Appendix to: "Safety-Net Care for Maintenance Dialysis in the United States"

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Exhibit S1. Chain Ownership.

We used two sources to identify facilities that were part of a larger dialysis chain. The first source was annual dialysis facility reports that are submitted to the Centers for Medicare and Medicaid Services (CMS) and are included in the United States Renal Data System (USRDS) database. These reports contain information about ownership by large dialysis chains and appear to be updated in a timely manner following facility acquisitions. The second source was the CMS Dialysis Facility Compare (DFC) database. This information is updated several times per year, and includes information about ownership by large dialysis chains and smaller, local and regional chains. These data require dialysis facilities to report ownership changes to End-Stage Renal Disease Networks. Occasionally, there is a lag in the time between when ownership changes are reported on the USRDS Facility Report and when they appear in the DFC database.

Because of the superior reliability of USRDS Facility Survey ownership data, we used the following algorithm to determine chain ownership in each calendar year:

1) If a facility was recorded as being a part of a dialysis chain in the Annual Facility Survey, we considered it to be chain-owned.
2) If a facility was recorded as being "independently-owned" in the Annual Facility Survey, we then assessed ownership in DFC.
   a. If the facility was reported in DFC as being owned by a smaller dialysis chain, we considered it to be chain-owned.
   b. If, instead, the facility was not a part of a chain in DFC, we considered it to be independently-owned.

Exhibit S2. Measuring Competition.

We adopted a method used to calculate HHI in healthcare markets based on HSAs that accounts for patients' decisions to dialyze outside of the HSA where they live and that reflects the numbers of nearby competing facilities from which patients can choose. We assumed facilities that shared ownership did not compete against one another for patients.

The equation used to calculate Herfindahl-Hirschman Index (HHI) is as follows:

$$HHI_{hospital\ service\ area} = \sum_{i=1}^{n} s_i^2$$

Where S_i represents the proportion of patients living in an HSA receiving dialysis at the ith firm in the HSA.

We calculate a measure of "observed HHI" for each hospital service area (HSA) from the following three steps:

1. Calculate a "first-stage" competition measure for each HSA (using the equation above), based on sum of squared market shares of firms where patients living in each HSA choose to dialyze. In this stage all patients residing in a given HSA define the "market" for each firm-HSA pair. Firms do not have to be located in the same HSA where patients reside, and a given dialysis facility can be included in the calculation of HHI for multiple HSAs if patients from multiple HSAs dialyze at that facility. For the purposes of this step, facilities owned by the same dialysis chain were considered to be one firm. The market share for a firm in an HSA is equal to the proportion of patients in that HSA who choose to dialyze at that firm. For example, in an HSA where half of the patients receiving dialysis went to one of four facilities owned by one firm and

the other half of patients went to one of two facilities owned by a second firm, the market share would be considered to be split evenly across the two firms, with an HHI for that HSA of $0.5^2 + 0.5^2 = 0.5$.

2. Calculate a dialysis-facility-level measure of competition, using a weighted average of the "first-stage" HSA-level HHIs for patients who actually dialyze at each facility. This measure is calculated for each separate facility, regardless of which firm owns a facility. It assumes that facilities compete for patients within HSAs and can discriminate against patients living in different HSAs when competing against rival firms.

3. Calculate a "second-stage" HSA-level measure of competition from a weighted average of the facility-level-HHIs at facilities where patients residing in each HSA receive dialysis.

In summary, this index represents a weighted average of competition indices for facilities that treat patients in a given HSA, where facility competition indexes are, in turn, weighted by choices available to patients they treat.

Exhibit S3. Conditional Logit Model.

We developed a conditional multinomial regression model of discrete dialysis facility choices to examine the extent to which patient assignment to certain facility types persists after accounting for choices available to each patient. This was based on a discrete choice model first described by McFadden in 1974.

In this model, we assumed that each patient, `$i$', living in zip-code '$k$', has a fixed set of `j_k' choices among different dialysis facilities. Dialysis facilities that were owned by the same organization served as unique choices in this model. For each patient, the set of available facilities ($j_1 .. j_k$) was defined to be all facilities where patients living in that zip-code initiated dialysis during the entire study period. Each dialysis facility had one characteristic, representing one of four discrete ownership types: 1) independently-owned, non-profit; 2) chain-owned, non-profit; 3) independently-owned, for-profit, and; 4) chain-owned, for-profit.

