Popularity and Peer Influence in a South Wales secondary school network

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Introduction

The question of how to eradicate smoking is at the heart of each nation´s policy creation. While researchers might struggle to agree on the most effective measure to successfully reduce smoking, there is general consensus that to succeed in this effort there needs to be understanding of the circumstances by which smoking is picked up as a habit and sustained in one´s life. An interesting starting point to the analysis of the processes that "generate" a smoker are middle schools, as they relate to a significant time of life when the habit might start, and because teenagers´ can be highly influenced by their peers both positively and negatively, meaning they might begin smoking or not as a result of their friends´ behavior or attitudes in that regard. The concept of peer influence, or contagion, is a familiar notion in studies of social network analysis. It entails that behavior, in a given network, spreads as a result of assimilation of the behavior of an actors´ relations (Snijders et al. 2010).

Previous research has shown that, in the case of smoking, there is clustering at the behavioral level, or, simply put, that smokers hang out with smokers while non-smokers are mostly surrounded by non-smokers. Competing explanations have emerged as to why this might be the case. While in peer influence the behavior is adopted as a result of the presence of a tie between two individuals, it can also be so that two individuals who behave similarily might form a friendship as a result of it. This concept, known as homophily or preferential attachment, has been used widely in literature to explain phenomena ranging from racial to gender segregation. Simultaneously, there are other aspects that might need to be taken into account: is everyone just as likely to pick up smoking, or are there preliminary individual-level characteristics that make a person less or more likely to start? Additionally, how does the presence, in the network, of influential individuals being smokers affect students´ likelihood to pick up the habit? And how does your network position (i.e. being popular or being an outcast) affect your chances to smoke?

A useful start point to the analysis of network dynamics and smoking is offered by Valente et al. (2005), who argue that there is a positive connection between smoking and popularity, meaning that more popular students in their middle-school sample were more likely to become smokers. Other research has shown that having smokers in a central network position, could increase the likelihood that non-smokers might adopt the habit, thus smoking as a behavior might be adopted as a display of social status or an attempt to improve it (Robalino and Macy 2018).

In this research, we aim at extending on the subject of popularity and smoking by incorporating selection, alongside peer influence, into the picture. As Mercken et al. (2010) state, friendship can be the result of self-selection into groups, driven by behavioral similarity. Our goal is to unveil the mechanisms by which adolescents pick up smoking in a classroom, mainly considering the presence of popular smokers in the network and the mechanisms of peer influence and selection. We avail of the ASSIST dataset, an empirical dataset collected as part of an intervention experiment called *'A Stop Smoking In Schools Trial' (ASSIST)*, which sought to diminish the number of smokers in its sample by using a peer-led approach. Essentially, the researchers trained influential students to provide support outside the classroom in an attempt to encourage peers to avoid smoking. While the dataset is comprised of 59 secondary schools situated in England and

Wales, some acting as control and some as treatment groups, we here avail of one school from rural South Wales, in the control group, to test two competing hypothesis as to how smoking emerges as a behaviour in our classroom, without the confounding effect of the intervention.

To test the relationship between popularity and smoking, we first attempt to answer the question: do you become popular because you smoke or do you smoke because you become popular? As Valente et al. (2005:324) explain, influential people shape social norms, however in turn their own behaviour is affected by the perceived norms of the community. Our first expectation is that *smokers are more popular*, by which we identify two possible mechanisms: that *H1a: people who are smokers receive more nominations*, and its conjugate mechanism that *H1b: people who are nominated more smoke more.* The first mechanism indicates that behavior implements changes at the network level, whereas the conjugate mechanism implies that the network induces changes in behavior.

