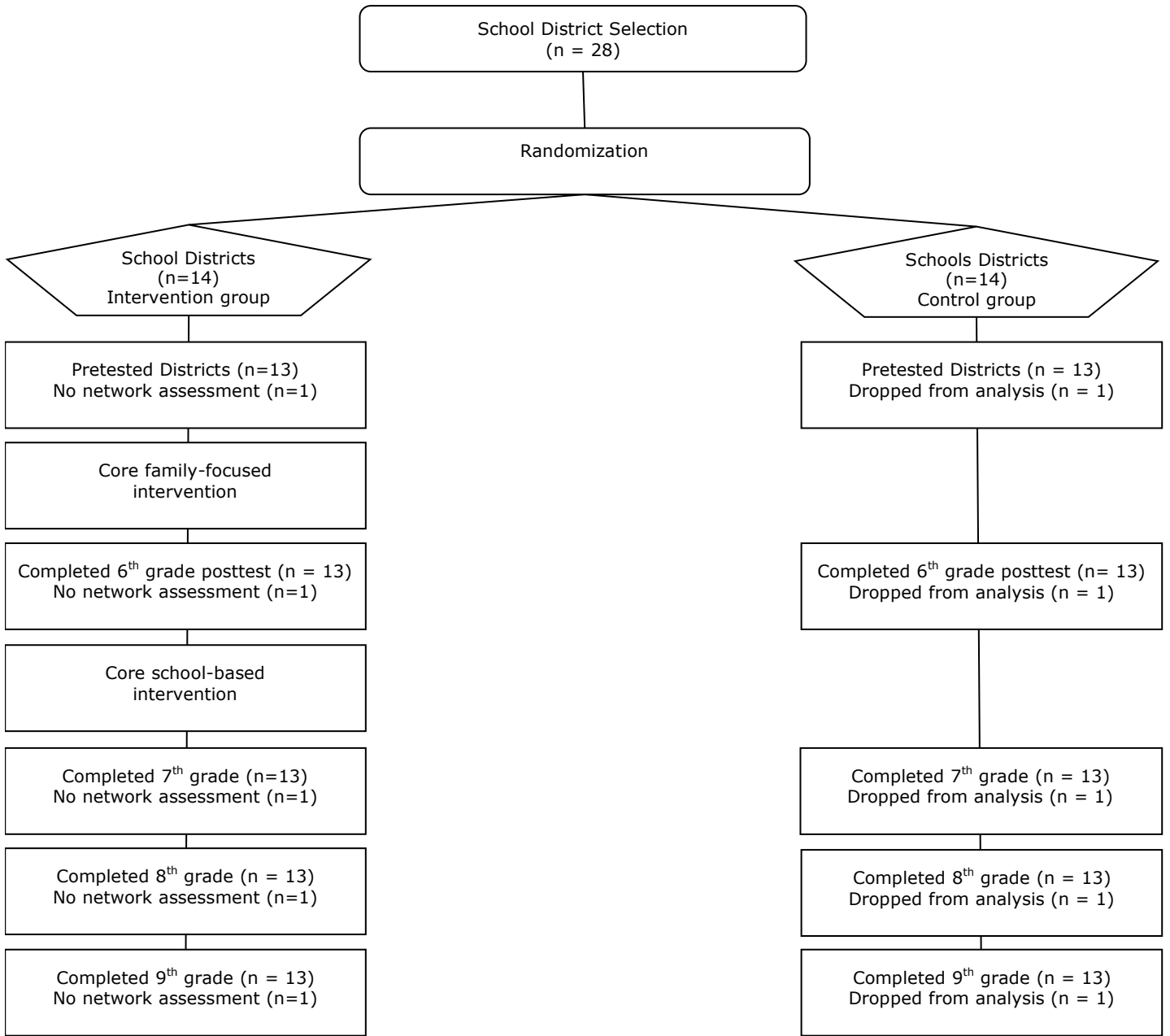**Prevention and Adolescent Friendship Networks:**
Effects on the Influence Potential of Prosocial Versus Antisocial Youth

