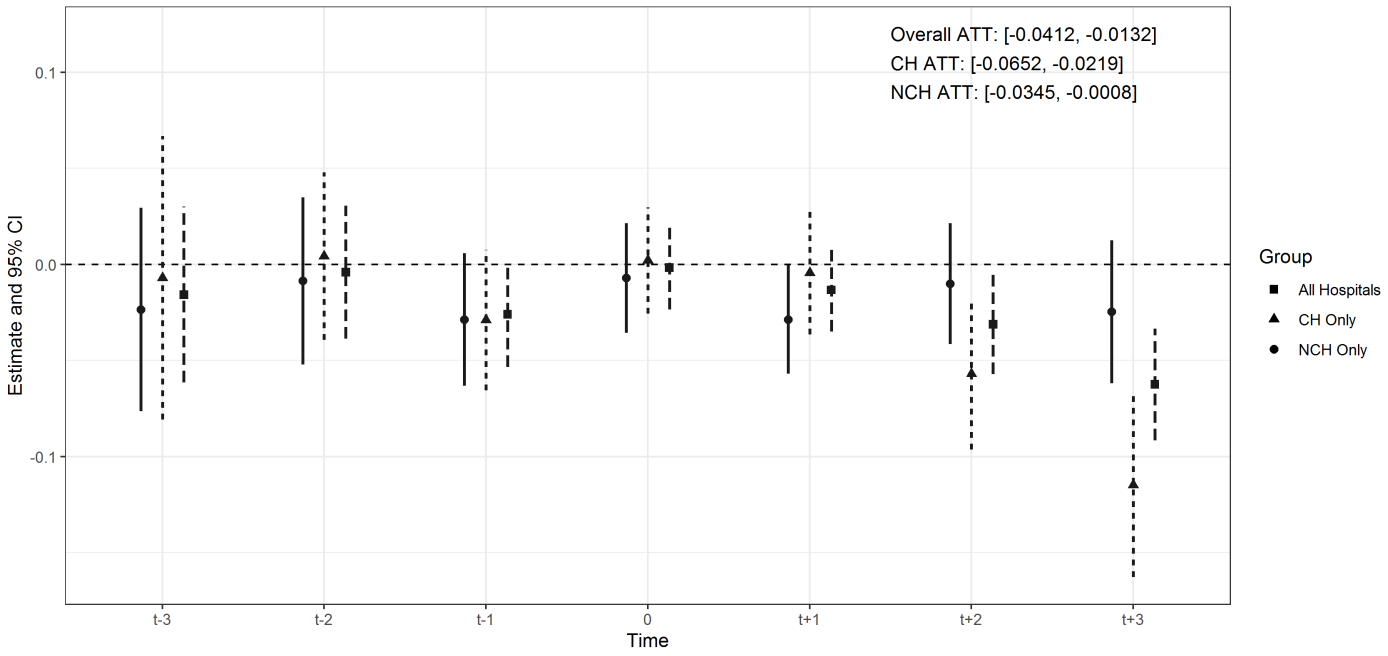
[a]Shaded markets reflect those experiencing entry of a new CH in the data, with entry defined and discussed in the main text.

Figure 8: **NCH Entry Events with Minimum 5-claim Threshold**[a]



