Online Appendix

Capacity and Utilization in Health Care: The Effect of Empty Beds on Neonatal Intensive Care Admission

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A NICU Admission Algorithm Details

This appendix provides additional details about the algorithm used to impute NICU admissions in the Calfiornia data. First, I divide observations into three types of records: births, transfers, and readmissions.[1] Second, I prevent NICU admission for transfer records more than two weeks after birth and readmission records more than 14 weeks after birth. According to a neonatologist that I interviewed, readmitted infants can be cared for in the NICU, but not if they are readmitted long after birth, particularly if they were healthy at birth and are too large for the NICU bassinets. I base these cutoffs on empirical patterns in the New York data that suggest readmitted and transferred infants are very unlikely to be admitted to the NICU after these time periods.[2]

All other birth, transfer, or readmission observations not described above are considered candidates for NICU admission. Phibbs et al. (1996) consider likely admission for infants with a length of stay greater than five days. I find in my data set that a threshold of 5 days is too inclusive and in many hospitals would impute admissions for more infants than my target allows. Therefore, the third step of my procedure assigns NICU admission to all infants with a length of stay greater than 10 days. This threshold still overshoots the target in some hospitals, but by far less than when using a five-day threshold. Fourth,

[1] Transfers are identified as any record in which the admission source is from another acute care hospital and follows a record for the same infant in which the discharge status is to another acute care hospital. All other records that are not birth records are identified as readmission records.

[2] I find that readmission records in the first week following birth have a 28.3% chance of NICU admission. This quickly falls to 8.1% during the second week after birth, 3.8% during the third week, and less than 2% for all subsequent weeks. Transferred infants within one week of birth have a NICU admission rate of 75%. This falls quickly in the second week to 39.9% and then gradually decreases over time, falling below 10% during the 15th week and below 5% during the 21st week.

I impute the rest of the admissions necessary to meet the target number in each hospital-year by selecting infants with the highest charges per day. NICU stays are extremely expensive, so it is very likely that the most expensive babies have accumulated their charges in the NICU.[3] 24.98% of admissions are imputed based on stays longer than 10 days. The remaining 75.02% are chosen based on charges per day.

B Sample Construction Details

This appendix provides details of the construction of the analysis samples and discusses some robustness checks regarding the sample composition. Appendix Table A.1 lists the number of observations remaining after each step. I begin with the universe of infant hospital admissions in each state. This includes 7,053,804 total observations in California from an average of 362.36 hospitals per year. Of these records, 6,221,001 are births, the remaining being transfer and readmission records. The corresponding numbers in New York are 2,838,998 total observations, 2,441,064 million births from 191.70 hospitals per year. As I continue describing my sample restrictions, I will refer to the number of birth records, since these will be the primary records used for analysis. Appendix Table A.1 also lists the number of total records at each step, as all of these records are included in the initial NICU admission imputation algorithm described above.

I first restrict the sample to hospital-year pairs that report a positive number of neonatal intensive care beds and patients in the hospital-level data sets. Because my research question and identification strategy are directly related to NICU capacity at the delivery hospital, I must restrict my sample to hospitals operating NICUs.[4] In New York I also exclude hospital-years with no infant records containing a Level IV accommodation code. After restricting to hospitals that operate a NICU, I am left with 4,269,275 births from 139.55 hospitals per year in California and 1,049,778 births from 39.90 hospitals per year in New York, as seen in the third row of Appendix Table A.1.

Next I make some minor restrictions based on data quality and to facilitate my NICU admission algorithm. I eliminate a small number of hospital-years that either report zero births in the hospital-level data or have no birth records

[3]Even if the infant does not receive a large amount of intensive treatment in the NICU, the amount charged by the hospital would be higher than in the normal newborn nursery.

[4]These restrictions eliminate birth records from non-NICU hospitals, but they do not eliminate subsequent records for patients who were born in a non-NICU hospital but transferred or readmitted to a NICU hospital.

present in the inpatient data.[5] I also eliminate a small number of hospital-years for which the number of births reported by the hospital-level data and the number of birth observations in the inpatient data differ by more than 10% in California and 25% in New York. I then eliminate hospital-years for which all patients are missing charge data in California. Without data on hospital charges, I cannot assign NICU admission for infants in these hospitals.[6] The result of these steps can be seen in the fourth through sixth rows of Appendix Table A.1. The remaining sample includes 3,566,527 births from 121.91 hospitals per year in California and 863,246 births from 29.8 hospitals per year in New York.