Supplemental Material

Random assignment and assessment process for PROSPER

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┌─────────────────────────────┐
│   School District Selection │
│          (n = 28)           │
└─────────────────────────────┘
              │
┌─────────────────────────────┐
│        Randomization        │
└─────────────────────────────┘
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School Districts (n=14) Intervention group	Schools Districts (n=14) Control group
Pretested Districts (n=13) No network assessment (n=1)	Pretested Districts (n = 13) Dropped from analysis (n = 1)
Core family-focused intervention	
Completed 6th grade posttest (n = 13) No network assessment (n=1)	Completed 6th grade posttest (n= 13) Dropped from analysis (n = 1)
Core school-based intervention	
Completed 7th grade (n=13) No network assessment (n=1)	Completed 7th grade (n = 13) Dropped from analysis (n = 1)
Completed 8th grade (n = 13) No network assessment (n=1)	Completed 8th grade (n = 13) Dropped from analysis (n = 1)
Completed 9th grade (n = 13) No network assessment (n=1)	Completed 9th grade (n = 13) Dropped from analysis (n = 1)

Formulas and Definitions for Centrality Measures

Degree: The number of individuals with friendship ties to the target individual.

Closeness centrality: Mean of inverted distance from all others in the network. Formula:

$$C_{Ci} = \frac{\sum (\frac{1}{d_{ij}})}{N-1}$$

Where d_{ij} is the distance from i to j (the minimum number of friendship links by which they are connected) and N is the number of individuals in the network. If i cannot reach j, then d_{ij} is infinite and $(1/d_{ij}) \rightarrow 0$.

Reach (in two steps): The number of people the individual can reach within two steps, which corresponds to the count of friends and friends of friends.

Bonacich centrality: Weights each individual's centrality by the centrality of the nodes they are connected to. The measure is formally expressed as:

$$C(\alpha,\beta) = \alpha(I - \beta A)^{-1} A 1$$

Where **A** is the adjacency matrix, **I** is the identity matrix, and **1** is a column vector of 1s. The score is controlled by two parameters: α which is a normalizing constant chosen to ensure that the sum of squared scores equals the number of nodes.[1] The power score, β, controls how much influence nodes at further distances have on the score. This weight can be no larger than the reciprocal of the largest eigenvalue of the network, and for consistency we use a β value of (0.75)*largest eigenvalue. As with *Information Centrality*, we treat the network as symmetric and exclude isolates and isolated dyads.

Information Centrality: Based on total connectivity, along all paths, between every pair in the network. Wasserman and Faust provide for calculation details.[2] To calculate, first define a new matrix **B** from the adjacency matrix (**A**) such that the diagonal is equal to the degree plus 1 and the off-diagonal cells are equal to 0 if **I** is incident with j, zero otherwise:

$$B_{ij} = 1 - A_{ij}$$

$$B_{ii} = \sum_{j=1}^{n} A_{ij} + 1$$

Then define **C** as the inverse of **B**, T as the trace of **C**, and R as the sum of an off-diagonal row of **C**:

$$C = B^{-1}$$
$$T = \sum_{i=1}^{n} C_{ii}$$
$$R = \sum_{j=1}^{n} C_{ij}$$

Then information centrality is:

$$I_i = \frac{1}{c_{ii} + (T - 2R)/n}$$

Since information centrality requires an invertible matrix, we use only the symmetric network ignoring the direction of the friendship direction. We exclude isolates and isolated dyads to ensure an invertible matrix.

Betweenness centrality: Captures the individual's ability to block flow between others. It is determined by the extent to which the individual sits on the shortest paths between pairs of other nodes. Specifically, betweenness centrality is computed as the proportion of the shortest friendship paths between all other pairs of individuals that pass through this individual:

$$C_B(n_i) = \sum_{j<k} g_{jk}(n_i) / g_{jk}$$

Where g_{jk} is the number of shortest paths connected nodes *j* and *k*, and $g_{jk}(n_i)$ is the number of such paths that node *i* is part of.