We assumed that the utility gained from a patient initiating dialysis at a given facility was a function of patient characteristics, 'X', facility ownership type, the interaction between patient characteristics and facility ownership, and an error term. We assumed that patients are assigned to a dialysis facility that maximizes this utility. In the model, each patient-facility choice combination represented a unique data record, we estimated the associations among facility ownership, and the interaction of patient characteristics (X_i) and each facility ownership type using the following conditional logit model, where the set of choices available to each patient (based on the zip-code where they live) represented a "group":

$\text{Utility(fac}_{ij}) = f[\text{ownership2}_j + \text{ownership3}_j + \text{ownership4}_j + \text{ownership2}_j*(X_{ij}) + \text{ownership3}_j*(X_{ij}) + \text{ownership4}_j*(X_{ij}) + \varepsilon_{ij}]$,

where:
- "ownership2, 3, and 4" are binary variables denoting the ownership type for each facility.
- "X" represents a set of patient-specific characteristics, including the covariate of interest (whether or not a patient is safety-net reliant).
- ε is an IID extreme-value-type error associated with a given patient and dialysis facility combination.

Estimates associated with "safety-net reliant"*ownership interactions represent the ratio of relative risks of patients with and without each characteristic, 'X', initiating dialysis at a given facility type compared with the reference facility type.

In rare instances when facilities changed ownership type during the study period, we assigned facility ownership type for each patient-facility combination according to the reported ownership category in the calendar year when a given patient initiated dialysis.

Exhibit S4. Sensitivity Analyses.

We examined the sensitivity of our findings to the following alternative specifications:

1) We Included all patients, including those >65 years old, in an analysis of the associations among safety-net reliance and dialysis facility ownership type. In this analysis, we used the following categories for age: <50, 50-75, >75. The relative risk ratio (RRR) of safety-net reliant patients receiving dialysis at non-profit chains was 0.93 (95% CI 0.89 to 0.97). The RRR of dialysis at non-profit/independent facilities was 1.33 (95% CI 1.28 to 1.39). The RRR of dialysis at for-profit chains was 0.96 (95% CI 0.94 to 1.00). These results are similar to those observed in our primary analysis of patients < 65 years old.
2) We examined the sensitivity of our findings to inclusion of home dialysis as an additional model covariate. When examining facility ownership type, the RRR of safety-net reliant patients receiving dialysis at non-profit chains was 0.89 (95% CI 0.85 to 0.94). The RRR of dialysis at non-profit/independent facilities was 1.28 (95% CI 1.22 to 1.33). The RRR of dialysis at for-profit chains was 0.94 (95% CI 0.90 to 0.97). The RRR of safety-net reliant patients receiving dialysis at hospital-based facilities was 1.28 (95% CI 1.24 to 1.33). This suggest that our results were not sensitive to inclusion of dialysis modality.
3) We also examined whether the observed associations between safety-net reliance and dialysis at different facility ownership types (and hospital affiliation) changed over the course of the study period. We did this by including an additional regression parameter representing the interaction between safety-net reliance and the calendar year of dialysis initiation, where calendar years was modeled linearly. When examining facility ownership types, the association between safety-net reliance and dialysis at non-profit/independently-owned facilities varied over time, with the association becoming smaller in magnitude in later years (p<0.001). The associations among other ownership types and safety-net reliance did not change over time. When examining hospital-affiliation, the associations among hospital-affiliation and safety-net reliance also became smaller in magnitude over time (p<0.001).

Exhibit S5. Analysis of facility switch rates.

We assigned patients to the first dialysis facility where they received dialysis. However, this may not accurately capture dialysis facilities that care for patients if patients who are uninsured or who have Medicaid switch facilities more or less frequently in the early dialysis period compared to other patients. To assess this possibility, we compared the distribution of facility switches among the two groups. We found that the frequency of switching facilities was similar in both groups. For both groups, the 10th, 25th, 50th, and 75th percentiles of patients did not switch dialysis facilities. In both groups, patients in the 90th percentile of facility number switched once. Slight differences only existed at the extremes of the distribution. Among safety-net reliant patients, the maximum number of facility switches in the first 6 months of dialysis was 4. Among patients who were not safety-net reliant, the maximum number of facility switches in the first 6-months of dialysis was 7. Based on these findings, we chose to assign dialysis facilities based on where patients initiated dialysis."