At this point I classify NICU admissions for all remaining observations and construct the daily empty beds measure. In California, there are some cases in which many infants had a length of stay greater than 10 days, leading to too many admissions identified by the admission imputation algorithm as compared to the target number of discharges. I drop all observations for a hospital-year in which the target number of discharges differs from the number of imputed admissions by more than 10%. This restriction only removes 1.27 hospitals per year and 1.9% of birth observations, as seen in the seventh row of Appendix Table A.1.

Finally, I construct the analysis sample from the remaining birth records. I drop a very small number of observations in California for which the admission date or birth weight is missing. I then exclude observations from 1991 in California and 1994 in New York, because I do not observe the stock of infants in a NICU at the beginning of the sample.[7] I also exclude observations from 2003 in New York because the data does not include observations on infants admitted in 2003 but discharged in 2004. These restrictions are listed in rows eight through ten of Appendix Table A.1, with the most consequential being the final step that drops full years of data. The final analysis sample includes 3,131,948 birth observations from an average of 121.1 hospitals per year in California and 687,086 birth observations from an average of 29.38 hospitals

[5]This restriction in effect eliminates children's hospitals from the sample. I am focusing on the NICU admission decision at the hospital of birth, so I do not consider children's hospitals that do not provide delivery services and only receive neonatal intensive care patients via transfer or readmission.

[6]This restriction excludes Kaiser-owned hospitals because they do not report hospital charges in the data. All hospitals excluded by this restriction are in fact Kaiser hospitals. No other hospitals are missing charges for all patients. In my final sample only 1,208 or 0.04% of individual infants are missing charge data. Therefore, the results of this paper are not relevant to Kaiser-owned hospitals.

[7]The 99th percentile of length of stay for NICU-admitted patients is 91 days, so excluding one year of data should allow the stock of patients to be accurate after one year.

per year in New York. For the years of data that remain in my final sample, in California my analysis includes 56% of all births and 81% of all births occurring in hospitals with NICUs. In New York, the corresponding numbers are 35% and 85%.

Note, there are some changes over time in the number of hospitals represented in my analysis sample. With hospital-specific month fixed effects, these composition changes should only affect my results if hospitals entering the sample over time respond to available capacity differently from hospitals in the sample from the start. In California 56.61% of patient observations are from hospitals that remain in the data for the full ten-year period, and 80.68% are from hospitals in the data for nine years. Appendix Table A.2 reports that my main estimates discussed in Section **??** are robust to including only those hospitals present for all ten years. The sample changes are more complicated in NY. While there is a general increase in the number of NICUs in New York, there is also a large increase in the number of hospitals in my sample between 1998 and 1999, when the sample increases from 20 to 36 hospitals. The main reason for this stark change is a large number of hospitals that do report operating NICU beds but do not record NICU accommodation codes for any patients in the inpatient data set during the earlier data years.[8] Robustness checks reported in Appendix Table A.2 show that the main estimates are robust to separating the sample into two time periods: 1994-1998 and 1999-2003.[9]

References

Phibbs, Ciaran S., Janet M. Bronstein, Eric Buxton, and Roderic H. Phibbs. 1996. "The Effects of Patient Volume and Level of Care at the Hospital of Birth on Neonatal Mortality." *Journal of the American Medical Association*, 276(13): 1054–1059.

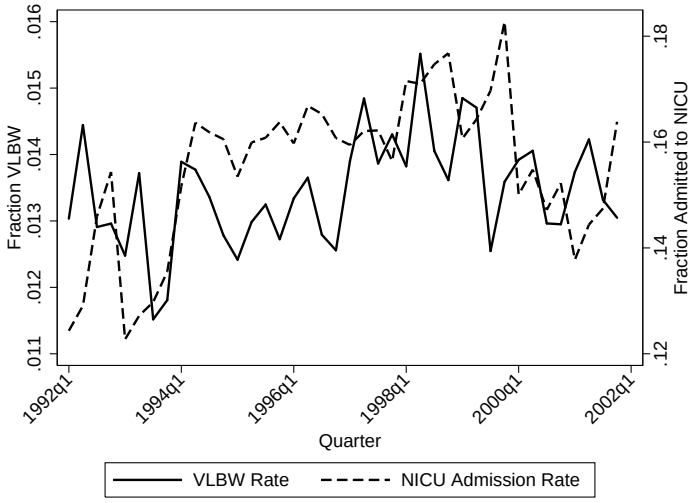
[8]In 1998, 34% of hospitals reporting NICU beds do not report any NICU accommodation codes. In 1999 this number drops to 16%.