1.   Bonacich P. Power and centrality: A family of measures. *Am J of Sociol*. 1987;92(5):1170-1182.
2.   Wasserman S, Faust K. *Social Network Analysis : Methods and Applications*. Cambridge: Cambridge University Press; 1994.

In all equations, * indicates the transformed index, i is the individual adolescent, and n_j is the number of adolescent respondents in the network

Total degree: The distribution was not dependent on network size and it was reasonably symmetric with the exception of positive outliers. Scores above 15 (0.3% of cases and 3.5 *SD* above the mean) were recoded to 15.

In degree: A square transformation adequately reduced skewness and outliers. Variance was relatively homogeneous in relation to network size.

$$ID_i^* = \sqrt{ID_i}$$

Closeness centrality, undirected: Isolates had received scores of zero, which made them extreme outliers, and they were therefore coded to the next lowest scores, which was .16. Dependence of variance on network size was reduced by multiplying by the ratio of the network size to the mean network size. The skew of the measure was reduced by taking the cube root of the result.

$$C_{U,i}^* = \sqrt[3]{C_{U,i} \frac{n_j}{186}}$$

Closeness centrality, incoming: Dependence of variance on network size was reduced by multiplying by the ratio of the network size to the mean network size. The skew of the measure was reduced by taking the cube root of the result.

$$C_{I,i}^* = \sqrt[3]{C_{I,i} \frac{n_j}{186}}$$

Reach, undirected: For relatively small school cohorts, the variance of this measure was reduced in smaller networks due to the limited number of potential friends. Therefore, in networks with fewer than 150 students we multiplied scores by a factor that diminished toward one as size approached 150.

$$\text{If } n_j < 150, \ R_{U,i}^* = R_{U,i} \sqrt{\frac{160}{n_j + 10}}$$

In addition, outliers were reduced by recoding values above 65 to 65 (the top 0.5% and 2.9 *SD* above the mean).

Reach, incoming: As with undirected reach, the variance of this measure was reduced in smaller networks by the limited number of potential friends. In this case, however, that effect was concentrated in networks of 100 students or less, given the smaller range of the measure itself. Therefore, in networks with fewer than 100 students we multiplied scores by a factor that diminished toward one as size approached 100.

$$\text{If } n_j < 100, \ R_{I,i}^+ = R_{I,i} \sqrt{\frac{100}{n_j}} \ , \text{ if } n_j \geq 100, R_{I,i}^+ = R_{I,i}$$

Unlike the undirected version of reach, these scores were still highly skewed, so outliers above 65 were recoded to 65 (less than 0.1%), and the final measure was the square root of these scores.

$$R^*_{I,i} = \sqrt{R^+_{I,i}}$$

Bonacich centrality: First, outliers with scores above 3.25 ($< 0.1\%$ and 4.3 SD above the mean), were recoded to 3.25. The square root was then taken to reduce skew.

$$B^*_{U,i} = \sqrt{B_{U,i}}$$

Information centrality: Scores had not been computed for students who were not members of the largest component (i.e., the largest connected cluster), so they were assigned the minimum value of zero. In order to compensate for an inverse relationship between variance and network size and for a negative skew, scores were first multiplied by the ratio of the size of their largest connected cluster (lc_j) and the mean of that size across networks and then squared. Squaring produced very small values for this fractional index, so the result was multiplied by 10,000.

$$I^*_{U,i} = 10{,}000 \left(I_{U,i} \frac{lc_j}{178} \right)^2$$

Betweenness, symmetrical and incoming. The same transformation was applied to both of these measures. In each case, variance was highly dependent on network size, and the distribution was positively skewed. To compensate, each was multiplied by the ratio of network size to mean network size, and the cube root was taken of the result.

$$B^*_i = \sqrt[3]{B_i \frac{n_j}{186}}$$

Substance Use

During the past <u>month</u>, how many times have you:
Smoked any cigarettes
Had beer, wine, wine coolers, or other liquor
Been drunk from drinking wine, wine coolers, or other liquor
Smoked marijuana (pot, reefer, weed, blunts)

Not at all 1
One time 2
A few times 3
About once a week 4
More than once a week 5