Our second expectation is that *smokers hang out with smokers*, thus covering the issue of homogeneity bias or network autocorrelation, or else the phenomena that friends behave similarily. The first mechanism, in line with peer influence, is that: *H2a: when one´s friends are smokers pupils pick up smoking* and its conjugate process is that *H2b: when two people smoke they form a friendship.*

Methodologically, we avail of stochastic actor-oriented models (SAOMs), a type of models that display network coevolution dynamics using panel data on a given network, availing of statistical inferencing to draw conclusions on which mechanisms are underlyingly affecting the network (Snijders et al. 2010). SAOMs constitute a powerful method to analyse mechanisms in networks, for a couple of reasons. First, unlike other models that limit network dynamics´ explanations to a single mechanism, SAOMs are built to account for the complex and simultaneous happening of joint actor-structural network dynamics. Here, coevolution is understood as an emergent group outcome driven by interdependent single choices made by individual actors (Snijders et al. 2010). Secondly, SAOMs combine statistical inferencing with simulations, providing flexibility to the models: several parameters (potentially underlying micro-mechanisms) can be tested at once, whilst also controlling for each competing explanatory tendency (Snijders et al. 2010). Finally, they are constructed in such a way that, given panel data (data is collected at some defined time-points), they attempt filling the gaps inbetween observations, as by nature panel data omit information about events happening on a continous time scale. In the case of our study, this indicates that we can tweak the parameters of peer influence, homophily and popularity, to test how smoking is picked up as a result of the aforementioned mechanisms.

Data

The ASSIST data was gathered by researchers as part of a school-based experiment to reduce smoking through peer-led intervention. Specifically, researchers trained a nominated small group of students to act as a source of discouragement in relation to smoking to their school peers, outside the classroom. The overall sample included 59 schools, 29 in the treatment group and 30 in the control group, totalling 10730 students. The students were aged 12-13 at the time, attending their second year of secondary school. Data was collected at four time points, at a distance of one year from each collection. Information gathered included friendship (nominating up to six friends), and various measures related to smoking: smoking behavior, smoking intention, attitudes towards smoking, and ability to refuse to smoke. Finally, the dataset includes sociodemographic variables such as age, gender and family affluence. As the data collectors only gathered friendship data from the second wave onwars, we avail of information from the second wave to the fourth within the scope of this analysis.

Our research focuses solely on one school from rural South Wales, comprised of 188 students. Although our school was part of the control group, thus intervention was never implemented, we expect it to provide an interesting case study to our research: as Campbell et al. (2009) mention, schools located in rural communities are more likely to be close-knit, and there intervention programs have had a greater effect. In a similar logic, we assume that the potential presence of popular smokers in the network might heavily impact pupils likelihood to pick up smoking. Importantly, we note this might give rise to some generalisability issues.

Smoking behavior. The smoking variable we avail of is smoking behavior, or self-reported cigarette consumption, ranging from 1, indicating the pupil has never smoked, to 6, which implies consumption of more than six cigarettes per week.

Popularity is measured through friendship nominations. A high indegree indicates high popularity, whereas low indegree indicates low popularity.