Table S1. Baseline Characteristics of Patients Stratified by Facility Ownership Type.

	Non-profit, chain-owned facility (% or mean, n=36,522)	Non-profit, independently-owned facility (% or mean, n=34,301)	For-profit, chain-owned facility (% or mean, n=338,288)	For-profit, independently-owned facility (% or mean, n=35,814)
Safety-net reliant	10.8	16.1	11.9	14.3
Patient demographic characteristics				
Age - yr - %				
<50	35.2	39.7	33.8	31.8
50-65	64.8	60.3	66.2	68.2
Female - %	41.5	40.3	41.7	41.5
Race - %				
Black	33.2	30.9	34.4	32.8
American Indian	2.9	2.3	1.0	1.0
White	57.6	61.3	60.1	59.7
"Other" Race	6.3	5.5	4.5	6.5
Hispanic Ethnicity - %	11.1	16.5	16.0	20.6
Patient health characteristics				
Medical comorbidities - # - %				
0-1	65.7	67.0	68.8	64.2
2	19.7	18.7	19.3	19.8
>2	14.6	14.3	11.9	15.9
Smokes - %	11.1	9.2	8.4	8.4
Drug or alcohol abuse - %	5.2	4.9	3.8	4.1
Immobile - %	5.4	5.7	4.8	7.9
Socioeconomic characteristics				
Employed - %	20.2	22.8	18.2	16.6
Median income (zip code) - $10,000	5.05 (2.15)	5.08 (2.04)	4.85 (1.89)	4.88 (1.85)
Facility & Geographic Characteristics				
Population Density - %				
Metropolitan area	80.6	80.7	83.6	85.9
Micropolitan area	10.2	10.0	9.4	7.6
Small town	5.6	5.3	4.7	4.3
Rural area	3.6	4.0	2.3	2.3
HSA level Facility market competition - %				
More competitive market	2.8	18.7	2.7	19.4
Moderately competitive market	51.1	61.7	56.5	59.8
Less competitive market	46.0	19.6	40.8	20.8

Table S2. Baseline Characteristics of Patients Stratified by Hospital Affiliation.

	Hospital-based facility (% or mean, n=38,210)	Free-standing facility (% or mean, n=406,715)
Safety-net reliant	14.8	12.1
Patient demographic characteristics		
Age - yr - %		
<50	39.5	33.8
50-65	60.5	66.2
Female - %	40.6	41.6
Race - %		
Black	29.1	34.4
American Indian	2.4	1.1
White	62.9	59.7
"Other" Race	5.6	4.8
Hispanic Ethnicity - %	16.5	16.0
Patient health characteristics		
Medical comorbidities - # - %		
0-1	66.7	68.2
2	18.9	19.3
>2	14.4	12.5
Smokes - %	9.3	8.7
Drug or alcohol abuse - %	4.6	4.0
Immobile - %	5.2	5.2
Socioeconomic characteristics		
Employed - %	23.6	18.2
Median income (zip code) - $10,000	5.11	4.87
Facility & Geographic Characteristics		
Non-profit - %		
Independently-owned	75.0	1.4
Chain-owned	21.4	7.0
For-profit - %		
Independently-owned	2.4	8.6
Chain-owned	1.2	83.1
Population Density - %		
Metropolitan area	79.7	83.6
Micropolitan area	9.8	9.3
Small town	5.9	4.7
Rural area	4.6	2.3
HSA level Facility market competition - %		
More competitive market	14.7	4.4
Moderately competitive market	61.6	56.3
Less competitive market	23.7	39.3

Table S3. Characteristics of Dialysis Facilities, Stratified by Proportion of Safety-Net Reliant Patients.

	1st * (n=8,945)[†]	2nd (n=12,701)[†]	3rd (n=12,564)[†]	4th (n=10,990)[†]
Proportion of safety-net reliant - mean	1.8	6.8	11.8	23.4
Non-profit				
Chain-owned - %	9.5	9.6	7.4	6.4
Independently-owned - %	8.5	5.2	6.2	9.7
For-profit				
Chain-owned - %	73.1	78.7	78.8	74.5
Independently-owned - %	9.0	6.4	7.6	9.4
Hospital-based facility	10.2	6.9	6.6	9.9
Facility size (# of patients) - mean	50.1	72.0	73.5	80.7

*Quartiles of "proportion safety-net reliant" are categorized at the facility-level based on the proportion of patient initiating dialysis who were safety-net reliant at a facility over the entire study period. However, because dialysis facility characteristics can change over time, data are reported at the facility-year level, aggregated within the assigned quartile of "proportion safety-net reliant."