Substance Use Attitudes
Anti-use Attitudes

How wrong do you think it is for someone your age to do any of the following things?
Smoke cigarettes
Drink beer, wine, or liquor
Use marijuana or pot

Not at all wrong 1
A little bit wrong 2
Fairly wrong 3
Very wrong.............................4

Expectations for Use

How much do you agree or disagree with each statement?
Kids who smoke have more friends
Smoking cigarettes makes you look cool
Smoking cigarettes lets you have more fun
Kids who drink alcohol have more friends
Drinking alcohol is a good way of dealing you're your problems
Drinking alcohol makes you look cool
Drinking alcohol lets you have more fun
Drinking helps you get along with other people
Kids who use marijuana (pot) have more friends
Smoking marijuana (pot) makes you look cool
Smoking marijuana (pot) lets you have more fun

Strongly disagree 1
Disagree.................................2
Not sure.................................3
Agree......................................4
Strongly agree........................5

Refusal Intentions

How likely are you to say "no" when someone tries to get you to:

Smoke a cigarette
Drink beer, wine, or liquor
Smoke marijuana or hashish
Use cocaine, methamphetamine (meth), or other hard drugs
Sniff glue, paint, gas, or other things you inhale to get high

Definitely would say "no" 1
Probably would say "no" 2
Not sure 3
Probably would not say "no" 4
Definitely would not say "no" 5

Refusal Efficacy

How confident are you that you could do well in the following situations?

Refusing marijuana/pot offered by a friend
Refusing a cigarette offered by a friend
Refusing an alcoholic drink offered by a friend

Not at all confident.................1
A little bit confident................2
Somewhat confident 3
Mostly confident.....................4
Very confident 5

Delinquency

During the past 12 months, how many times have you:

Taken something worth less than $25 that didn't belong to you
Taken something worth $25 or more that didn't belong to you
Beat up someone or physically fought with someone because they made you angry (other than just playing around)
Purposely damaged or destroyed property that did not belong to you
Broken into or tried to break into a building just for fun or to look around
Thrown objects such as rocks or bottles at people to hurt or scare them
Been picked up by the police for breaking a law
Run away from home
Skipped school or classes without an excuse
Carried a hidden weapon
Avoided paying for things such as movies, rides, food, or computer services
Taken something from a store that you did not pay for

Never......................................1
Once 2
Twice......................................3
Three or four times.................4
Five or more times 5

7

Pretest Comparison of Antisocial Influence Potential for Intervention and Comparison School Districts