Model Specification

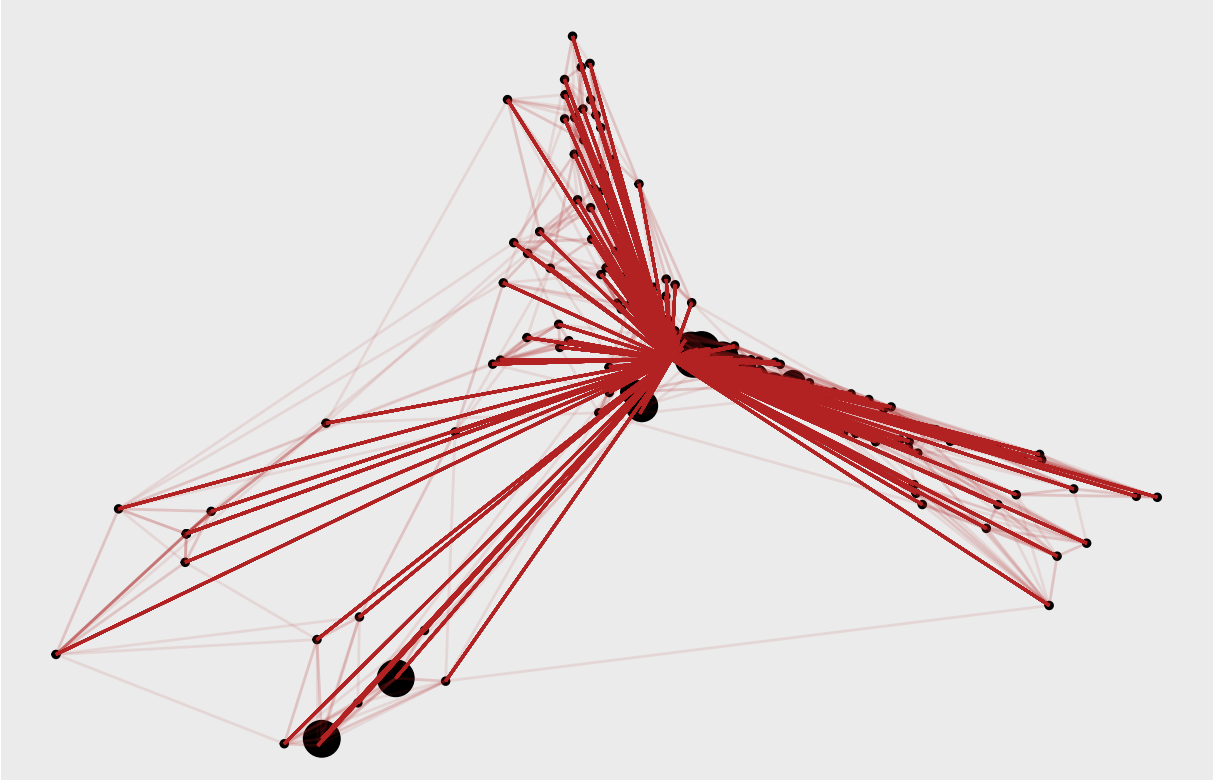
As mentioned above, we will avail of SAOMs to analyse our data and test our hypotheses. By method of stochastic actor-oriented models, we start the analysis by selecting effects that will be used to build two objective functions aimed at testing our hypothetized mechanisms. The first function models behavioural changes, thus it captures alteration in pupils´ smoking rates and intensity, which evaluates peer influence in the network. The second function instead overviews changes at a structural level, mainly the formation or dissolution of ties, thus it provides the base to assess homophily based on smoking behavior (Steglich et al. 2012). Crucially, both functions operate dependently to examine selection and influence simultaneously whilst controlling for each other (Mercken et al. 2010). Here follows a description of the effects chosen to run our model estimation: *Average similarity* (effect on the dynamics of smoking) measures, in the behavior´s objective function, the tendency for an individual to behave more similarily to his peers overtime. *Smoke ego*, whether an actor smokes, *Smoke alter*, whether a peer smokes, *Smoke similarity*, the similarity in smoking between two friends, are included to measure the overall effect of smoking on friendshipor in other words an individuals´ tendency to choose as friends people who have similar smoking behavior.

Friendship in network arises as a result of various well-known mechanisms alongside our hypothesised ones, thus it is necessary to add parameters to our model that allow us to control for determinants of friendship selection beyond smoking. *Transitivity* or in other words becoming a friend of a friend´s friend, is a regular occurrence in social network studies of tie formation. We here control for it in our model by adding the effect of transitive triplets, transitive reciprocate triplets and triadic closure. *Reciprocity* or mutuality, is the tendency to return an incoming tie. *Gender segregation* or gender homophily, is the tendency to form ties with peers of the same sex, a phenomena that is rather common in young teenagers. *Affluence*: we control for affluence, where each peers has a score, measured during the third wave (counts as second in our analysis since we have dropped the first one when friendship was not measured), and keep it as a constant during all waves, assuming that there is likely to be little variation over affluence for young teenagers during the four years of secondary school. Affluence ranks between 0 and 6 and was calculated through the questions: "Does your family have a car or van?" (No, Yes, or Yes two or more), "Do you have your own bedroom for yourself?" (No or Yes), and "During the last 12 months, how many times did you travel away on holiday with your family?" (Not at all, Once, Twice, or More than twice). *Age*: we control for age, as friendships have the tendency to be more fluid in earlier years of schools and to consolidate overtime.