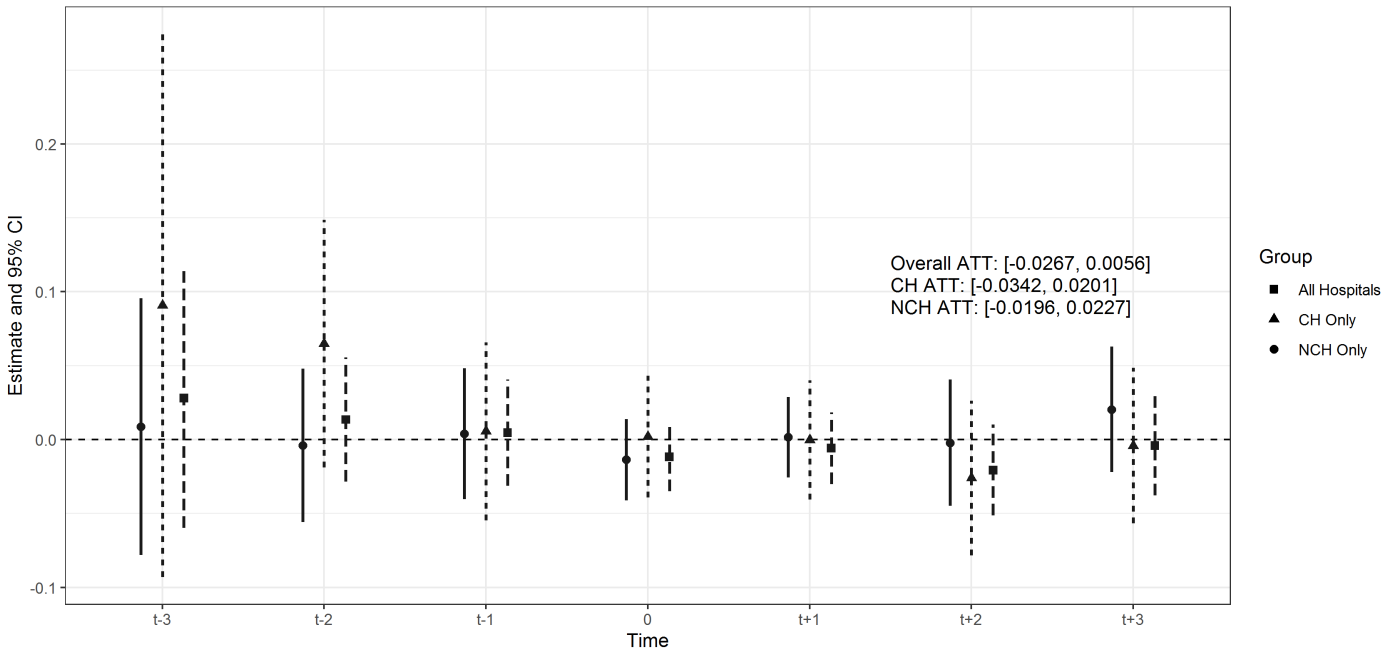
[a]Depiction of markets experiencing an entry of a non-children's hospital over time, where "entry" requires a hospital to have had at least 5 routine pediatric claims following a year in which we observed 0 such claims. Shaded markets reflect those experiencing entry.

Figure 9: **CH Entry Effects with Minimum 5-claim Threshold**[a]