Centrality Measures Based on Undirected Ties					
Centrality Measure	**Antisocial Measure**	**B**	**S.E.**	**z**	**p**
Composite, undirected	Composite	0.042	0.057	0.74	0.458
Composite, undirected	Substance Use	0.070	0.047	1.50	0.135
Composite, undirected	Subst Use Attitudes	0.051	0.047	-1.09	0.276
Composite, undirected	Delinquency	-0.002	0.045	-0.05	0.957
Total degree (in & out)	Composite	0.034	0.056	0.60	0.550
Total degree (in & out)	Substance Use	0.043	0.042	1.02	0.306
Total degree (in & out)	Subst Use Attitudes	0.041	0.046	-0.91	0.362
Total degree (in & out)	Delinquency	0.008	0.042	0.19	0.853
Closeness, undirected	Composite	0.026	0.057	0.45	0.649
Closeness, undirected	Substance Use	0.025	0.037	0.67	0.500
Closeness, undirected	Subst Use Attitudes	0.025	0.047	-0.53	0.594
Closeness, undirected	Delinquency	0.009	0.042	0.20	0.839
Reach, undirected	Composite	0.017	0.055	0.30	0.763
Reach, undirected	Substance Use	0.040	0.036	1.09	0.277
Reach, undirected	Subst Use Attitudes	0.020	0.044	-0.45	0.653
Reach, undirected	Delinquency	-0.002	0.042	-0.06	0.954
Bonacich, undirected	Composite	0.054	0.068	0.80	0.422
Bonacich, undirected	Substance Use	0.110	0.056	1.97	0.048
Bonacich, undirected	Subst Use Attitudes	0.075	0.051	-1.48	0.139
Bonacich, undirected	Delinquency	-0.009	0.051	-0.18	0.854
Information centrality	Composite	0.036	0.068	0.53	0.598
Information centrality	Substance Use	0.030	0.045	0.66	0.512
Information centrality	Subst Use Attitudes	0.037	0.055	-0.68	0.498
Information centrality	Delinquency	0.004	0.050	0.08	0.933
Betweenness, symmetric	Composite	0.013	0.041	0.32	0.747
Betweenness, symmetric	Substance Use	0.000	0.044	0.00	1.000
Betweenness, symmetric	Subst Use Attitudes	0.006	0.045	-0.13	0.894
Betweenness, symmetric	Delinquency	-0.005	0.029	-0.16	0.871
Centrality Measures Based on Incoming/Directed Ties					
Centrality Measure	**Antisocial Measure**	**B**	**S.E.**	**z**	**p**
Composite, inward	Composite	0.006	0.056	0.11	0.915
Composite, inward	Substance Use	-0.013	0.049	-0.25	0.799
Composite, inward	Subst Use Attitudes	0.023	0.048	-0.49	0.626
Composite, inward	Delinquency	-0.019	0.041	-0.46	0.642
In Degree	Composite	0.000	0.054	0.01	0.994
In Degree	Substance Use	-0.023	0.050	-0.47	0.636
In Degree	Subst Use Attitudes	0.023	0.047	-0.48	0.632
In Degree	Delinquency	-0.018	0.035	-0.52	0.600
Closeness, In	Composite	0.013	0.054	0.25	0.805
Closeness, In	Substance Use	-0.002	0.049	-0.05	0.961
Closeness, In	Subst Use Attitudes	0.026	0.044	-0.59	0.556
Closeness, In	Delinquency	-0.020	0.038	-0.52	0.606
Reach, in	Composite	-0.001	0.056	-0.02	0.985

Reach, in	Substance Use	-0.012	0.046	-0.27	0.787
Reach, in	Subst Use Attitudes	0.023	0.047	-0.49	0.626
Reach, in	Delinquency	-0.035	0.040	-0.86	0.390
Betweenness, incoming	Composite	0.019	0.044	0.43	0.668
Betweenness, incoming	Substance Use	0.026	0.044	0.59	0.555
Betweenness, incoming	Subst Use Attitudes	0.002	0.043	-0.06	0.955
Betweenness, incoming	Delinquency	0.006	0.030	0.21	0.832

Note: Undirected composite includes all 6 undirected position measures. Incoming composite does not include betweenness, which is distinctly less correlated with the other 3 than they are with one another. N = 80 schools/cohort combinations, except for measures with substance use, where N = 77.

Program Effect Estimates for All Measures of Antisocial Influence Potential:
Base Model, Controlling only for Wave