[†]'n' refers to facility-years.

Table S4. Baseline Characteristics of the Population Under 65 Years Old Included in Conditional Logit Model Based on Patient Zip-Codes.

	Medicaid or Uninsured (% or mean, n=45,868)	Other Insurance (% or mean, n=300,889)
Patient demographic characteristics		
Age - yr - %		
<50	45.6	32.8
50-65	54.4	67.2
Female - %	46.9	40.6
Race - %		
Black	42.4	35.0
American Indian	1.0	1.1
White	49.5	59.1
"Other" Race	7.0	4.8
Hispanic Ethnicity - %	24.5	15.8
Patient health characteristics		
Medical comorbidities - # - %		
0-1	72.0	68.2
2	17.7	19.3
>2	10.3	12.5
Smokes - %	10.7	8.0
Drug or alcohol abuse - %	8.1	3.5
Immobile - %	6.6	5.0
Socioeconomic characteristics		
Employed - %	6.7	20.4
Median income (zip code) - $1,000	45.5	50.0
Facility & Geographic Characteristics		
Non-profit - %		
Independently-owned	11.1	8.3
Chain-owned	8.1	9.8
For-profit - %		
Independently-owned	10.9	9.7
Chain-owned	69.9	72.2
Population Density - %		
Metropolitan area	90.7	86.4
Micropolitan area	5.5	8.3
Small town	2.6	3.8
Rural area	1.2	1.5
HSA level Facility market competition - %		
More competitive market	11.2	5.9
Moderately competitive market	65.2	63.0
Less competitive market	23.5	31.1

Table S5. Regression Results of Multinomial Logit Model Conditional upon the Set of Dialysis Facility Ownership Choices Available within a Given Zip-Code.

Outcome:	Non-profit Chain-owned				Non-profit Independently-owned				For-profit Chain-owned			
	OR	LCI	UCI	p-value	OR	LCI	UCI	p-value	OR	LCI	UCI	p-value
Safety-net reliant	0.95	0.90	1.00	0.07	1.19	1.14	1.25	<0.001	1.00	0.96	1.03	0.82
Demographics, Race and Ethnicity												
Female	1.00	0.96	1.03	0.94	0.98	0.95	1.01	0.23	0.99	0.96	1.01	0.26
Race (white is referent)												
Black	1.09	1.05	1.14	<0.001	1.01	0.98	1.05	0.47	0.89	0.87	0.92	<0.001
Native American	1.30	1.10	1.54	0.002	1.30	1.10	1.55	0.002	0.72	0.62	0.82	<0.001
Other	0.88	0.81	0.95	0.001	0.73	0.68	0.79	<0.001	0.65	0.61	0.68	<0.001
Hispanic ethnicity	0.88	0.84	0.93	<0.001	0.99	0.94	1.04	0.63	0.79	0.76	0.81	<0.001
Age (<50 is referent)												
50-65	0.88	0.85	0.92	0.00	0.73	0.70	0.75	<0.001	0.97	0.95	1.00	0.04
Health and Socioeconomics												
Comorbidities (<2 is referent)												
2	0.96	0.92	1.01	0.10	0.93	0.89	0.98	0.002	0.89	0.87	0.92	<0.001
≥3	0.90	0.86	0.95	<0.001	0.85	0.81	0.90	<0.001	0.70	0.67	0.73	<0.001
Immobility	0.70	0.65	0.76	<0.001	0.81	0.75	0.87	<0.001	0.62	0.59	0.65	<0.001
Smokes	1.13	1.06	1.20	<0.001	1.05	0.99	1.12	0.12	0.94	0.90	0.98	0.01
Drug or alcohol abuse	1.06	0.97	1.15	0.21	1.05	0.96	1.14	0.30	0.86	0.80	0.91	<0.001
Employed	1.17	1.12	1.23	<0.001	1.31	1.25	1.37	<0.001	1.03	0.99	1.06	0.15
Dialysis at facility type	1.51	1.45	1.58	<0.001	1.58	1.51	1.65	<0.001	1.90	1.84	1.97	<0.001

Note: Includes 346,757 patients under the age of 65 with at least two choices of facility-types in their zip-code. For-profit, independently-owned facilities serve as the reference "alternative" choice.