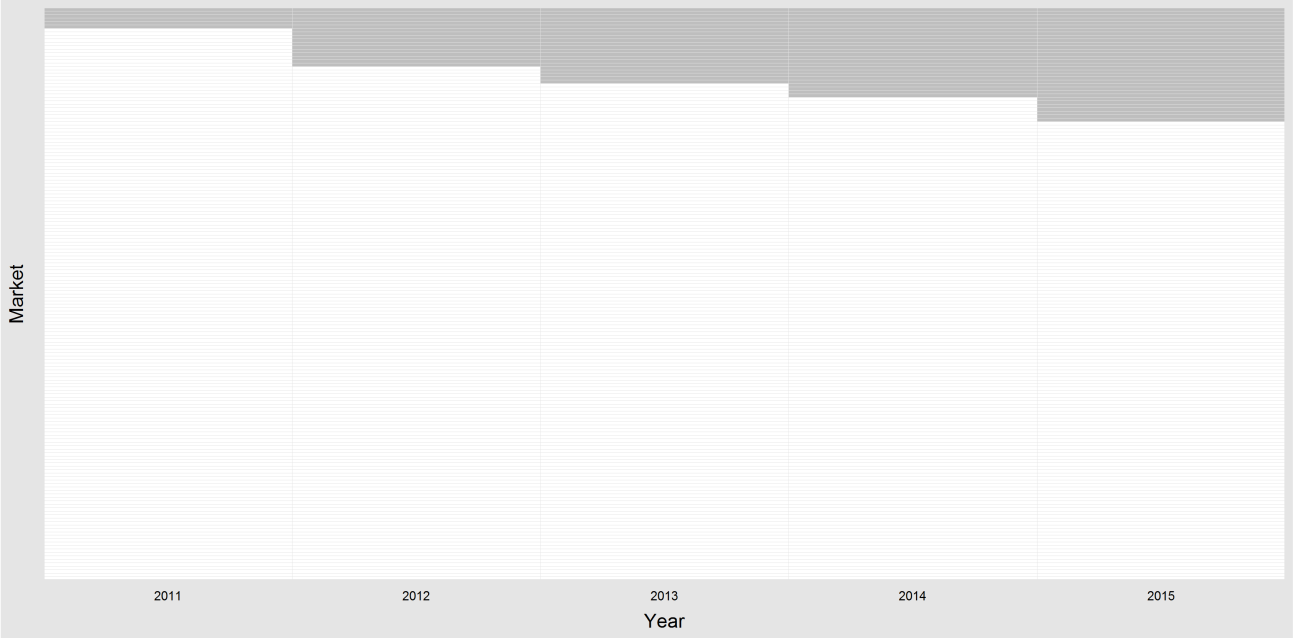
[a]Estimated treatment effects on price from entry of children's hospitals using a 10-claim threshold for identifying entry events. Dynamic treatment effects estimated using Callaway & Sant'Anna (2021), with our residualized price outcome as described in the main text.

Figure 10: **NCH Entry Effects with Minimum 5-claim Threshold**[a]



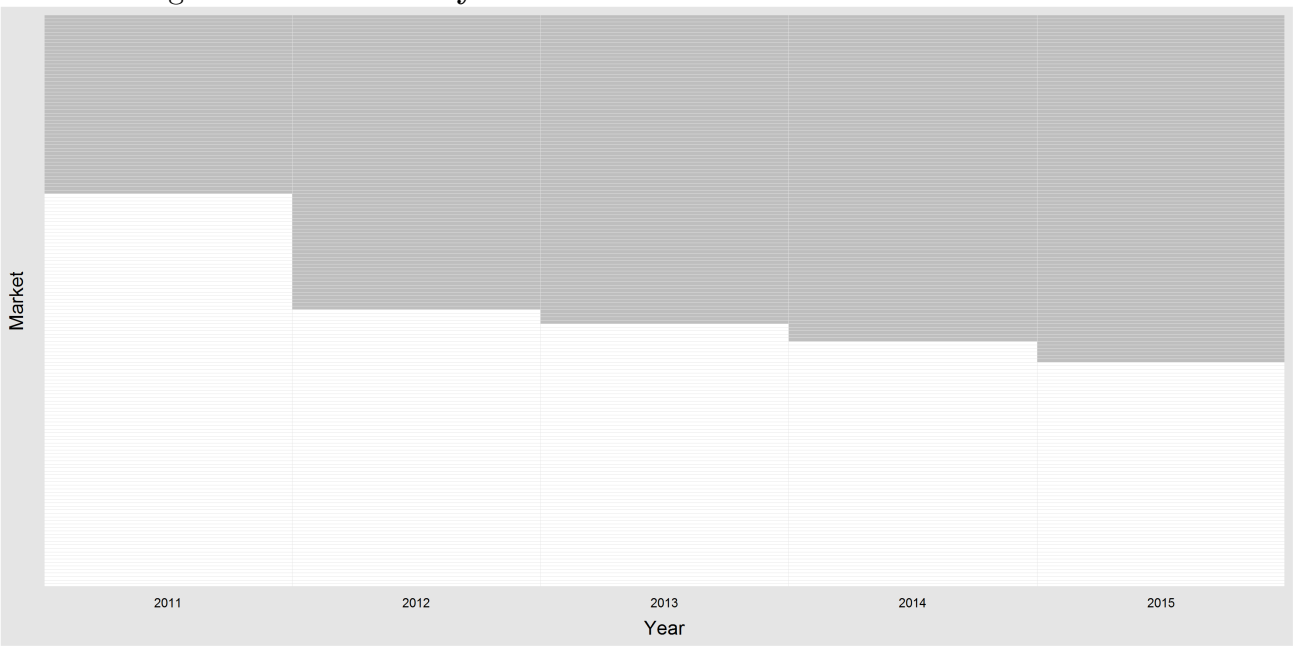
[a]Estimated treatment effects on price from entry of non-children's hospitals using a 5-claim threshold for identifying entry events. Dynamic treatment effects estimated using Callaway & Sant'Anna (2021), with our residualized price outcome as described in the main text.