[9]The only difference between results during these two time periods is a larger positive effect of capacity on utilization for heavier infants in the later period.

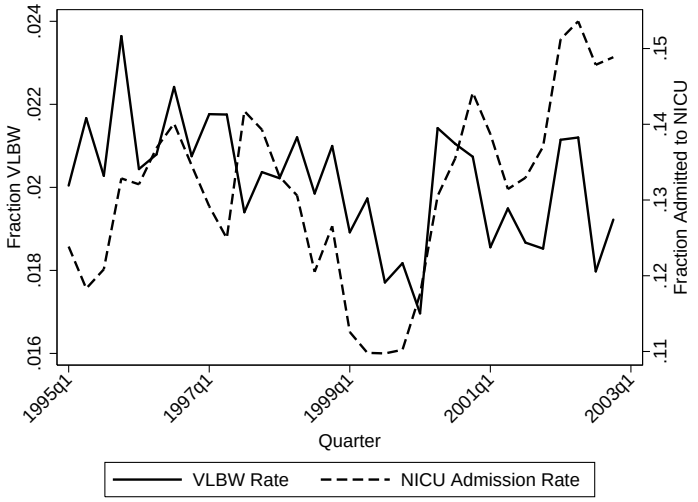
C Supplemental Tables and Figures

Figure A.1: Very Low Birth Weight and NICU Admission Over Time

(a) California



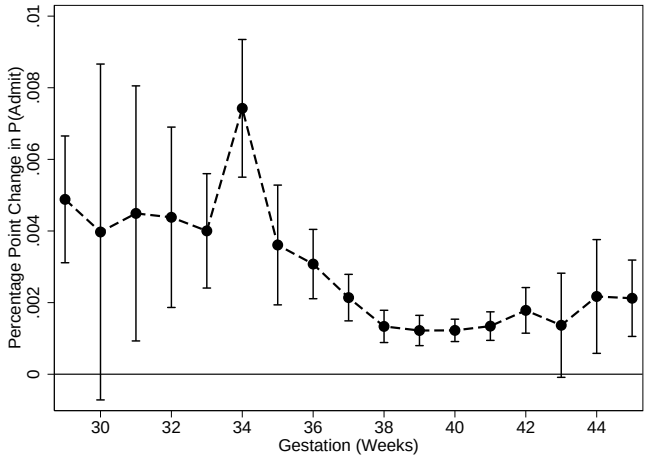
(b) New York



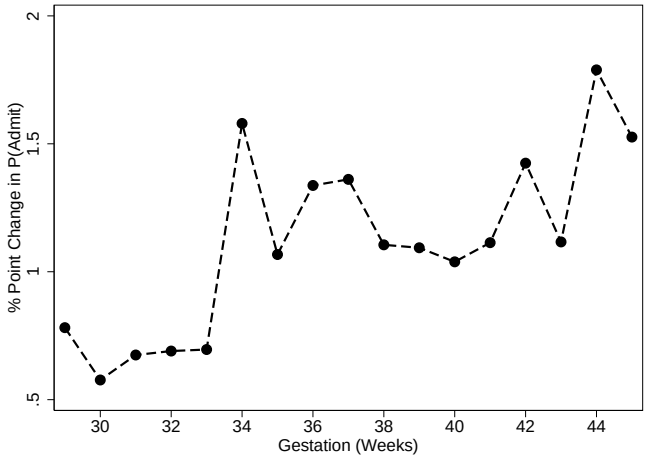
Notes: This figure plots trends in the fraction of VLBW infants and the fraction of infants admitted to the NICU by quarter from the analysis samples. VLBW infants are measured on the left hand side axis while NICU admission is measured on the right hand side axis.

Figure A.2: Effect of Empty Beds on NICU Admission by Gestation

(a) Coefficients and 95% Confidence Intervals



(b) Coefficients Normalized by NICU Admission Rate



Notes: The top panel plots coefficient estimates and 95% confidence intervals from separate regressions of NICU admission on the number of empty beds the day before birth for samples stratified by gestation in 1-week increments. Specifications include all control variables described in the notes to Table **??**, including hospital-specific month fixed effects. All standard errors are clusters at the hospital level. The bottom panel plots these coefficient estimates divided by the NICU admission rate of each gestation subgroup.