Table S6. Regression Results of Logistic Regression Model Conditional upon the Set of Dialysis Facility Choices (Hospital-Based vs. Free-Standing) Available within a Given Zip-Code.

	Hospital-based Facility			
	OR	LCI	UCI	p-value
Safety-net reliant	1.19	1.15	1.23	<0.001
Demographics, Race and Ethnicity				
Female	1.00	0.97	1.02	0.81
Race (white is referent)				
Black	1.09	1.06	1.12	<0.001
Native American	1.43	1.28	1.60	<0.001
Other	1.04	0.98	1.10	0.19
Hispanic ethnicity	1.15	1.11	1.19	<0.001
Age (<50 is referent)				
50-65	0.75	0.73	0.77	<0.001
Health and Socioeconomics				
Comorbidities (<2 is referent)				
2	1.03	1.00	1.07	0.05
≥3	1.15	1.10	1.19	<0.001
Immobility	1.05	0.99	1.11	0.13
Smokes	1.10	1.05	1.15	<0.001
Drug or alcohol abuse	1.08	1.01	1.14	0.02
Employed	1.34	1.30	1.39	<0.001
Dialysis at facility type	0.97	0.94	1.00	0.05

Note: Includes 426,262 patients under the age of 65 with at least two choices of facility-types in their zip-code. Free-Standing Facilities serve as the "alternative" choice.

Table S7. Results of Analyses Examining Each Component of Safety-Net Reliance.

Covariates	Non-profit Chain			Non-profit Independent			For-profit Chain			Hospital-based		
	Odds Ratio	LCI	UCI	Odds Ratio	LCI	UCI	Odds Ratio	LCI	UCI	Odds Ratio	LCI	UCI
Safety-net reliant separated into Medicaid and No Insurance – Multinomial Logit												
Medicaid	0.88	0.83	0.92	1.15	1.10	1.21	0.96	0.92	0.99	1.11	1.07	1.15
No insurance	1.05	0.95	1.16	2.03	1.86	2.22	1.02	0.95	1.10	1.97	1.86	2.09
Safety-net reliant separated into Medicaid and No Insurance – Conditional Logit												
Medicaid	0.91	0.86	0.96	0.99	0.94	1.04	0.98	0.95	1.02	0.98	0.94	1.02
No insurance	1.24	1.11	1.39	2.61	2.37	2.88	1.10	1.02	1.19	2.34	2.19	2.50

Table S8. Results of Analyses of Alternative Specifications of Safety-Net Reliance.

Covariates	Non-profit Chain			Non-profit Independent			For-profit Chain			Hospital-based		
	Odds Ratio	LCI	UCI	Odds Ratio	LCI	UCI	Odds Ratio	LCI	UCI	Odds Ratio	LCI	UCI
Safety-net reliant but obtain Medicare coverage after 3 months												
Estimate	1.04	1.01	1.08	1.20	1.15	1.24	0.96	0.93	0.98	1.21	1.18	1.24
Patients who are dual-eligible for Medicare and Medicaid after 3 months.												
Estimate	1.02	0.98	1.05	1.05	1.01	1.09	0.90	0.88	0.93	1.11	1.08	1.14