Figure 11: **CH Entry Events with Minimum 10-claim Threshold**[a]



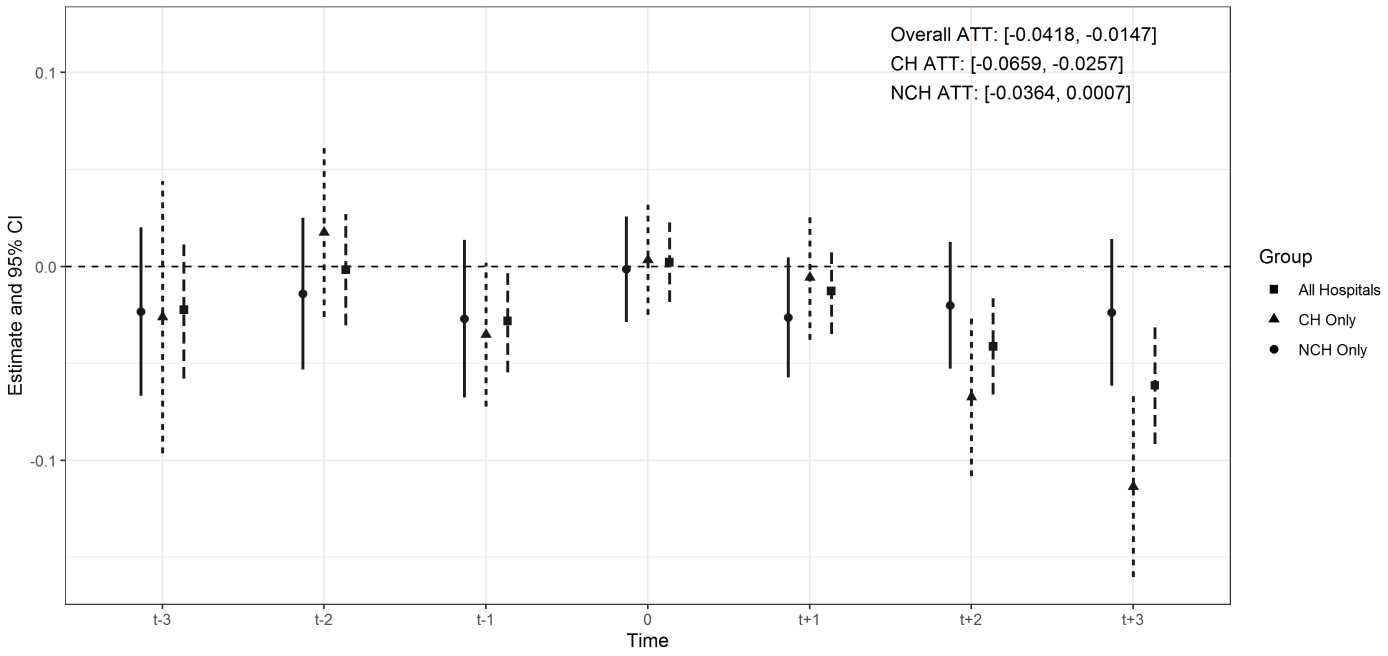
[a]Depiction of markets experiencing an entry of a children's hospital over time, where "entry" requires a hospital to have had at least 10 routine pediatric claims following a year in which we observed 0 such claims. Shaded markets reflect those experiencing entry.