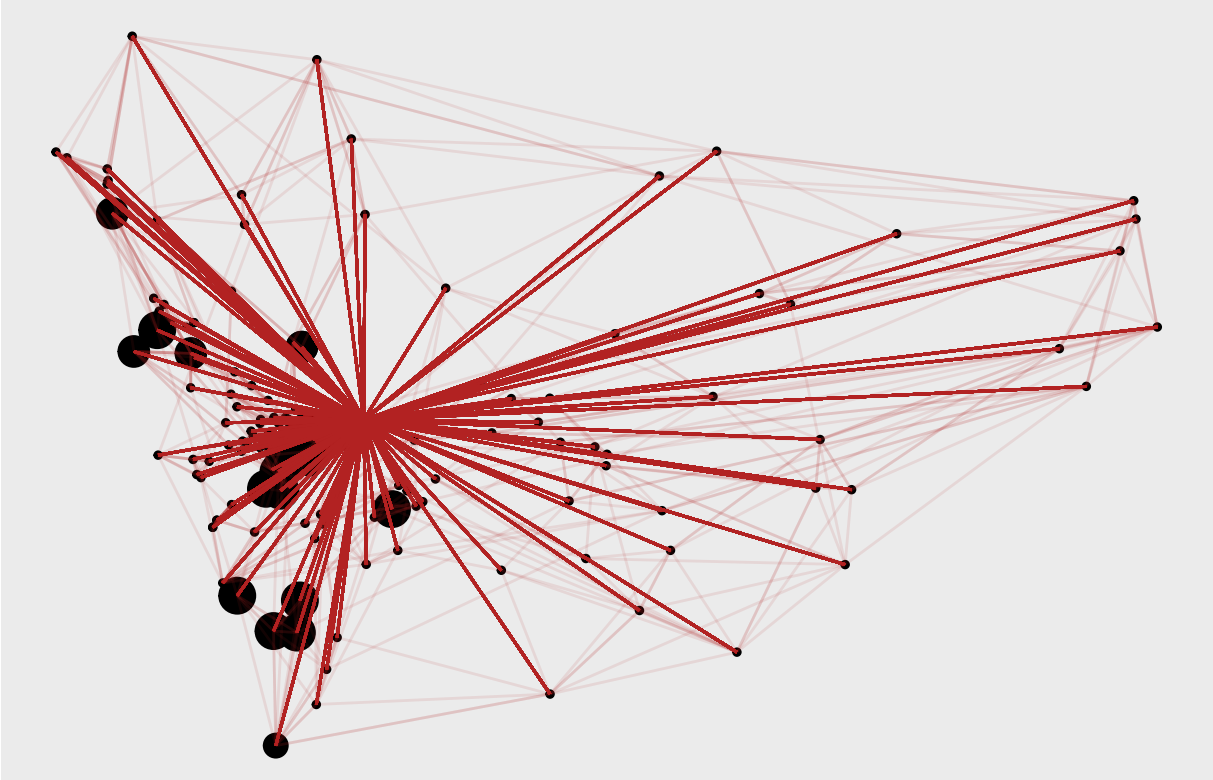
Results

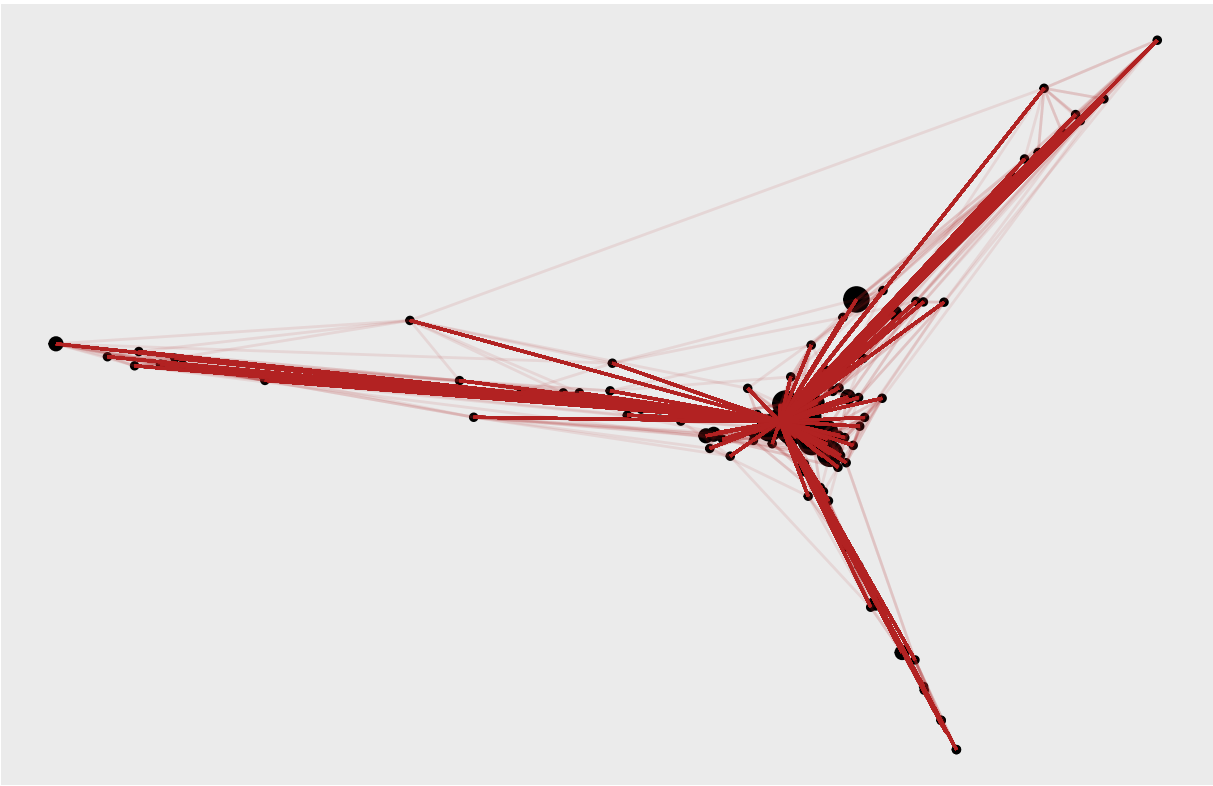
A first visual glance of the networks at the three time points (node sized by smoking intensity, edges by friendship weight), indicates that our school network is rather connected, with no isolates and highly reciprocated ties. Interestingly, there appears to be a "core", with influential nodes, where the heavier smokers seems to be mostly located, potentially indicating that smokers are popular, and friends among each other.

A South Wales rural school network − wave1



A South Wales rural school network − wave 2





Descriptive of friendship network

Here below are presented descriptive statistics of the network: we can see from the table that density grows overtime, indicating larger amounts of friendship groups in the network. Both reciprocity and transitivity are rather high in the network, as could be expected.

Table 1: Descriptive Network Statistics Overtime

	V	W	X
average degree	36.02	61.64	69.61
sd outdegree	46.64	55.97	57.40
sd indegree	46.64	55.97	57.40
reciprocity	0.89	0.98	0.85
transitivity	0.14	0.39	1

Data from ASSIST dataset: a comprehensive secondary school in a rural valley in South Wales

Descriptives of smoking

Here below are presented a visual representation of smoking behavior overtime, as well as descriptive statistics of smoking behavior. As we can see, smoking rates are on average rather low within the school, and the maximum given score, at all three time points, is 4, on a scale that measures up to 6. The mean smoking score is between 1.3 in the first wave, and goes up to 1.5 in the last wave, suggesting either that more people pick up smoking or that the smoking behavior of some individuals intensifies overtime. The standard

deviation also appear to become wider overtime, suggesting perhaps a phenomena of polarization, that is, people either become heavier smokers or quit smoking overtime.