Figure S1: Proportion of Patients with Medicaid or No Health Insurance who Do not Receive Medicare or Private Group Insurance at Each Day Following Dialysis Initiation.
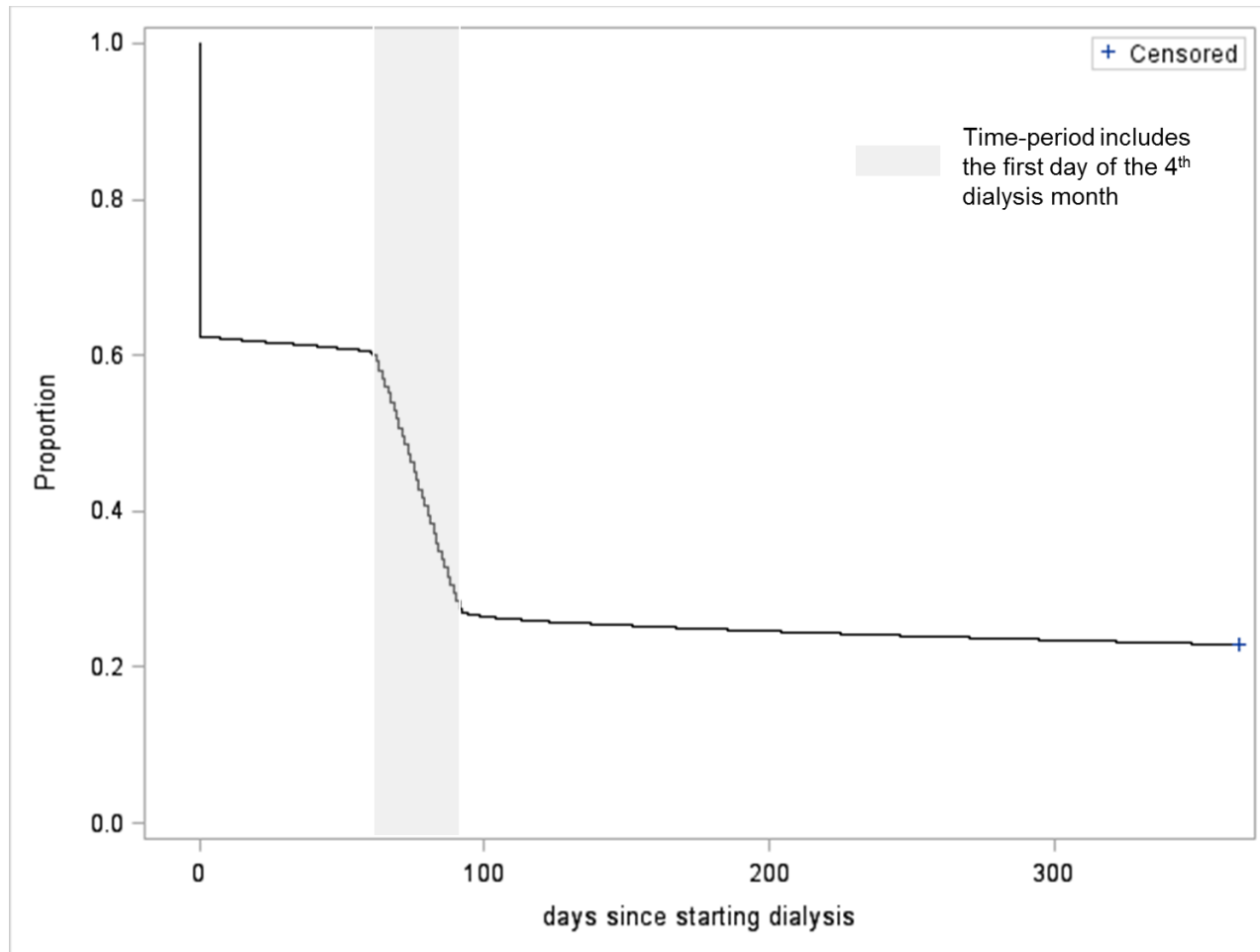
Note: Proportions over time were obtained using the Kaplan Meier method, where patients are censored for death and loss to follow-up.