Centrality Measures Based on Undirected Ties					
Centrality Measure	**Antisocial Measure**	**B**	**S.E.**	**Z**	**p**
Composite, undirected	Composite	-0.052	0.019	-2.70	0.007
Composite, undirected	Substance Use	-0.036	0.015	-2.36	0.018
Composite, undirected	Subst Use Attitudes	-0.044	0.021	2.07	0.038
Composite, undirected	Delinquency	-0.058	0.019	-2.97	0.003
Total degree (in & out)	Composite	-0.063	0.024	-2.67	0.008
Total degree (in & out)	Substance Use	-0.027	0.013	-2.01	0.044
Total degree (in & out)	Subst Use Attitudes	-0.040	0.018	2.23	0.026
Total degree (in & out)	Delinquency	-0.046	0.015	-3.13	0.002
Closeness, undirected	Composite	-0.039	0.017	-2.36	0.018
Closeness, undirected	Substance Use	-0.019	0.012	-1.55	0.121
Closeness, undirected	Subst Use Attitudes	-0.029	0.017	1.70	0.090
Closeness, undirected	Delinquency	-0.039	0.015	-2.64	0.008
Reach, undirected	Composite	-0.046	0.017	-2.67	0.008
Reach, undirected	Substance Use	-0.025	0.013	-1.87	0.062
Reach, undirected	Subst Use Attitudes	-0.036	0.017	2.05	0.040
Reach, undirected	Delinquency	-0.045	0.015	-2.95	0.003
Bonacich, undirected	Composite	-0.072	0.024	-2.98	0.003
Bonacich, undirected	Substance Use	-0.049	0.018	-2.66	0.008
Bonacich, undirected	Subst Use Attitudes	-0.057	0.023	2.47	0.014
Bonacich, undirected	Delinquency	-0.066	0.020	-3.34	0.001
Information centrality	Composite	-0.053	0.020	-2.70	0.007
Information centrality	Substance Use	-0.030	0.016	-1.92	0.055
Information centrality	Subst Use Attitudes	-0.042	0.020	2.06	0.039
Information centrality	Delinquency	-0.053	0.017	-3.05	0.002
Betweenness, symmetric	Composite	-0.014	0.013	-1.12	0.264
Betweenness, symmetric	Substance Use	-0.004	0.011	-0.36	0.721
Betweenness, symmetric	Subst Use Attitudes	-0.015	0.015	1.03	0.301
Betweenness, symmetric	Delinquency	-0.015	0.012	-1.27	0.206
Centrality Measures Based on Incoming/Directed Ties					
Centrality Measure	**Antisocial Measure**	**B**	**S.E.**	**z**	**p**
Composite, inward	Composite	-0.031	0.016	-1.97	0.049
Composite, inward	Substance Use	-0.015	0.013	-1.11	0.268
Composite, inward	Subst Use Attitudes	-0.019	0.016	1.21	0.225
Composite, inward	Delinquency	-0.037	0.015	-2.55	0.011
In Degree	Composite	-0.029	0.015	-1.94	0.052
In Degree	Substance Use	-0.014	0.013	-1.10	0.272
In Degree	Subst Use Attitudes	-0.020	0.016	1.29	0.198
In Degree	Delinquency	-0.034	0.014	-2.37	0.018
Closeness, In	Composite	-0.023	0.015	-1.48	0.140
Closeness, In	Substance Use	-0.009	0.013	-0.70	0.486
Closeness, In	Subst Use Attitudes	-0.011	0.015	0.74	0.462
Closeness, In	Delinquency	-0.033	0.014	-2.38	0.017
Reach, in	Composite	-0.037	0.016	-2.30	0.021

Reach, in	Substance Use	-0.020	0.014	-1.44	0.149
Reach, in	Subst Use Attitudes	-0.025	0.017	1.52	0.129
Reach, in	Delinquency	-0.042	0.015	-2.85	0.004
Betweenness, incoming	Composite	-0.008	0.013	-0.58	0.560
Betweenness, incoming	Substance Use	0.006	0.013	0.46	0.649
Betweenness, incoming	Subst Use Attitudes	-0.013	0.015	0.90	0.367
Betweenness, incoming	Delinquency	-0.007	0.012	-0.60	0.550

Note: Undirected composite includes all 6 undirected position measures. Incoming composite does not include betweenness, which is distinctly less correlated with the other 3 than they are with one another. N's = 256 school/cohort/wave combinations, except measures with substance use, where N = 255, and for substance combined with composite incoming measures and with Bonacich centrality, where N = 253.

Program Effect Estimates for All Measures of Antisocial Influence Potential:
Controlling for Wave, Pretest, State, and Number of Students