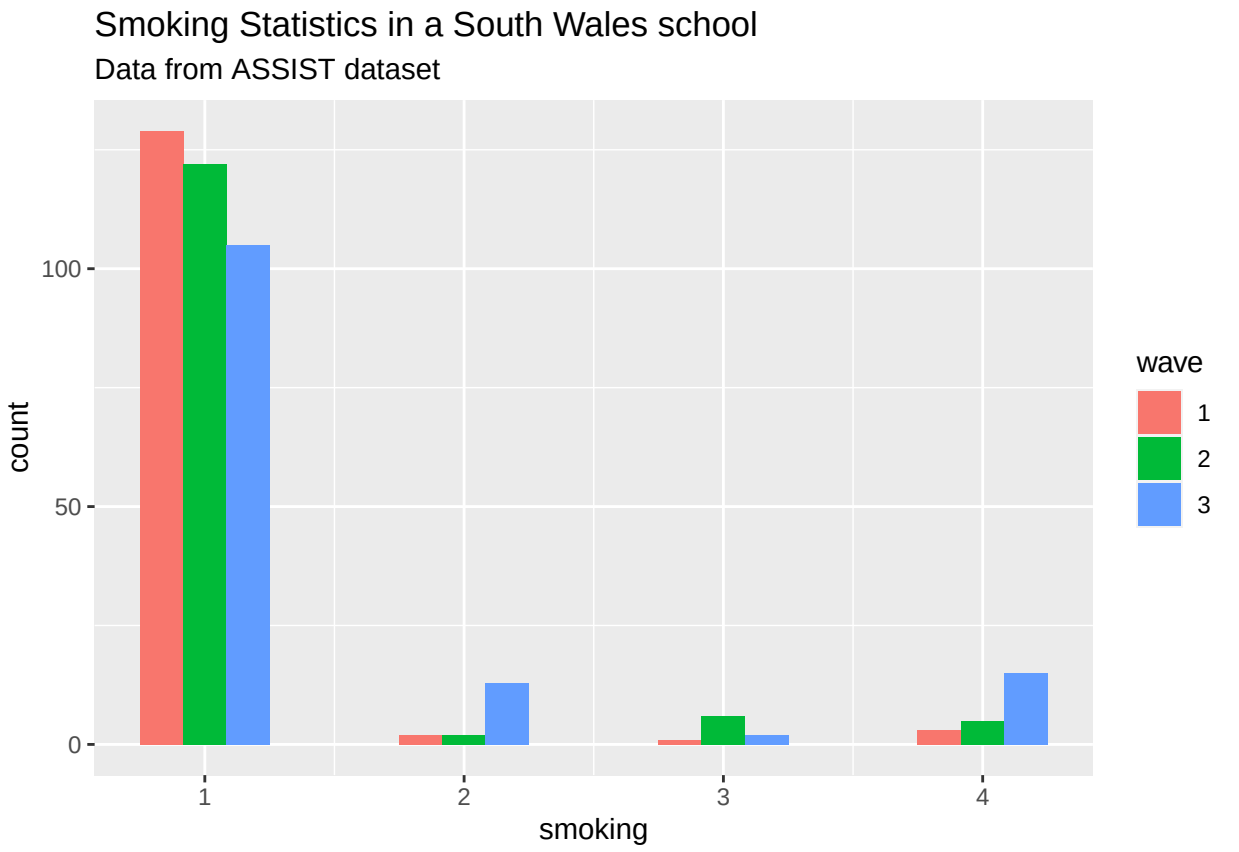


Table 2: Descriptive Smoking Statistics Overtime

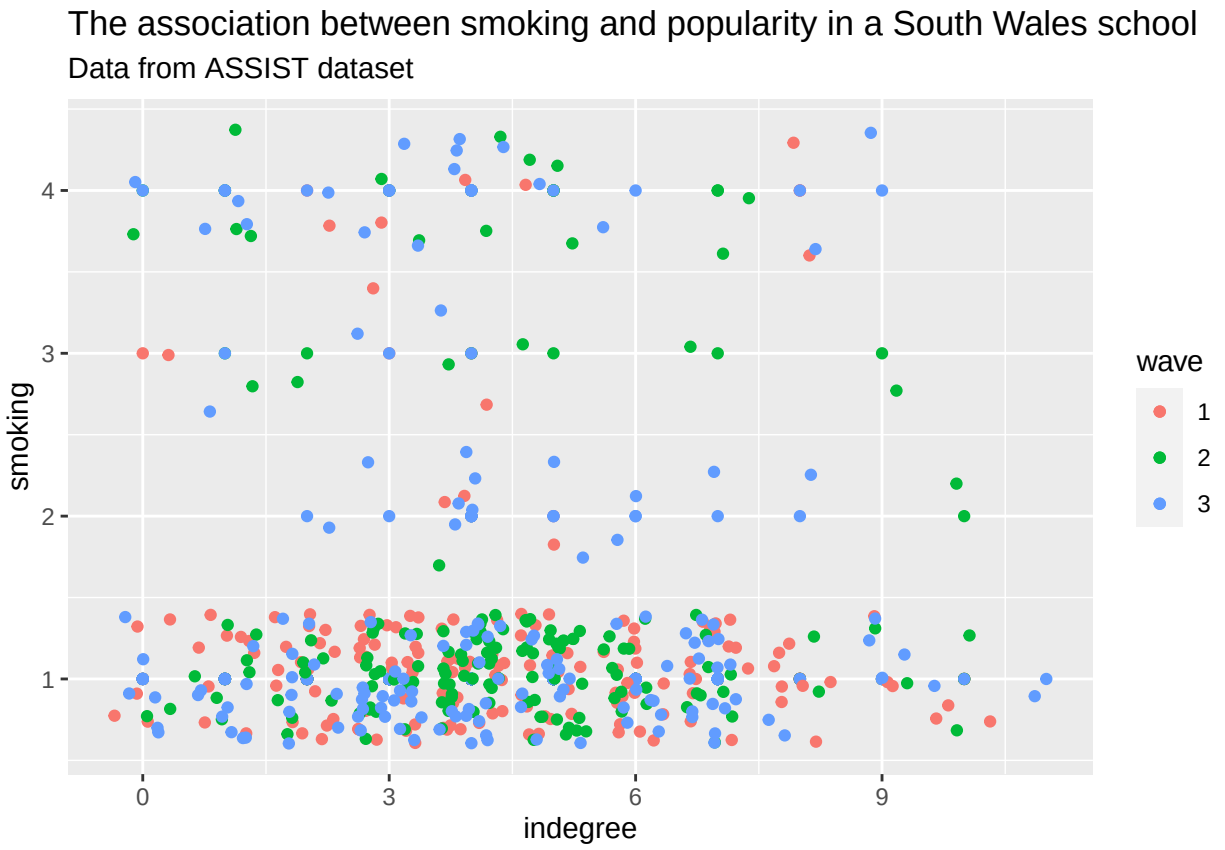
	t1	t2	t3
average smoking	1.167	1.351	1.462
sd smoking	0.633	0.911	0.979

Data from ASSIST dataset: a comprehensive secondary school in a rural valley in South Wales

Descriptive of the association between the two: more popular people smoke more & smokers hang out with smokers

In the figure below, the association between popularity and smoking is observed overtime. Each dot indicates a student, and its location is based on the student incoming nominations (x axis) and smoking behavior (y axis). The plot is coloured by time wave. What can we infer about the association from smoking and indegree by looking at this plot? At a first glance, the first noticeable fact is that, compared to the first wave, school children seem to receive higher nominations overtime, probably as a result of consolidation of friendships. Additionally, the number of smokers goes up overtime, although not by a large margin. The top right corner shows that there are two highly popular individuals within the school who are also smokers. Whilst the sample is large, as we have assessed previously the numbers of non-smokers is much larger than the number of smokers, thus whilst two influential smokers in a school of over 150 students might not appear like a lot, comparatively their level of popularity, given their smoking behavior, is an indication that perhaps

smoking and popularity go hand in hand, as formulated in our hypothesis. The analysis following will reveal whether our expectation that popularity and smoking are positively associated is confirmed or not.



Model results