Figure S2. Distribution of Proportion of Patients who are Safety-Net Reliant Stratified by Facility Ownership Type.
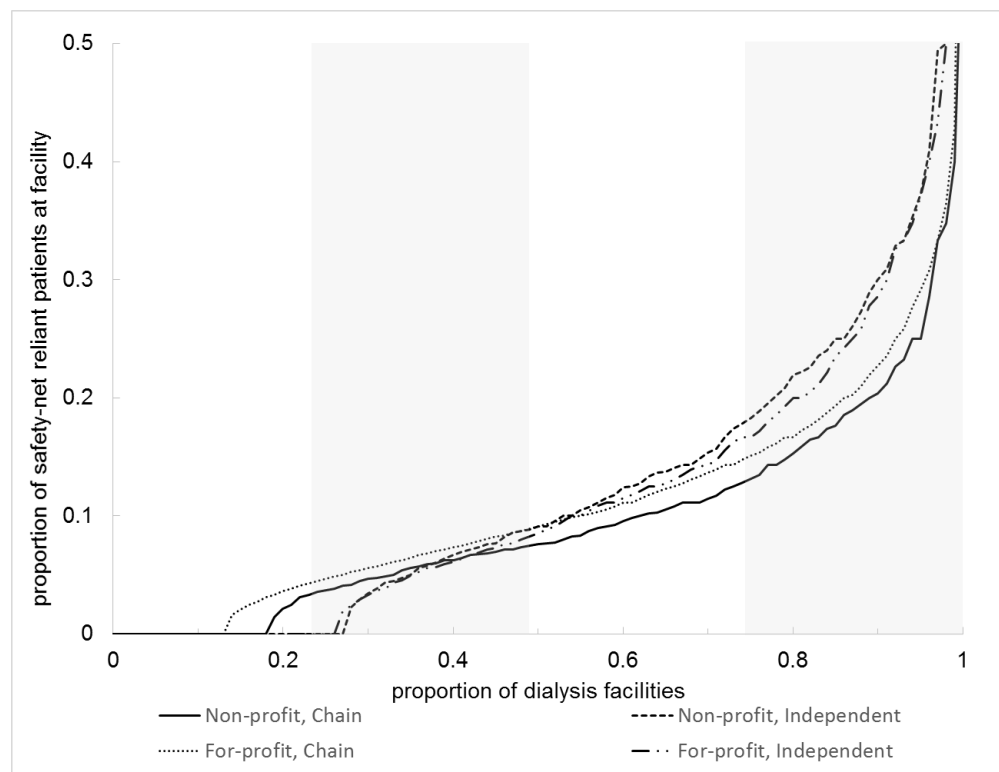
Figure S3. Distribution of Proportion of Patients who are Safety-Net Reliant Stratified by Facility Hospital Affiliation.
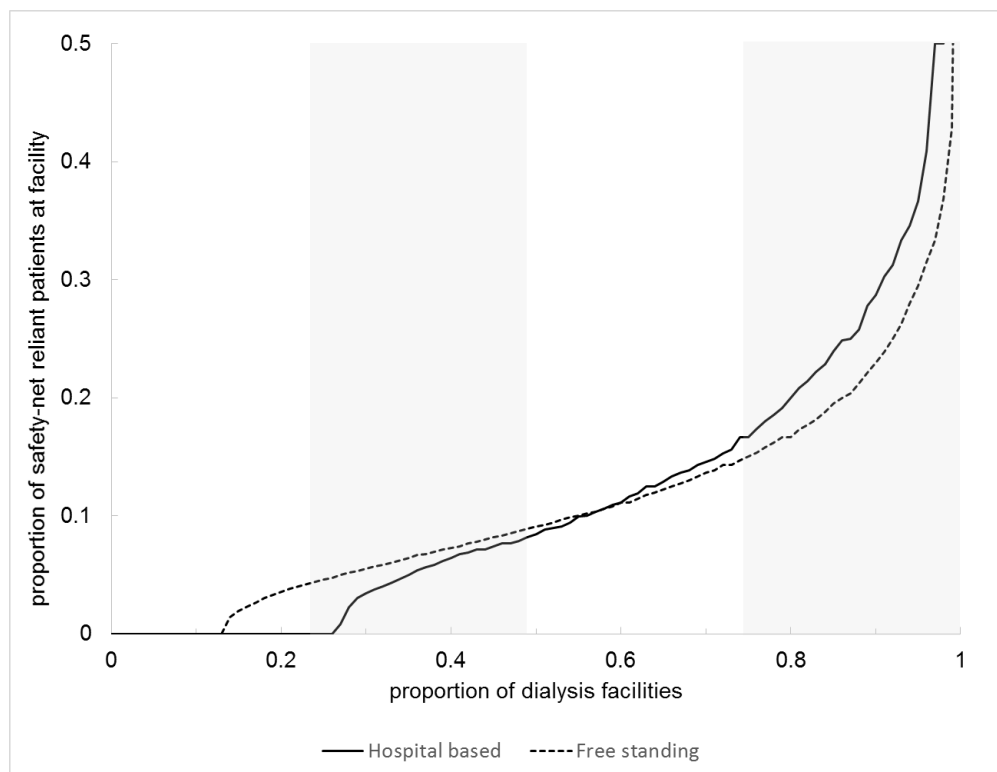
Figure S4. Absolute Probability of Initiating Dialysis at Different Facility Types by Health Insurance Category.