Table A.1: Constructing Analysis Sample

Panel A: California

	Average # of	# of Observations			
	Hospitals per Year	Births	Transfers	Readmissions	Total
1. Initial	362.36	6,221,001	96,041	736,762	7,053,804
2. # of NICU Beds > 0	158.27	4,445,751	92,925	596,589	5,135,265
3. # of NICU Admissions > 0	139.55	4,269,275	91,600	581,939	4,942,814
4. # of Births > 0	144.27	4,264,353	67,554	469,546	4,801,453
5. Birth Diff < 10%	140.45	4,152,220	64,329	452,827	4,669,376
6. Non-Missing Charges	121.91	3,566,527	57,440	404,768	4,028,735
7. Algorithm Diff < 10%	119.64	3,495,411	55,926	393,283	3,944,620
8. Admission Date Present	119.64	3,477,195	55,926	393,283	3,926,404
9. Birth Weight Present	119.64	3,440,074	55,717	392,429	3,888,220
10. Year > 1991	121.10	3,131,948	50,492	369,092	3,551,532

Panel B: New York

	Average # of	# of Observations		
	Hospitals per Year	Births	Transfers/Readmissions	Total
1. Initial	190.70	2,441,064	397,934	2,838,998
2. # of NICU Beds > 0	54.50	1,288,038	246,575	1,534,613
3. # of NICU Admissions > 0	40.00	1,049,779	198,946	1,248,725
4. # of Births > 0	37.80	1,004,792	187,301	1,192,093
5. Birth Diff < 25%	29.80	863,246	152,120	1,015,366
6. Non-Missing Charges	29.80	863,246	152,120	1,015,366
7. Algorithm Diff < 10%	29.80	863,246	152,120	1,015,366
8. Admission Date Present	29.80	863,246	152,120	1,015,366
9. Birth Weight Present	29.80	863,246	152,120	1,015,366
10. Year > 1994 or < 2003	29.38	687,086	125,909	812,995

Notes: This table lists the number of observations and average number of hospitals per year after the imposition of each sample restriction. Hospital-level restrictions include dropping hospitals with 0 NICU beds, 0 NICU admissions, 0 births, a large discrepancy between the number of births in the patient-level and hospital-level data sets, all patients missing charges in CA, and the admission imputation algorithm exceeding the target number by greater than 10% in CA. The final three restrictions are at the patient level and exclude observations with missing birth date, missing birth weight, and from the first year of the sample in CA and the first and last year in NY.

Table A.2: Sample Robustness

	Panel A: California			Panel B: New York	
Dependent Var: NICU Admission	1992 - 1994	1995 - 2001	Balanced Panel of Hospitals	1995 - 1998	1999 - 2002
	(1)	(2)	(3)	(1)	(2)
Full Sample	0.145**	0.162**	0.157**	0.082	0.179**
	(0.018)	(0.016)	(0.015)	(0.076)	(0.028)
N	999,757	2,132,191	1,773,106	247,264	439,822
VLBW	0.206**	0.349**	0.298**	0.172*	0.1112
(0 to 1,499 Grams)	(0.068)	(0.069)	(0.073)	(0.097)	(0.101)
N	13,042	28,998	23,825	5,173	8,591
LBW	0.424**	0.535**	0.483**	0.588**	0.442**
(1,500 to 2,499 Grams)	(0.063)	(0.077)	(0.065)	(0.146)	(0.120)
N	55,275	118,620	97,503	17,267	30,248
NBW1	0.141**	0.157**	0.161**	0.062	0.180**
(2,500 to 3,249 Grams)	(0.021)	(0.017)	(0.015)	(0.067)	(0.037)
N	329,710	702,689	585,187	83,047	153,531
NBW2	0.100**	0.092**	0.099**	-0.009	0.097**
(3,250 to 4,000 Grams)	(0.016)	(0.014)	(0.014)	(0.096)	(0.019)
N	496,748	1,063,362	885,610	117,134	206,206
HBW	0.133**	0.178**	0.157**	-0.003	0.168**
(4,000+ Grams)	(0.039)	(0.031)	(0.026)	(0.098)	(0.065)
N	104,982	218,522	180,981	24,643	41,246

Notes: Each row presents coefficient estimates in percentage points with standard errors in parenthesis (clustered at the hospital level) from separate regressions of NICU admission on the number of empty beds for the full sample and each of the five birth weight subsamples in each state. Columns 1 and 2 separate the sample by years. Column 3 for California excludes hospitals that are not present in the analysis sample in all ten years of data. Specifications include all control variables described in the notes to Table **??**, including hospital-specific month fixed effects. * p<.10, ** p<.05