Upon running our model, we first assess its convergence. The value of 0.19 indicates good overall convergence, as the parameters by convention should be lower than 0.25, and for each effect lower than 0.1 in absolute terms. Here follows a description of the model output.

Determinants of friendship dynamics The constant rate friendship indicates the average amount of opportunities each actor has had to make a change in friendship ties (including dropping a tie). Density is negative and significant, which is to be expected in networks. Reciprocity is positive and significant, also rather common, as most people reciprocate their friendships. Transitive triplets is positive and significant, which indicates that there is a tendency to become friends of your friends. Reciprocated transitivity is negative and significant, which indicates that there is no tendency overtime towards reciprocity in transitive triads. Triadic closure is negative yet non-significant. Gender alter is the effect of a person´s gender on attractiveness of the potential friendship. The negative coefficient indicates that gender makes a potential friend not-attractive, yet it is not significant. Gender ego is the effect of your gender on selection of friends, and it is positive and non-significant. Same gender indicates gender segregation in the network, and it is positive and significant. Affluence is found not to be significant at any level, as it is age. Interestingly, smoking is not significant at any level either, which indicates that smoking doesn´t make you more attractive to others, or make others more attractive to you; thus smoking has no significant impact on friendship formation, or popularity, which indicates no presence of smoking homophily.