Figure 12: **NCH Entry Events with Minimum 10-claim Threshold**[a]



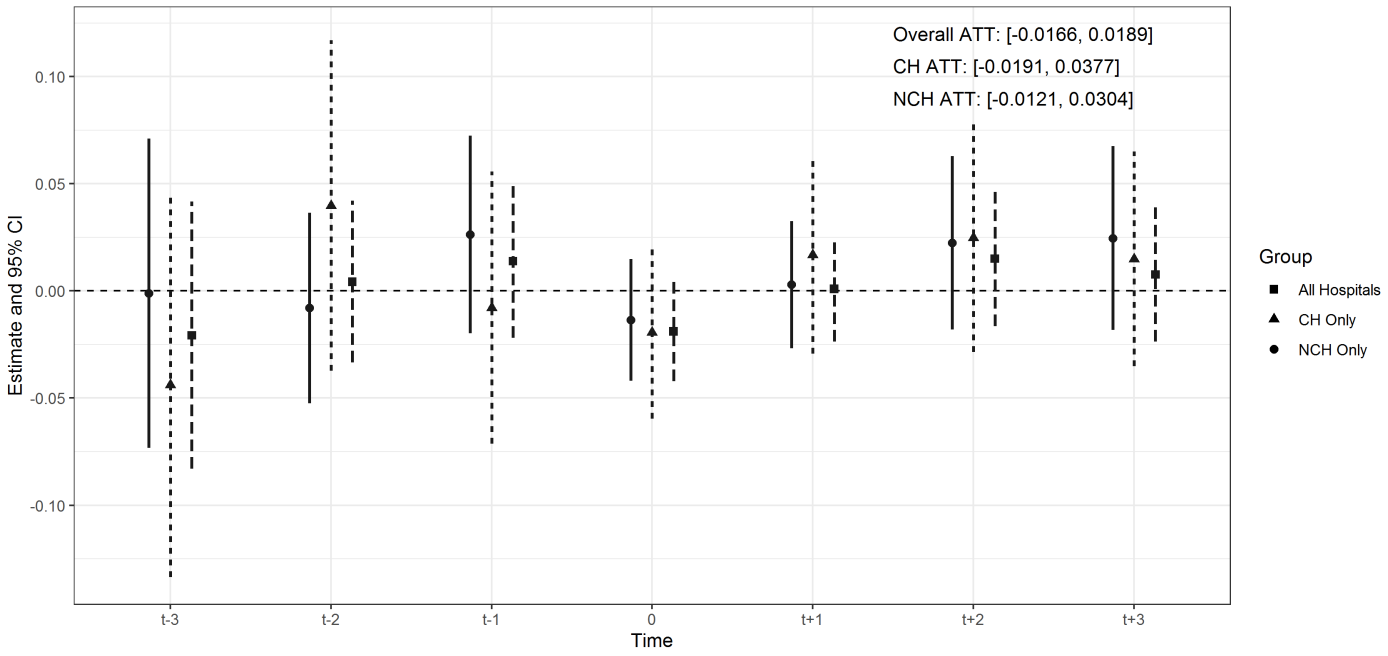
[a]Depiction of markets experiencing an entry of a non-children's hospital over time, where "entry" requires a hospital to have had at least 10 routine pediatric claims following a year in which we observed 0 such claims. Shaded markets reflect those experiencing entry.

Figure 13: **CH Entry Effects with Minimum 10-claim Threshold**[a]



[a]Estimated treatment effects on price from entry of children's hospitals using a 10-claim threshold for identifying entry events. Dynamic treatment effects estimated using Callaway & Sant'Anna (2021), with our residualized price outcome as described in the main text.

Figure 14: **NCH Entry Effects with Minimum 10-claim Threshold**[a]



[a]Estimated treatment effects on price from entry of non-children's hospitals using a 10-claim threshold for identifying entry events. Dynamic treatment effects estimated using Callaway & Sant'Anna (2021), with our residualized price outcome as described in the main text.