Table A.3: Conditional Logit Estimates

Dependent Var:	CA	NY
NICU Admission	(1)	(2)
Full Sample	–	0.004
	–	(0.003)
VLBW	0.040**	0.042**
(0 to 1,499 G)	(0.006)	(0.019)
LBW	0.030**	0.029**
(1,500 to 2,499 G)	(0.003)	(0.005)
NBW1	0.013**	0.015**
(2,500 to 3,249 G)	(0.002)	(0.004)
NBW2	–	0.008
(3,250 to 4,000 G)	–	(0.006)
HBW	0.013**	0.009
(4,000+ G)	(0.002)	(0.006)

Notes: Each row presents coefficient estimates with standard errors in parenthesis (clustered at the hospital level) from separate conditional logit regressions of NICU admission on the number of empty beds for the full sample and each of the five birth weight subsamples in each state. Estimation for the full and HBW samples in California are missing due to non-convergence. Specifications include all control variables described in the notes to Table **??**, including hospital-specific month fixed effects. * p<.10, ** p<.05

Table A.4: Comparing Parameterizations of Empty Beds

	Panel A: California			**Panel B: New York**		
Independent Var:	Empty Beds	Empty Beds/ Births per Day (10s)	Percent Empty Beds	Empty Beds	Empty Beds/ Births per Day (10s)	Percent Empty Beds
	(1)	(2)	(3)	(1)	(2)	(3)
Full Sample	0.157**	0.145**	0.023**	0.141**	0.143**	0.022*
	(0.014)	(0.010)	(0.002)	(0.034)	(0.025)	(0.013)
VLBW	0.309**	0.268**	0.073**	0.128	0.101	0.054**
(0 to 1,499 G)	(0.053)	(0.046)	(0.012)	(0.084)	(0.068)	(0.022)
LBW	0.497**	0.455**	0.088**	0.494**	0.432**	0.110**
(1,500 to 2,499 G)	(0.056)	(0.045)	(0.007)	(0.095)	(0.076)	(0.018)
NBW1	0.153**	0.133**	0.022**	0.134**	0.133**	0.020*
(2,500 to 3,249 G)	(0.013)	(0.013)	(0.002)	(0.032)	(0.025)	(0.011)
NBW2	0.095**	0.094**	0.015**	0.054	0.070**	0.004
(3,250 to 4,000 G)	(0.012)	(0.009)	(0.001)	(0.041)	(0.034)	(0.015)
HBW	0.163**	0.159**	0.024**	0.095*	0.111**	0.014
(4,000+ G)	(0.023)	(0.017)	(0.003)	(0.055)	(0.043)	(0.015)

Notes: Each row presents coefficient estimates in percentage points with standard errors in parenthesis (clustered at the hospital level) from separate regressions of NICU admission on various parameterizations of the number of empty beds for the full sample and each of the five birth weight subsamples in each state. Column 1 repeats the main estimates from Table **??**. Column 2 replaces the number of empty beds with the number of empty beds divided by the hospital-year average number of births per day (in 10s). Column 3 replaces the number of empty beds with the percent of beds that are empty. Specifications include all control variables described in the notes to Table **??**, including hospital-specific month fixed effects. * p<.10, ** p<.05

Table A.5: Fraction of Births by Payer Over Time

Panel A: California

Year	Private, Non-MC	Private, MC	Medicaid	Self Pay	Other	Missing
1992	0.192	0.241	0.493	0.051	0.023	0.000
1993	0.169	0.255	0.510	0.043	0.024	0.000
1994	0.158	0.271	0.511	0.041	0.018	0.001
1995	0.057	0.382	0.504	0.039	0.019	0.000
1996	0.052	0.401	0.497	0.034	0.016	0.000
1997	0.057	0.437	0.454	0.038	0.014	0.000
1998	0.058	0.471	0.423	0.034	0.013	0.000
1999	0.030	0.485	0.432	0.031	0.017	0.006
2000	0.029	0.482	0.441	0.031	0.016	0.001
2001	0.027	0.459	0.467	0.027	0.019	0.000
Total	**0.085**	**0.384**	**0.475**	**0.037**	**0.018**	**0.001**

Panel B: NY

Year	Private, Non-HMO	Private, HMO	Medicaid, Non-HMO	Medicaid, HMO	Self Pay	Other Gov.	Other
1995	0.374	0.200	0.307	0.019	0.093	0.002	0.006
1996	0.354	0.220	0.304	0.030	0.081	0.004	0.006
1997	0.354	0.254	0.276	0.055	0.049	0.007	0.005
1998	0.326	0.313	0.214	0.073	0.051	0.014	0.008
1999	0.310	0.243	0.294	0.075	0.063	0.009	0.007
2000	0.286	0.243	0.333	0.073	0.047	0.012	0.007
2001	0.297	0.235	0.353	0.065	0.035	0.010	0.005
2002	0.264	0.239	0.320	0.129	0.035	0.009	0.005
Total	**0.311**	**0.244**	**0.307**	**0.071**	**0.052**	**0.009**	**0.006**