Determinants of smoking dynamics The rate smoking indicates how many opportunities each person had to make a change in relation to smoking. Smoking linear shape indicates that overtime people tend to smoke less. Smoking quadratic shape is positive and significant which indicates that people overtime consolidate

their habit of either smoking or non-smoking (an indication of polarization). Smoking total similarity is positive and significant, and indicates an actor´s tendency to become more similar to his friends overtime, thus it confirms the presence of peer influence in relation to smoking. Smoking indegree is positive but not significant; thus we cannot support the hypothesis that becoming popular impacts your smoking behavior.

Table 3: Dynamics of friendship and smoking behavior - SAOM output

	parameter	estimate	st.error	normal.variate	p.value
1	constant friendship rate (period 1)	18.978	1.685	11.260	0
2	constant friendship rate (period 2)	24.838	5.301	4.690	0
3	outdegree (density)	-3.045	0.174	-17.540	0
4	reciprocity	2.457	0.132	18.620	0
5	transitive triplets	0.775	0.040	19.620	0
6	transitive recipr. triplets	-0.430	0.119	-3.610	0.0003
7	3-cycles	-0.172	0.135	-1.280	0.202
8	gender alter	-0.228	0.279	-0.820	0.414
9	gender ego	0.113	0.279	0.410	0.685
10	same gender	0.637	0.149	4.270	0
11	affluence alter	0.032	0.071	0.450	0.649
12	affluence ego	0.047	0.037	1.270	0.203
13	affluence similarity	0.006	0.300	0.020	0.984
14	age alter	0.135	0.109	1.240	0.216
15	age ego	-0.235	0.239	-0.980	0.326
16	age similarity	0.028	0.173	0.160	0.870
17	smoking alter	0.130	0.070	1.870	0.062
18	smoking ego	-0.091	0.067	-1.350	0.177
19	smoking similarity	0.498	0.259	1.920	0.055
20	rate smoking (period 1)	7.792	9.815	0.790	0.427
21	rate smoking (period 2)	9.188	6.031	1.520	0.128
22	smoking linear shape	-2.607	0.623	-4.180	0
23	smoking quadratic shape	1.166	0.178	6.550	0
24	smoking total similarity	0.979	0.400	2.440	0.014
25	smoking indegree	0.138	0.110	1.260	0.207

Data from ASSIST dataset: a comprehensive secondary school in a rural valley in South Wales

Conclusion

The aim of this analysis was to unveil whether popularity impacts smoking, or viceversa, and to assess why people tend to hang out with individuals who are behaviourally similar. For the purpose of this research, we have availed of a South Wales school network data, gathered in relation to the ASSIST peer-led intervention program. Our stochastic actor-oriented analysis reveals that in our school smoking has little impact on friendship dynamics and popularity, but rather that teenagers´ friends have a large influence on individual behavior in relation to smoking. It appears therefore that influence is a much stronger determinant of behaviour than behaviour is of friendship formation. This finding has relevant implications for policy formation, as it indicates that prevention or reduction of smoking might be more successful with the implementation of peer-led intervention programs, similarly to the ASSIST research. Our model output indicates no evidence to support our first expectation of a relationship between popularity and smoking, thus we can only make conclusions at the level of homogeneity of the sample overtime.

Limitations We note that there might be generalisability issues, given the nature of our school, which is situated in rural South Wales. The likelihood that our school presents a tight-knit community scenario where there might be greater effect of influence than in a more dispersed community suggests that this study could be extended to include a wider sample of schools. In this research, we do not control for which classroom each peer belongs to. We acknowledge that including such information in the analysis would provide a more realistic estimation, given students´extensive exposure to just a subsample of peers. Methodologically, our goodness of fit indicates that the models fit the data suitably, however with less precision at certain distribution values, for instance towards central values of the outdegree and indegree empirical distribution, and for certain types of triads.

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