Centrality Measures Based on Undirected Ties					
Centrality Measure	**Antisocial Measure**	**Std. b**	**S.E.**	**z**	**p**
Composite, undirected	Composite	-0.058	0.018	-3.17	0.002
Composite, undirected	Substance Use	-0.038	0.015	-2.61	0.009
Composite, undirected	Subst Use Attitudes	-0.051	0.020	2.56	0.010
Composite, undirected	Delinquency	-0.048	0.015	-3.10	0.002
Total degree (in & out)	Composite	-0.050	0.015	-3.34	0.001
Total degree (in & out)	Substance Use	-0.029	0.013	-2.30	0.021
Total degree (in & out)	Subst Use Attitudes	-0.044	0.016	2.75	0.006
Total degree (in & out)	Delinquency	-0.044	0.013	-3.42	0.001
Closeness, undirected	Composite	-0.036	0.015	-2.50	0.012
Closeness, undirected	Substance Use	-0.019	0.012	-1.64	0.101
Closeness, undirected	Subst Use Attitudes	-0.028	0.015	1.93	0.054
Closeness, undirected	Delinquency	-0.036	0.014	-2.62	0.009
Reach, undirected	Composite	-0.045	0.016	-2.73	0.006
Reach, undirected	Substance Use	-0.026	0.013	-1.97	0.049
Reach, undirected	Subst Use Attitudes	-0.035	0.016	2.21	0.027
Reach, undirected	Delinquency	-0.041	0.015	-2.83	0.005
Bonacich, undirected	Composite	-0.079	0.021	-3.78	0.000
Bonacich, undirected	Substance Use	-0.053	0.018	-2.95	0.003
Bonacich, undirected	Subst Use Attitudes	-0.068	0.021	3.17	0.002
Bonacich, undirected	Delinquency	-0.061	0.017	-3.69	0.000
Information centrality	Composite	-0.052	0.018	-2.91	0.004
Information centrality	Substance Use	-0.031	0.015	-2.01	0.044
Information centrality	Subst Use Attitudes	-0.041	0.018	2.26	0.024
Information centrality	Delinquency	-0.048	0.016	-3.08	0.002
Betweenness, symmetric	Composite	-0.014	0.011	-1.26	0.207
Betweenness, symmetric	Substance Use	-0.004	0.010	-0.41	0.680
Betweenness, symmetric	Subst Use Attitudes	-0.012	0.013	0.94	0.345
Betweenness, symmetric	Delinquency	-0.013	0.011	-1.25	0.212
Centrality Measures Based on Incoming/Directed Ties					
Centrality Measure	**Antisocial Measure**	**Std. b**	**S.E.**	**z**	**p**
Composite, inward	Composite	-0.027	0.014	-1.90	0.057
Composite, inward	Substance Use	-0.014	0.013	-1.09	0.277
Composite, inward	Subst Use Attitudes	-0.017	0.015	1.19	0.233
Composite, inward	Delinquency	-0.031	0.013	-2.34	0.020
In Degree	Composite	-0.028	0.013	-2.07	0.039
In Degree	Substance Use	-0.014	0.012	-1.14	0.254
In Degree	Subst Use Attitudes	-0.020	0.014	1.46	0.145
In Degree	Delinquency	-0.029	0.012	-2.48	0.013
Closeness, In	Composite	-0.018	0.014	-1.31	0.191
Closeness, In	Substance Use	-0.008	0.013	-0.60	0.547
Closeness, In	Subst Use Attitudes	-0.009	0.014	0.62	0.533
Closeness, In	Delinquency	-0.027	0.012	-2.21	0.027
Reach, in	Composite	-0.032	0.015	-2.21	0.027

Reach, in	Substance Use	-0.024	0.014	-1.74	0.082
Reach, in	Subst Use Attitudes	-0.022	0.015	1.47	0.142
Reach, in	Delinquency	-0.035	0.013	-2.70	0.007
Betweenness, incoming	Composite	-0.009	0.012	-0.77	0.440
Betweenness, incoming	Substance Use	0.004	0.012	0.31	0.759
Betweenness, incoming	Subst Use Attitudes	-0.012	0.013	0.91	0.364
Betweenness, incoming	Delinquency	-0.006	0.011	-0.59	0.556

Note: Undirected composite includes all 6 undirected position measures. Incoming composite does not include betweenness, which is distinctly less correlated with the other 3 than they are with one another. N's = 256 school/cohort/wave combinations, except measures with substance use, where N = 255, and for substance combined with composite incoming measures and with Bonacich centrality, where N = 253.