Notes: This table presents the fractions of the full samples in each state by primary payer. Prior to 1995 in California, all Blue Cross/Blue Shield (BC/BS) plans are categorized as private, non-managed care. Beginning in 1995, BC/BS managed care plans can be separately identified and are categorized accordingly.

Table A.6: Comparing Actual and Imputed NICU Admissions in New York

Dependent Var:	Actual Admission	Imputed Admission
	(1)	(2)
Full Sample	0.141**	0.174**
	(0.034)	(0.018)
VLBW	0.128	0.245**
(0 to 1,499 G)	(0.084)	(0.091)
LBW	0.494**	0.568**
(1,500 to 2,499 G)	(0.095)	(0.079)
NBW1	0.134**	0.188**
(2,500 to 3,249 G)	(0.032)	(0.020)
NBW2	0.054	0.087**
(3,250 to 4,000 G)	(0.041)	(0.016)
HBW	0.095*	0.138**
(4,000+ G)	(0.055)	(0.034)

Notes: Each row presents coefficient estimates in percentage points with standard errors in parenthesis (clustered at the hospital level) from separate regressions of NICU admission on the number of empty beds for the full sample and each of the five birth weight subsamples in New York. Column 1 repeats the main estimates from Table **??** and Column 2 presents estimates in which NICU admission and the number of empty beds is determined by performing the NICU admission imputation algorithm on the New York data. Specifications include all control variables described in the notes to Table **??**, including hospital-specific month fixed effects. * p<.10, ** p<.05

Table A.7: Maternal Transfers in California

	Empty Beds and Maternal Transfer	Main Results, Excluding Maternal Transfers
	(1)	(2)
VLBW	-0.039**	0.323**
(0 to 1,499 G)	(0.017)	(0.058)
N	40,835	39,335
LBW	-0.003	0.502**
(1,500 to 2,499 G)	(0.004)	(0.057)
N	172,136	170,859

Notes: Each row presents coefficient estimates in percentage points with standard errors in parenthesis (clustered at the hospital level) from separate regressions for the VLBW and LBW samples in California. Column 1 presents coefficient estimates from regressions of an indicator for maternal transfer on the number of empty beds at the mother's first hospital of admission within a day of delivery. Column 2 presents estimates of regressions of NICU admission on empty beds, excluding infants whose mother's experienced a maternal transfer. Specifications include all control variables described in the notes to Table **??**, including hospital-specific month fixed effects. * p<.10, ** p<.05

Table A.8: Interacting Empty Beds with Distance to Nearest Other NICU

Dependent Var:	CA	NY
NICU Admission	(1)	(2)
Empty Beds	0.140**	0.142**
	(0.015)	(0.033)
Empty Beds X Distance	0.046**	-0.002
to Nearest Other NICU	(0.014)	(0.009)

Notes: Each column presents coefficient estimates in percentage points with standard errors in parenthesis (clustered at the hospital level) from separate regressions of NICU admission on the number of empty beds and the number of empty beds interacted with distance to the nearest other hospital operating a NICU for the full sample in each state. Specifications include all control variables described in the notes to Table **??**, including hospital-specific month fixed effects. * p<.10, ** p<.05

Table A.9: Capacity at Nearby NICUs, Full Sample

Dependent Var: NICU Admission or Transfer	California (1)	New York (2)
Empty Beds at Birth Hospital	0.145**	0.135**
	(0.014)	(0.035)
Empty Beds at 1st Closest Hosp	0.006	-0.030*
	(0.007)	(0.016)
Empty Beds at 2nd Closest Hosp	0.008	-0.010
	(0.006)	(0.015)
Empty Beds at 3rd Closest Hosp	-0.005	0.033**
	(0.006)	(0.015)

Notes: Each column presents coefficient estimates in percentage points with standard errors in parenthesis (clustered at the hospital level) from separate regressions for the full sample in each state. Independent variables include the number of empty beds at the birth hospital and at each of the three closest NICUs. Specifications include all control variables described in the notes to Table **??**, including hospital-specific month fixed effects. * p<.10, ** p<.05